CASE METHOD TEACHING IN SENIOR BIOLOGY: A SYNTHESIS OF CURRICULUM CONTENT AND GOALS WITH YEAR 2000 GOALS

BY

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Case Method Teaching in Senior Biology: A Synthesis of Curriculum Content and Goals with Year 2000 Goals

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ABSTRACT

This thesis examined the feasibility of developing case studies that would address the major concepts of the Biology 12 curriculum as well as meet the curriculum and learning goals articulated in the Ministry of Education's Year 2000 program. Case method teaching, used primarily in social science and business school contexts, was explored as a viable alternative to address some of the problems found in the existing biology curriculum.

The research methodology used in this thesis included systematic analysis of curriculum content and case method structure to determine if these two frameworks could be synthesized to produce teaching cases.

Five cases were constructed, each of which reflected particular science concepts contained in the Biology 12 curriculum. An in-depth analysis of the process of case construction for the first case was made. This process involved a survey of the curriculum, extraction of the "big ideas," data collection, writing and editing. The literature on case development was consulted and the goals of the curriculum for the Year 2000 program as well as the biology course were matched with methodology. The big ideas were then transformed into compelling case narratives designed to

challenge students' knowledge acquisition and understanding. Research into the writing of provocative study questions and follow-up activities informed the generation of questions and related activities that completed each case package.

Findings of this study indicate that cases in science may be constructed to reflect the goals of senior Biology as well as the challenges inherent in the Ministry of Education's goals for the Year 2000 program. Findings also reveal that cases that are content rich can be written as narratives, thus providing an alternative pedagogy for bioscience. Suggestions for further research include the need for field testing these case studies in Biology 12 to determine their effectiveness in delivering the goals and objectives of both the Year 2000 and the biology curriculum.

DEDICATION

To my family, Hugh, Michael and David, for their unfailing and unquestioning support of work that seemed to never end and for living without a computer for ten months.

To Selma, who saw the possibilities when all I could see were the obstacles.

To Allan, who encouraged and cajoled with such grace and good humour.

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CHAPTER ONE

INTRODUCTION

Background

The province of British Columbia recently identified a number of goals considered important for educating students for the next century. These goals, articulated in the Year 2000: A Curriculum and Assessment Framework for the Future, state that the mandate of the schools should be:

> 1. to develop the ability of students to analyze critically, reason and think independently and acquire basic learning skills and bodies of knowledge
>
> 2. to develop in students a lifelong appreciation of learning, a curiosity about the world around them and a capacity for creative thought and expression
>
> 3. to develop in students a sense of self-worth and personal initiative
>
> 4. to develop a sense of social responsibility, and a tolerance and respect for the ideas and beliefs of others
>
> 5. to prepare students to attain their career and occupational objectives
>
> 6. to assist in the development of effective work habits and the flexibility to deal with change in the workplace (Ministry of Education, 1989).

In 1990, the Ministry of Education published the Biology 11/12 Curriculum Guide in which the specific goals of the graduation level biology program were outlined. These goals are:

Goal A

The biology curriculum should provide opportunities for students to develop scientific attitudes, and to develop positive attitudes towards science.

Goal B

The biology curriculum should provide opportunities for students to acquire the skills and understand the processes of science.

Goal C

The biology curriculum should provide opportunities for students to increase their understanding of the basic concepts and principles of biological science.

Goal D

The biology curriculum should provide opportunities for students to develop critical and abstract thinking skills (Ministry of Education, Biology 11/12 Curriculum Guide, 1990, p.9).

Statement of the Problem

This thesis attempted to synthesize the curriculum goals and the objectives of the Biology 12 course and the educational goals of the Year 2000 document into the theoretical framework of case method teaching. Case method teaching, used primarily in social sciences, law, business and medical faculties, was explored as a potentially viable approach for this synthesis. The major question investigated in this thesis was: Can the principles of case narrative and case method teaching be applied in synthesizing curriculum

content of Biology 12 and Year 2000 learning goals? Several sub-questions flow from this major question:

1. What evidence supports the use of case method teaching as a pedagogy that effectively delivers the goals for education in the year 2000?

2. How are "big ideas" or major concepts extracted from curriculum, particularly Biology 12 curriculum?

3. How are cases written that promote examination of the big ideas of the biology curriculum?

4. How may the theoretical framework of case narrative encompass Biology 12 content?

5. What processes are involved in building the framework of cases?

6. How may cases lead to development of content knowledge as set out in the learning outcomes for the course?

7. What activities can be used with cases that will give an experiential base for student research?

Need for the Study

Ministry of Education goals for the preparation of students for twenty-first century life require that teachers throughout the province re-examine curriculum in all subject areas and at all grade levels. In the area of Primary Programs, committees of teachers and others have been meeting for over three years, developing curriculum which is consistent with the goals of the Ministry. At the Intermediate and Graduate levels, meetings are now underway which hope to accomplish the same objectives for the middle and senior years of students' education.

A new approach to curriculum and methodology is needed that will develop students' abilities to analyze, think independently, appreciate learning and curiosity, develop self-worth and social responsibility, prepare for a career and develop effective work habits. As well, students will need opportunities to develop skills and attitudes in science. Researchers and practitioners in science education at both the college and high school level have identified problems in the area of science teaching. The curriculum is overly concerned with factual content and does not adequately address those thinking skills listed above (Wassermann and Ivany, 1988).

This thesis investigated the feasibility of synthesizing curricular goals for Biology 12 and educational goals of the Year 2000, into the theoretical framework of

case method teaching. A successful synthesis would have implications for new approaches to curriculum as well as methodology in the content area of Biology 12.

The research methodolgy employed in this thesis began with a systematic search into the curriculum content of Biology 12 - a search for the "big ideas" or major concepts which form the framework of the curriculum. The search yielded a spectrum of concepts which then had to be assessed in terms of their degree of relevance and the viability of each for case narrative. A synthesis of what is proposed by the Biology 12 curriculum guide and the Year 2000 Graduation program was then undertaken, with a view towards accumulating such a synthesis into case method teaching framework.

There is some evidence to suggest that the framework of case method teaching is one way of accommodating such a synthesis of goals. Although little data are available at the high school level because case method teaching is not yet used extensively in that setting, Adam's study in 1991 provided data which showed that students in a high school Social Studies course taught using the case method perceived in themselves positive changes in the areas of critical analysis, perception or point of view, curiosity about the world around them and acquiring bodies of knowledge. These results were also confirmed by the teacher in the study and by the researcher in analyzing audiotapes of student interactions over the course of a semester. Wassermann at

Simon Fraser University believes that the level of participation of high school students in classes taught by the case method is consistently high (Wassermann, 1992). She suggests that students learning by the case method are more actively engaged and take more responsibility for what they are learning.

In the university setting, case method teaching increases students' abilities to spot issues in problematic situations, to analyze dilemmas in sophisticated ways, and to identify possible alternatives for action (Kleinfeld, 1991). Floyd and Scott also suggest that case method teaching will promote higher levels of critical thinking where verbalization, interaction and reflection are emphasized (Floyd and Scott, 1991).

The theoretical framework of building case narratives used in case construction at the Harvard Business School (Hansen, 1987) was also used in the development of each "case package." This included the following procedures:

1. The identification of "big ideas". These "big ideas" are the major concepts which form the focus for the case. Big ideas are extracted from the grade level curriculum.
2. The construction of the case narrative. This is the story which contains within it the data and problems needed to generate examination of the big ideas.

3. The development of the study questions. These open-ended, higher-order questions require students' thoughtful, reasoned examination of the concepts and content around the issues. Questions are framed to focus thinking on higher order thinking operations (Raths, Wassermann, Jonas and Rothstein, 1986).

4. The generation of the replay activities. These include a wide range of follow-up assignments that are carried out by the students independently or in small groups and that allow them to explore the issues from new perspectives. These activities may take students out of the classroom and into the community. As well, "replay" activities become tools for student assessment and evaluation.

5. The synthesis of the case "package" in an introduction to the teacher. These "Teacher Notes" contain an explanation of the rationale behind the case, a list of compatible learning outcomes from the Biology 12 curriculum guide and a list of the "big ideas" on which the case is founded.

The framework of building case narratives involves identification of issues or "big ideas" within the curriculum of the course for which the case is required. Big ideas may be extracted from the curriculum, in conjunction with textbooks recommended for the course, or from other relevant material, such as reference books. The big ideas

must be synthesized from an in-depth study of the goals of the course with the learning outcomes and the curriculum content. In content-laden courses, such as Biology 11 and 12, big ideas may be more concerned with complex, fact-based concepts rather than values issues.

From the identification of the big ideas, the case writer moves to gather additional information about the content or issues. The basis for a case should be firmly rooted in reality (Hansen, 1987 and Andrews, 1953) and therefore the writer is responsible for collecting data and confirming its authenticity. This prewriting stage is vital to a successful case.

In the writing stage of case construction, elements of good narrative writing are followed in order that the reader will not only want to read to the end of the story but will be intrigued and compelled to know more. Cases do not resolve conflicts or dilemmas for the reader, but instead, elevate the dilemma and end with a "kicker." Feedback and editing are crucial at this stage.

The study questions and follow-up activities that follow a case are also constructed by synthesizing the issues of the case with the properties of good "higher order" thinking questions and activities. Both the questions and the "replay" activities should focus student thinking on the big ideas, enabling the students to extend their learning and thinking into new areas and in new ways.

The search for "big ideas" in the Biology 12 curriculum and the synthesis of these with the goals of the Biology course and of the Year 2000, led to the generation of five case narratives. Each of these was developed within the theoretical framework of a "case", as defined by Hansen (in Christensen, Hansen and Moore, 1987). The cases constructed for this thesis reflected the following biological areas:

Case 1 - Circulatory and respiratory systems

Case 2 - Nervous system

Case 3 - Endocrine and nervous systems

Case 4 - Homeostasis of water balance

Case 5 - Immune system and allergic response

Definition of Terms

1. Play - Debrief - Replay The term Play - Debrief - Replay (Wassermann and Ivany, 1988) was used to describe the instructional design in the case method teaching.

Play - The initial stage of the process begins with the active participation of the students in the analysis of case materials. During this time, the students read the case and discuss with each other in small groups the study questions which focus on the

ideas generated by the case. In some instances, the play involves hands-on activities, while in case method teaching it is primarily "minds-on."

Debrief - The second stage of the process, a discussion conducted with the whole class, involves the teacher working with the students to extract meaning from the case and promote further examination of the major concepts or big ideas. Working with the ideas presented by the students, the teacher uses skilled listening, responding and questioning techniques to move student thinking deeper into the analysis of the concepts and stimulate students' higher order thinking (Raths, Wassermann, Jonas and Rothstein, 1986).

Replay - The last phase of the process gives students the opportunity to follow-up particular issues and concepts generated during the play and debriefing stages of the case. In this study, replay includes independent activities or small group assignments which allow students to apply and extend knowledge related to the case.

2. Big ideas (Wassermann, 1990) - Case method teaching, framed around the methodology of play-debrief-replay, involves developing cases that allow for the examination of certain significant ideas and

issues. These ideas and issues provide the framework for learning through the design of the study questions and the debriefing sessions. Big ideas are extracted from the curriculum and form the nucleus for a case.

Design of the Thesis

The thesis examined the viability of constructing cases in Biology 12 which synthesize both the major concepts of the course and the goals of the Year 2000 Graduation Program. The thesis includes a description of the process used in the synthesis, and how this was then applied within the theoretical framework of case narrative, leading to the development of the first biology case, A Shot of Reality. This synthesis and application process is presented, beginning with the early stages of research and writing, particularly the formation of the big ideas, distilled from the Biology 11 and 12 Curriculum Guide (Ministry of Education, 1990), and the construction of the narrative for this first case.

Four other cases were then constructed using similar research, synthesis and development strategies.

Limitations of the Thesis

The intent of the thesis was to examine the viability of constructing case narratives that would represent a synthesis of Biology 12 curriculum content and goals with the Year 2000 goals. While five cases were constructed for this thesis, these cases do not encompass the entire Biology 12 curriculum and are not intended to do so. The case narratives are examples of how such a process is undertaken in a content bound curriculum area such as senior Biology.

Organization of the Thesis

This first chapter discussed the need for the study, stated the problem and briefly described the research methods. The terms that have been used with regard to case method teaching were defined.

Chapter two examines case method teaching from a historical and philosophical perspective; current ideas and initiatives in teaching science, particularly biology; and the effectiveness of case method teaching for the acquisition of knowledge, understanding, skills and attitudes.

Chapter three examines the research methodology used to construct cases for Biology 12. It provides an overview of the prewriting process, including the research that yielded the extraction of the big ideas. It also follows the stages

of case construction and the generation of study questions and replay activities that complete the curriculum package.

Chapter four presents the five cases along with the teacher notes, study questions and replay activities written to stimulate student thinking during small group discussion, debriefing and extension activities.

Chapter five focuses on the findings, implications and limitations of the study.

CHAPTER TWO

LITERATURE REVIEW

Chapter two examines the historical perspective of case method teaching from its inception at the Harvard Law School to its expansion to various other graduate schools and to secondary education. The need for new methods in the teaching of science, in particular biology, is explored and the support for case method teaching as a means of meeting those needs is outlined. As well, case method teaching is analyzed for its ability to meet the objectives of the Year 2000 Graduation Program.

HISTORICAL PERSPECTIVE OF CASE METHOD TEACHING

Harvard Schools of Law and Business

Early in this century, the Dean of the fledgling Graduate School of Business at Harvard University, Edwin Gay, was considering the relationship between the intent of the curriculum - the training of the professional administrator - and the teaching method which would achieve this goal. Dean Gay looked to another graduate school at the university, the Law School, to find the method which would over the years become more closely associated with the Business School than the Law School.

In 1870 Dean Christopher Columbus Langdell of the Harvard Law School, met with his class in Contracts Law for the first time. He did not deliver the expected lecture, instead he presented a "case" which he asked students to analyze - to "state the case" (Cruickshank, 1987). In his unique classes students were asked to study real cases in law, to analyze and relate the data to principles of law and to extrapolate from the data. Discussions were directed by the careful questioning of Dean Langdell who took pains to have the students speak, even when they were unused to speaking. By asking for student opinion and ideas, Langdell was able to extract from the students the information vital to the understanding of the concepts under study rather than having the instructor simply dispense the facts. In this way, students increased their responsibilities for their learning.

At first, the case method classes met with much resistance from students who expressed anger with the lack of direct information transfer. They wanted to learn the law; not listen to their peers' thoughts. The "Langdell Method" seemed to be failing as students stopped registering and attending the classes. However, as the students of the Law School graduated, it became apparent that those who had attended Langdell's classes were achieving unprecedented success in identifying and acting on complex situational problems. While content knowledge of both the non-case method group and Dr. Langdell's group were comparable, those

trained using case method were found to react to situations in ways that led to productive action and so the Law School began expanding its case method courses (Cruikshank, 1987).

By the time the Harvard Graduate School of Business was framing its program, case method had become the predominant instructional technique in most law schools in the United States (Bauer, 1955). The experience of these schools informed the planning and design of the Business School curriculum. The neophyte faculty determined that the educational purpose of the school should be "...to give each individual student a practical and professional training suitable to the particular business he plans to enter" (Christensen and Hansen, 1987). The terms "practical" and "professional" delineated the mission of the school. Dean Gay encouraged faculty to consider not only what they taught but how they taught it. The current dean of the Harvard Graduate of Business, John McArthur, concurs with this vision, believing that "How we teach is what we teach" (in Elmore, 1989).

The biggest problem facing the new school, according to Dean Gay, was the lack of case materials needed to initiate discussion teaching (Cruikshank, 1987). Writing cases became a priority for the Harvard Business School that is still evident today. Abby Hansen writes of the art and science of case writing in Teaching and the Case Method (Christensen and Hansen, 1987) and discusses the importance of rich,

relevant cases to inform issues of current as well as historical interest.

Not long after the Harvard Business School opened its doors, the university's Board of Governors asked a group of distinguished practitioners in the field of business to report on the school's activities. Their conclusions, and those of other independent reviewers, suggested that other schools adopt the case method teaching in order to move away from placing too much emphasis on memorizing. The review board also found that students who had enrolled in courses where case method was used extensively showed "...a marked increase in the intelligent application of ideas and the breadth of judgment in their discussion of problems" (Cruikshank, 1987). The independent advisers urged Dean Gay to "...teach less theory and more deduction of principles from actual examples. Discussion in the classroom should be encouraged even more than it is at present" (Cruikshank, 1987).

C.R. Christensen, Professor Emeritus of the Harvard Graduate School of Business, is recognized as one of the authorities on case method teaching (Graf, 1991). It is his contention that case method marries two goals: a substantive lesson, incorporating data and content, and an effective pedagogy. "Classic cases provide ample opportunity for a participant to confront, explore, and learn from the stubbornness of practice" (Christensen and Hansen, 1987). It

is the power of self-discovery, he contends, that makes case method so successful.

> First, we believe that when educational objectives focus on qualities of mind (curiosity, judgment, wisdom), qualities of person (character, sensitivity, integrity, responsibility), and the ability to apply general concepts and knowledge to specific situations, discussion pedagogy may well be the most effective approach. Lectures about judgment typically have limited impact. Reading about problems or memorizing principles does little to prepare the practitioner - architect, doctor, or manager - to apply concepts and knowledge to the complexity of real-life problems. Discussion teaching achieves these objectives better than alternative pedagogies. It puts the students in an active learning mode, challenges them to accept substantial responsibility for their education, and gives them first-hand appreciation of, and experience with, the application of knowledge to practice (Christensen and Hansen, 1987, p.3).

In Teaching and the Case Method (Christensen and Hansen, 1987), one of the early professors of the Harvard Graduate School of Business, Arthur Stone Dewing, was quoted:

> This method [lecture] has great advantages. Above all, it is efficient, it is also economical of the time, energy, and the patience of instructor and student. Further, this method produces brilliant results. A student trained under it seems to possess a sureness, a precision, a firming of grasp remarkable for the relatively short time which he is compelled to spend on acquiring his knowledge...
>
> The other method [case method] starts with an entirely different purpose and ends with an entirely different result. ...Business people must be able to meet in action the problems arising out of new situations of an everchanging environment. Education, accordingly, would consist of acquiring facility to act in the presence of new experience. It asks not how a man may be trained to know, but how a man may be trained to act (in Christensen and Hansen, 1987, p.23).

Harvard School of Medicine

Case method teaching became fairly common in business and law schools during the twentieth century but it wasn't until the last quarter of the century that medical schools began to examine the pedagogy in any serious way. Cases had indeed been used prior to this in faculties of medicine but they did not form the main pedagogical framework. They were used instead as an adjunct to the lecture, a foundation for research and experimentation (Sperle, 1933). The explosion of scientific and technological information during the last quarter century has made the task of teaching and learning medicine increasingly difficult. Traditionally, a medical education involved passing on a vast amount of knowledge about the way the human body functioned and the ways to treat it when it malfunctioned. In a relatively short amount of time, the amount that was known about the body and how to treat it became unwieldy, too much for any one person to absorb and retain. Medical schools began to look for alternatives to traditional lecture teaching.

As well as concern for the amount if material that a medical student had to absorb, Professor Daniel A. Goodenough of the Harvard Medical School, suggests that ethical and moral education in medicine was lacking. He believes that it is "...crucial to confront the disturbing problems in modern medicine such as the absence of values from most curricula and the long-term inadequacy of rote

memorization as a means for coping with the information explosion" (in Christensen and Hansen, 1987). He believes that traditional methods of training doctors, primarily lecture and lab, were resulting in physicians so narrowly specialized that they had difficulty seeing beyond their areas of expertise to the personality and situation of the patient. The human factor was being ignored.

After a personal experience with the medical world as the husband of a patient, Dr. Goodenough went back to his classroom and spoke with his students about feelings and emotions, values and ethics. His students were so pleased that someone had acknowledged their needs, they asked him to sponsor a forum to deal with the human issues in medicine. It was this experience that drew Dr. Goodenough into the New Pathways Program developed at the Harvard Medical School, built on the framework of case method teaching. He describes the goals of the committee chosen to oversee the shift to case method teaching in Education for Judgment, (Christensen, Garvin and Sweet, 1991).

> Teachers were to guard against dominating classes by slipping into the lecture mode. Our pedagogical purpose was both to bring out key content through questioning and to model the learning process itself. We agreed to measure our success by students' performance on written examinations and the degree to which they learned to formulate fruitful questions on their own.
>
> One of our aims was to create an environment in which the students could succeed only through teamwork. We selected cases that could lead deep into the content of our course by stimulating straightforward questions that could not be answered without rigorous scientific inquiry and study. Such questions would, we hoped, rapidly immerse the students in textbooks of anatomy, physiology, and internal medicine. Their groups would

> either build a collective raft of knowledge or founder and sink in a sea of information (in Christensen, Garvin and Sweet, 1991, p. 90).

Goodenough's observations of student interactions in first years of the new program are encouraging. He saw that the goal of training competent and self-confident professionals who are also cooperative, caring, consulting team workers, was within reach. Goodenough also believes that the power of case method and discussion teaching is broadly applicable to other disciplines. "It is the power of meaningful interconnection among the students and teachers as they all learn and, in a very real sense, transcend themselves, adding a vital new layer to the growing coral reef of human understanding" (in Christensen, Garvin and Sweet, 1991).

Harvard Graduate School of Education

Among many of the graduate schools at Harvard University, the Graduate School of Education was one which resisted the impetus to adopt case method teaching. They did not consider the method economically viable and argued that, while the case method was appropriate for developing skills associated with problem solving and decision making, the mandate of the school was program implementation. In examining the reasons for ignoring a method that had been

successful in both the Law and Business Schools, Merseth (1991), found that the School of Education believed that:

1. The Graduate School of Education did not have the same funds available to the other professional schools to develop case materials. External financial support was available to the Schools of Law and Business but not to the School of Education.

2. While case writing was recognized as true research by the Faculty of Business, it was not recognized as such by the Faculty of Education at Harvard. Faculty at the Business School are encouraged to study the art of case teaching at regular seminars held by the faculty and to write cases as part of their academic commitment to research. The faculty of the Education School had no such incentive to build a cadre of case materials as the endeavor was not considered research.

3. At its inception, the School of Education lacked the clear vision that had guided the introduction of case method in both the Faculties of Law and Business. Instead, there was disagreement within the new Education School about the most appropriate method for developing and implementing the new curriculum at the school.

Recently, there has been a renewed interest in the area of case method teaching at the Harvard Graduate School of Education. Under the urging of former president, Derek Bok, Professor C.R. Christensen of the Harvard Business School has been conducting case method teaching seminars for the faculty of the Education School over the past year and it is possible that the school may reconsider its opposition to the method (from a conversation with C.R.Christensen, 1991).

Other University and Professional Experiences

The use of case method teaching in other fields in both universities and professional schools is well documented. Cases are used to train professionals in the areas of law, medicine, business, banking, financial consulting, social science (Andrews, 1953; Christensen, 1987). Case study is also used with success in various other fields at the university level.

Pearson Hunt, in 1951, analyzed the case method teaching used at the Harvard School of Business as an approach that could apply to college teaching generally. He suggests that case method can be used in narrowly professional courses or in programs of more general education. The goal of case teaching, he contends, is the ability to reason in dealing with problems in the students' areas of study.

> Appropriate use of the theory (of case study),and the acquisition of factual material and procedural skills are also important goals, but the heart of the method is the use of problems to train the student to discover and then to fix in his mind ways of thinking that are productive in the chosen field (Hunt, 1951, p.175).

Hunt identified seven goals implicit in the case method:

> 1. The power to analyze and to master a tangle of circumstances, by selecting the important factors from the whole set of facts, and by weighing their importance in context.
>
> 2. The ability to utilize ideas, to test them against the facts of the problem, to throw both ideas and facts into fresh combinations, thus discovering ways which make them appropriate for the solution of the problem at hand.
>
> 3. The ability to recognize a need for a new factual material or the need to apply technical skills to a problem, and the ability to assimilate such facts and skills...
>
> 4. The ability to use later experience as a test of the validity of the ideas already obtained, with flexibility to revise goals and procedures as experience is deepened.
>
> 5. The ability to communicate their thinking to others in a manner which induces thought.
>
> 6. The ability to use ideas in theoretical form. That is to say, one should be able to create a coherent structure of generalized propositions from his problem-solving experiences. From this, one should be able to make inferences, both by adding the theoretical ideas of others as they are pertinent, and by one's own thinking on a high level of analysis.
>
> 7. The ability to attain the goal simply, completely, and without any more waste than is necessary in any thinking about an unfamiliar problem (Hunt, 1951, p.178).

In the area of instructional design, David Graf believes that the use of cases provides "...a bridge between theory and practice by allowing students to apply classroom

instruction to real and/or fictional case situations and problems" (Graf, 1991).

In the area of creative writing, David Tedlock of Iowa State University, also refers to cases as making learning "real" and maintains that, "When used most effectively, the case approach makes the need to write seem real, emphasizes problem-solving and the writing process, and provides students with a clear sense of audience" (Tedlock, 1981). Recognizing that the use of case method is relatively new in the area of composition, Tedlock gave anecdotal evidence as support for the use of the method. He observed students who were:

> ...especially willing to discuss cases, perhaps because analyzing and understanding them does not seem to require the kind of ability possessed only by those students who are "good" in English....Moreover, their willing participation in class discussion seems to extend to their prompt completion of written assignments based on cases (Tedlock, 1981, p.254).

While Tedlock advocates the use of cases in creative writing, he also identifies some areas that he deems problematic and limiting. A few students resist having to write about a particular case or even about any one of a number of cases. He admits, however, that this problem is probably universal and not a result of the specific method. A larger problem he saw is with the difficulty in managing the discussion. Professors, he feels, will need more education in the process before it is widely accepted.

Vivian Clark, a graduate student at the School of Educational Administration and Research, University of Tulsa, studied the effectiveness of using case studies in the training of principals. Her study showed that case method teaching, while not a panacea for training principals, can be very useful, stimulating pre-service and in-service principals "...to share techniques, feelings, successes and failures, promoting the dialogue that Lieberman and Miller (1984) stress as extremely important. This interaction and deliberation cannot help but produce better training programs and better-performing principals" (Clark, 1986).

Support for case method teaching in teacher training programs is evidenced by the work of Deborah Floyd and Kathryn Scott (1991), of Florida State University. Floyd and Scott believe that there is general consensus that critical thinking is a process that can be taught and that case method teaching is a viable way to accomplish this. They conclude that "When implemented in a cooperative learning environment where verbalization, interaction, and reflection are emphasized, the case method is predicted to promote higher levels of critical thinking" (Floyd and Miller, 1991).

Judith Kleinfeld of the University of Alaska, had similar results when she studied two classes of students enrolled in a teacher education program at the university (Kleinfeld, 1991). One class was taught with case method

teaching and the other using discussion of readings as the main method of instruction. Her results indicate that the use of case method teaching increased education students' abilities to identify issues given specific situations, to analyze educational predicaments in critical ways, and to choose possibilities for action. Unfortunately the results of the effect of case method teaching on the students' ability to analyze classroom situations were inconclusive as half the control group did not respond to the analytic questions. Kleinfeld speculates that this may be due to the fact that the respondents from the control group had weaker analytic skills than those of the case study group. However, there is no empirical evidence to support this position (Kleinfeld, 1991).

Use in Secondary Education

The use of case method teaching at the secondary level is not as widespread as at the university level. Still, there is evidence from a number of studies that support the findings of the university-based studies at higher educational levels. One study of environmental education taught at the grade 10 level by case method teaching showed that students had a much clearer understanding of the issues and their positions on those issues when exposed to case method instruction. Compared to a control group the post-test results of the case method group showed significant

differences in attitudes toward environmental issues. The conclusion of the study indicates that case method teaching is a viable strategy for positively influencing students' attitudes toward environmental issues (Wilson, 1980).

Adam's study of grade 11 Social Studies students showed that the use of case method teaching affects teacher and student perceptions of change in critical thinking, interest and curiosity about learning, and the extent to which students respect alternate views, attitudes and beliefs. Students who took part in the classes taught by the case method reported an increased likelihood to read additional material and to discuss issues with family and friends. They described themselves as better communicators and decision makers after the case study experience (Adam, 1991).

Theoretical Support for Case Study

Case method teaching is founded upon sound philosophical and experiential learning theory. The work of John Dewey (1938) provides the theoretical basis for the basic premises of case method teaching. This theorist suggested that learning does not occur without experience and that experience is necessary to form knowledge. He believed in the importance of personal interaction with material (content in personal context) so that learning can occur.

In Education for Judgment (Christensen, Garvin and Sweet, 1991), Richard Elmore, Professor at the Harvard Graduate School of Business, describes the way in which he perceives case study methodology meeting the needs of learning through experience. He suggests that case study is contextual:

> People learn to the degree to which they can actively manipulate facts within some general framework and can relate general ideas to specific events in their experience. We have knowledge, in other words, only as we actively participate in its construction. Students do so by engaging, with other students and with the teacher, in a process of inquiry, critical discourse, and problem-solving....One insight from the current research is that all learning is contextual in at least three senses: new knowledge is acquired by extending and revising prior knowledge; new ideas acquire meaning when they are presented in a coherent relationship to one another; and knowledge becomes usable when it is acquired in situations that entail applications to concrete problem-solving.
>
> Discussion teaching (case study teaching), as defined by the authors, is essentially a systematic way of constructing a context for learning from the knowledge and experience of students, rather than exclusively from the canons of disciplinary knowledge (in Christensen, Garvin and Sweet, 1991, p.XII and XIV).

When students read a case and actively engage in dialogue during examination of the study questions, they work with the material in a "minds-on" way that brings them as close to life experience as it is possible to get in a classroom. During the "debriefing," students have an opportunity to reflect on the experience, to construct new understanding from the experience. Learning is extended once again into the experiential realm through the "replay" activities.

MacKinnon, at Simon Fraser University, believes that science teaching should allow students to continually construct meaning of classroom events based on their prior understandings and experience. He identifies three principles of pedagogy which support case method teaching:

> (1)Teachers must first develop strategies that will permit them to become aware of their students' ideas about natural phenomena and scientific principles;
>
> (2) These ideas must then be taken into account in the instructional program in order to provide a foundation for extending concepts, or constructing new concepts and the meanings derived from them; and
>
> (3) As learning is seen to be a purposive activity, students should be actively engaged in the learning situation and should become aware of the purposes that lie behind instruction (MacKinnon, 1990).

SCIENCE TEACHING: SOME CURRENT PERSPECTIVES

Many science research/educators are beginning to question the longstanding tradition of the lecture/lab format for the teaching of science. They have many reasons for believing that science teaching needs to be reformed but there is general agreement that change is desirable.

The province of British Columbia published an Assessment of Science Report (1991) which set out some goals for the improvement of science teaching in the province. Among its recommendations are:

1. A greater emphasis needs to be placed on developing students' abilities to recognize and describe different points of view and to construct and support their own point of view when presented with issues.

2. A greater emphasis on process rather than results or "right" answers, on reasoning rather than rote memorization, on individual, small group and large group work rather than extended periods of individual activity, on learners as active participants involved in discussion, writing, questioning and debating rather than on learners as passive recipients of knowledge, on exploring relationships, constructing meaning, and developing understanding rather than teaching by telling.

3. A move to "minds-on" as well as hands-on learning, rather than simply hands-on labs without the attendant understanding that comes from engagement of the mind on stubborn issues.

4. A move to a variety of teaching strategies rather than the traditional lecture/lab/text format now most often used in science education. As well, a steady decline in the amount of time spent in lab activities is evident as students move into the higher grades.

5. A greater emphasis on rational and critical thinking skills in the sciences.

These concerns and needs are born out by other educators and researchers with an interest in science education.

Teaching for Thinking in Science

Wassermann and Ivany, in Teaching Elementary Science: Who's Afraid of Spiders?, describe the differences they perceive between the terms "science" and "sciencing" as they encourage teachers to embrace sciencing. "Science," they argue, the way it has been taught, emphasizes the known.

> This picture of science teaching is that of a body of knowledge, well delineated and utterly without equivocation, from which all the profound implications of hypothesizing, of tentatively held concepts, of experimentation, have been extinguished. There is no margin for error; answers are either right or wrong. We carry on pseudo investigations to "find" what has already been found. If a pupil has done an "experiment" that doesn't provide the expected results, she is admonished to try it again until she does. The prevailing attitude in not to err; we are in fact penalized for it. The most important goal in teaching science is to know the "facts." The concern is with product (Wassermann and Ivany, 1988, p.5).

Scientists in real life research problems to which the solutions or answers are not known. They make predictions which are often wrong and carry on with new questions and insight. Much of the learning in science comes from "wrong" answers. Sciencing is an attempt to bring that ambiguity

into the classroom and to have students wrestle with thorny problems as a scientist might.

> Sciencing calls upon the ability to use several higher-order thinking skills: observing; comparing; suggesting and testing hypotheses; gathering and classifying data; interpreting and evaluating results. We would like to suggest that science plus thinking equals sciencing....From work in sciencing...we expect that pupils will become competent to chart unexplored terrain. We expect that they will become experienced as investigators - learning to think, to take cognitive risks, to predict and test, to evaluate wisely and thoughtfully - and through the process gain and use scientific knowledge more effectively (Wassermann and Ivany, 1988, pp.5-6).

Writing in the Journal of College Science Teaching, Rau points out some of the paradoxes of science teaching. According to Rau, we might encourage students to ask questions but we seldom discuss the types of questions that scientists ask. We stress the relevance of science in our technological society and we teach abstractions. We want our students to understand that neither science nor scientists have all the answers, but we demand only right answers. We also acknowledge that we should teach students to think analytically, to interpret data, and to solve problems, but we settle for insisting only that they learn some facts (Rau, 1991).

Also writing in the Journal of College Science Teaching, Schamel and Ayres contend that students would be better learners if we taught them less. They argue that what has often been called "hands-on" activities or inquiry method is in reality "minds-off." Unless we move away from the typical predetermined exercise with foregone

conclusions, the typical science "lab," we will continue to produce students who cannot think as scientists. Schamel and Ayres suggest that students must be engaged in minds-on learning, challenging themselves to behave in ways that scientists behave.

Other faculty at the University of Alaska, Fairbanks, where Schamel and Ayres teach, have adopted their "minds-on" approach and have agreed that because students are fully engaged in the scientific process, they find a real purpose in thinking, sharing, critiquing, discussing and writing.

Alease Bruce and Brenda Jochums studied first year biology students at the University of Lowell. Their study showed that faculty and instructors were much more likely to classify students as ready to memorize factual information and use it to solve close-ended questions, those with a single solution. Far fewer students were identified who could tackle the task of moving beyond novice problem solving by learning to recognize patterns or by developing higher-order thinking skills. Based upon this information the faculty at Lowell undertook the process of reviewing their own program to ensure that critical thinking skills are not ignored (Bruce and Jochums, 1990).

In a study of first year science students, Abour Cherif and Marv Wideen from Simon Fraser University, found that students were not easily making the transition from high school science to university science courses. They identified problems in students' abilities to think

critically, to work independently and in laboratory situations, and to understand the revisionary aspect of science. Teachers at high school contended that their job was to teach the fundamentals of science but in doing so they taught facts and information "...as though it were the gospel" (Cherif and Wideen, 1992). Students at the university level complained about the nature of high school science teaching:

> ...what was being taught at the high school was often not applicable to university science which was not highly fact-oriented but more theoretical . Students expressed confusion that the facts learned in high school were now being cast in a different light and often seen as inaccurate (Cherif and Wideen, 1992).

Lipson and Tobias at the University of Arizona studied drop-out rates among freshman biology students and found that they frequently drop out of the program. They discovered that many students perceived the curriculum lacked context. Students were impatient with the emphasis placed on computation, memorization and pace-keeping rather than understanding. Often biology faculty would argue that the rigorous program was designed to "weed out" those students who could not cope with the difficult programs. Lipson and Tobias contend, however, that the traditional, structured program is instead turning off deep thinkers and creative minds. They believe that reform should focus on teaching for understanding which touches students' lives (Lipson and Tobias, 1991).

Looking at secondary lab activities with an eye to identifying thinking process, William Leonard, Professor of Science Education at Clemson University, identified three major problems with secondary lab texts:

1. There is little focus or advance organization for the student, preventing students from recognizing and selecting relevant from irrelevant procedures and information. Mental connections between procedure and purpose are therefore not made.
2. There is an overabundance of scientific jargon in lab texts which becomes all encompassing. Students spend inordinate amounts of time deciphering instructions and have reduced time to consider questions of science, procedure and analysis. Students' common response to the question "What are you doing?" was "I'm not sure but it tells you in the lab manual."
3. The third problem is that instruction tends to be "numbifying," that it not only fails to teach science process skills and concepts, but it is tediously boring. Students do not enjoy labs (Leonard, 1991).

Ethical Considerations in Teaching Science

Ethical issues in biology are becoming more a focus of media attention during the past years. Environmental, medical, and other research issues are being debated in government, law courts and living rooms of the world. Peter

Kelly, Professor of Educational Studies at the University of Southhampton, believes that we cannot ignore the ethical issues in the classroom and that we must give students the opportunity to grapple with these issues within the framework of science curricula. Students, he contends, should be exposed to the historical and future perspectives of issues, to critical thinking and empathy. These considerations must be an integral part of curriculum (Kelly, 1990).

Science Textbooks

Another prevalent problem in the teaching of science is the textbooks that are used in science classes. Arthur Stinner of the Faculty of Education at the University of Manitoba, conducted a study in which he examined textbooks and methodology in classrooms from middle school to university. Methods and books, he found, were predominantly fact-laden with the result that students feel disconnected from science and cannot relate it to their lives. As students move through the school years, they become increasingly bored, disinterested and overburdened with facts. Without connections, Stinner argues, students cannot perceive the possibilities of science or come up with new ideas and therefore cannot firmly grasp concepts.

In an effort to introduce a new curriculum which would meet the needs of students more effectively, Stinner uses

science stories which he or his students develop. Stinner has found, as has Egan (1988) and Wandersee (1990), that young students respond much better to narrative mode than to textbook mode. Stinner recommends the use of teacher generated science stories from elementary to high school. While textbooks generally address the needs of students on the logical plane, science stories respond to needs on an evidential plane (Stinner, 1991).

In a study by Andrew Lumpe and Lawrence Scharmann of Kansas State University, textbooks were found to fall far short of the goals of biology education. They did not call for students to design experiments, develop hypotheses, apply results to new situations, all goals which teachers and text writers claimed were important. Rather they found that the textbooks presented science as a body of facts to be learned and accepted as truths. The spirit of science was not present (Lumpe and Scharmann, 1991).

Connecting science, in particular biology, to real life is important for students to link textbook material and content knowledge with the meaningful events that influence their lives (Hoots, 1991). Attempts should be made, according to the author, to enable learners "...to connect textbook details with daily reported events" (Hoots, 1991).

Matching Objectives and Methodology

Another study by Robert Yager and Paul Tweed of the University of Iowa and the Augusta School District respectively, showed that most teachers agree that the following outcomes are desirable for a biology course:

*problem identification

*questioning

*problem solving abilities

*resource identification

*formats for addressing problems and issues

At the same time, teachers neither model nor expect behaviour which will lead to these outcomes. "Most biology teachers seem to hate uncertainty and prefer to be very prescriptive. It is all too common to treat science teaching from a basic belief system (religion) that is accepted by faith - one that should remain beyond question and healthy skepticism" (Yager and Tweed, 1991).

To challenge the status quo, they state, teachers must make students the center of the teaching process rather than recipients of the teacher's dispensations. They must plan biology lessons and courses based upon questions as opposed to based upon accepted truths.

Integration of Curriculum

Paul DeHart Hurd, Professor Emeritus of Science Education at Stanford University, agrees with Yager and Tweed. The new science curriculum, he claims, should be integrated, should reflect modern content that teaches higher-order thinking, "learning to learn" skills, and the uses of science in human affairs. Students who complain that they shouldn't have to study chemistry in biology class have been misguided by the separation of the natural sciences into discrete units which do not reflect reality. The content is taught in isolation for the sake of understanding the discipline. As a result, the curriculum is functionally inert outside the classroom (DeHart Hurd, 1991).

Hurd sees a need for reform to bring modern science, such as biochemistry, into the curriculum. Societal needs are interwoven in science and an integrated program must reflect the social issues and applications of science. Reform must also address the goal of science courses training students to practise science as researchers. We have for years taught students something called the "scientific method" which delineates the way scientists think. In reality, researchers proceed in a multitude of ways, many of which have little resemblance to the "scientific method" (DeHart Hurd, 1991).

Hurd would have science teaching make use of better texts with less jargon; attend to the issues of values,

ethics, probability, policy, preference, limitations of the knowledge base and trade-offs; acknowledge the pace of change in technology and the explosion of information; and focus on a vision of teaching that will encompass the whole of the learner and the subject (DeHart Hurd, 1991).

Three researchers from King's College and the University of Alberta, Brian Martin, Heidi Kass and Wytze Brouwer have examined science teaching and found that much of it is unauthentic, that is, it does not address the needs of the students. To be authentic, science teaching and learning should be personal and personally involve the learner in process, it should be reflect society and portray contextual values, attitudes and issues and it should be constructive, allowing students to build a view of themselves as well as about natural phenomena (Martin, Kass, and Brouwer, 1990).

SUPPORT FOR CASE METHOD TEACHING TO MEET THE NEEDS OF SCIENCE EDUCATION

While there are many textbooks and curricula which profess to teach students conceptual understanding and thinking skills, the evidence suggests that textbooks and classroom practice actually work against those goals. Selma Wassermann (1987) reported in the Phi Delta Kappan that studies carried out in junior and senior high schools revealed that curriculum which highlighted higher order thinking operations (for example, comparing, interpreting, observing, summarizing, classifying, making decisions, suggesting hypotheses, imagining and creating, criticizing and evaluating, designing projects and investigations, identifying assumptions, applying principles in new situations, recognizing patterns, and gathering and organizing data) had a positive effect on pupil behaviour and academic skills. She also reported that although many curricula call for student thinking, most, in actual practice, do not include the opportunity for thinking. This discrepancy is similar to the textbook analysis reported earlier by Lumpe and Scharmann, (1991) and Stinner,(1992), in that Wassermann found that many classrooms where teaching for thinking was claimed to be occurring, were, in actual practice, doing little in the way of engaging students' thinking. Teachers were using materials which were rooted in single, correct answers and asked students for factual

recall of data. As well, teachers had little or no education in the process of teaching for thinking. Her contention is that, with proper materials and with in-service training for teachers, it is possible to move teaching for thinking, in the form of play-debrief-replay, into classrooms (Wassermann, 1987).

Wassermann and Ivany suggest that one model of teaching for thinking, play-debrief-replay, which is described in detail in Teaching Elementary Science: Who's Afraid of Spiders? (Wassermann and Ivany, 1988) underlies case study methodology. The first stage of the process, play, is analogous to the scientific experiment or research. It is a hands-on and/or minds-on activity which focuses student thought on scientific inquiry. Play is the basis for acquiring data and engaging the mind with concept development. In case method teaching, the "play" comprises the reading of the case and the small group discussion of the study questions.

Debriefing of a case differs from simple discussion in that the teacher's role changes from a disseminator of information to a facilitator whose job it is to help students extract meaning from the play experience. Reflective questioning and response strategies form the basis for the interaction between teacher and learner and enables students to develop their own thoughts and to examine them from a number of view points. Debriefing,

according to Wassermann and Ivany, lays the framework for the final stage, replay.

In replay activities, play activities may be repeated or new questions raised in the play and debriefing sessions may be investigated. Projects and further study grow out of the replay process. Finally, student understanding of the concepts can be assessed and evaluated during this stage.

Jane Hannaway of Stanford University has also found that teachers tend to teach on a simplistic level. She suggests that:

> While there is little agreement about the details of teaching practice, there appears to be a growing consensus that the curriculum as taught in schools is "out of balance." Most analysts feel the emphasis on basic skills outweighs to a far greater extent than appropriate the emphasis on problem solving and reasoning (Hannaway, 1992).

One of the reasons that teachers may concentrate more heavily on teaching basic skills is that there are very few well developed programs and materials in place to guide teachers' work. Teaching higher-order thinking skills is demanding and materials need to be in place, along with in-service, before such a curriculum can be set in place.

Raths, Wassermann, Jonas and Rothstein point out that many educators still believe that by teaching lower-order thinking such as rote memory, students will make connections to higher-order skills. They suggest that by teaching only lower level skills, students become "lesson learners" and do not develop higher-order thinking skills:

> As one compares, analyzes, interprets, and evaluates, the lower processes of recognition, recall, and association must be involved. However, the reverse is not true: The lower processes do not automatically envelop the higher ones. There is abundant evidence to indicate that the lower processes are engaged and strengthened as the higher processes are given emphasis....it is erroneous to suppose that higher mental processes are the by-products of an emphasis upon lower mental processes; just the reverse is true (Raths, Wassermann, Jonas and Rothstein, 1986).

An innovative teaching technique which has been successful at the college level bears a strong resemblance to the play-debrief-replay framework of case study. John Dunkhase and John Penick of the University of Iowa, discuss a program that has evolved in three stages. Stage one involves problem identification in the real world. A major characteristic of the program is that the problems to be studied are true to life or relevant to the lives of the students. In stage two, students investigate or analyze the problems identified in many different ways. Finally, in stage three, students report on their results, sometimes in unconventional ways and often those results are published (Dunkhase and Penick, 1991).

Support for a play-debrief-replay methodology comes from a number of other sources. Stories, the basis of case narratives, suggests Neil Postman, provide a structure for our perceptions so that facts can assume meaning. "Without stories as organizing frameworks we are swamped by the volume of our own experience, adrift in a sea of facts" (Postman, 1989). While Postman is speaking on a higher level

than personal story, the advice appears relevant at any level.

A prominent humanist, Arthur Combs, identified four certainties for our future and related these to education and teaching for thinking (Combs, 1981). The first certainty, information explosion, has a direct impact on education in that students can no longer be expected to learn everything about a discipline and teachers cannot be expected to know all the answers. Combs points out that there were 100,000 technical journals available in 1981 and that the number was doubling every 10 years. As a result, today's teachers often find themselves in a position where their students are more knowledgeable in some areas than they are. Methodology that values learning is needed.

The second certainty is the increasing pace of change. The implications for education are that we can no longer expect to design a single curriculum which will be required for everyone and meet everyone's needs. We must judge an educated person not by how much she knows but by how well she solves problems that could not be foreseen because of the rate of change. "To achieve this end, education must concentrate on the growth and development of persons rather than on content and subject matter" (Combs, 1981).

Other implications of the second certainty are that education must place more emphasis on process, values and lifelong education. Curriculum which addresses these needs will be necessary for the future.

The third certainty is the primacy of social problems. Curriculum must include within its framework, according to Combs, issues of social and moral responsibility. Factual knowledge alone will not equip students to deal with the complex situations which will bombard them in adulthood. Although Combs sees a fourth certainty, personal fulfillment becoming increasingly important, this closely resembles certainty three. Education must therefore focus on the human condition and the curriculum must become personal and individual, relating to the lives of the learners. Combs envisions a curriculum that emphasizes social interaction and responsibility (Combs, 1981).

A characteristic of case method teaching is the active involvement of students. Richard Elmore of the Harvard Graduate School of Business, is a prominent educator who believes in the process of learning as active student engagement. In the Journal of Policy Analysis and Management, Elmore discusses the case method.

> Learning is not recall; learning is the active use of ideas to solve problems. Teaching-as-telling, therefore is not simply a neutral way of transmitting the stuff; it conveys a passive and uncritical view of learning that removes the student from the role of active problem solvers. Most university professors subscribe to the ideal of students as problem solvers. Christensen (Harvard) and colleagues define a pedagogy that implements that ideal, and it is quite different from the pedagogy that is practiced in many university classrooms....analysis creates a language for discourse about teaching. From this discourse grows heightened attention to more and less effective ways of actively engaging students in the creation of their own knowledge.
>
> Case studies of teaching are one way of fostering this critical discourse. They encourage analysis of a common set of facts (Elmore, 1989).

Elmore's colleague, D.N. Perkins of the Harvard Graduate School of Education, agrees with Elmore's assessment and wrote in 1991 of the need for thoughtful learning in the classroom. He suggested three important elements for making this a reality.

1. Construct a curriculum out of generative topics that engage students deeply and encourage connection-making.

2. Deploy ways of teaching for understanding that help students to build understanding performances.

3. Emphasize assessment in context, which, rather than treating testing as a separate matter, includes in the instruction itself complex authentic tasks that gauge students' progress. (Perkins, 1991).

Perkins' concern is with connection-making. He believes that students must not only be able to retrieve information but must be able to put that information into new relationships. "A concern with connecting things up, with integrating ideas within and across the subject matters, and with elements of out-of-school life, inherently is a concern with understanding in a broader and a deeper sense" (Perkins, 1991).

In the area of biological sciences at the university level, Lynn Hansen and Erik Gottlieb of Modesto Junior College, (1991) wrote in support of the use of case method teaching in biology courses as a means of implementing interdisciplinary education and developing critical thinking skills in undergraduate biology majors. Hansen, an instructor and Gottlieb, a student, articulated their

dissatisfaction with the traditional didactic method of lecture and regurgitation of facts. While they did not want to discard content, they did not believe that lecture was the best way to teach biology. Instead, they recommended that:

> ...instructors provide a classroom environment in which students incorporate factual biological information within a context greater than the classroom and in which they relate the discipline of biological sciences to other areas of the curriculum. The goal is that students become able to problem solve, that they engage in critical thinking, and that they apply these skills within the larger framework of their educational and life experience (Hansen and Gottlieb, 1991, p.148).

Hansen implemented case study in her freshman biology classes as well as with majors and nonscience students. The results, again largely anecdotal because of the newness of the process, indicate that the students found the use of case study successful.

> Its importance, according to the students, was that the exercise connected biological information, biotechnology, and everyday experience. Defending a view not personally held proved challenging to the students, while collaborating to generate particular arguments created a sense of camaraderie and community. According to the students, the lively debates following the various presentations demanded critical thinking and were energizing.
>
> My observations support those of the students and therefore it is my intention to repeat this exercise using other topics and different scenarios (cases). This technique represents departure from the didactic approach and, in addition, combines a number of important pedagogical experiences: Students learn to work together, to integrate information in an interdisciplinary context, to problem solve, to generate and present effective arguments, and to appreciate other points of view while developing critical thinking skills within the context of learning so that content is not sacrificed to process (Hansen and Gottlieb, 1991, p.151).

Reg Wild and Steve Cardwell, of the University of British Columbia, in a paper to the National Science Teachers' Association Conference, propose the use of case studies as an approach to teaching science. They argue that cases allow students to learn from past experience and build on what they bring into the classroom. "Case studies and related strategies can be an important focus for interpreting STS (Science, Technology and Society) curriculum and support materials. Both sides of an issue are discussed with no "correct" answer. Cooperative group work is often an important part..." (Cardwell and Wild, 1992). The use of case studies, they suggest, is strongly supported by a constructivist theory of learning.

Scott Campbell, writing about the Harvard Colloquium on Teaching and the Case Method, held at Harvard in 1983, discusses the benefits of case method as practised at the Business School. He identifies the importance of using real life situations to give students practice in decision-making and applying knowledge and understanding.

> ...the case method helps develop a student not only grounded in concepts, but also comfortable with ambiguity and capable of determining the real problems and options before him. The technique helps develop sensitivity to the interrelationships and different perspectives of the various participants in any situation. And, perhaps most importantly, it instills an action orientation - a sense of what is possible, a sense of what is critical, a willingness to make firm decisions and convert them into action, and an appreciation of the limits of those actions (Scott, 1984).

Case method teaching presents the students with experience in the form of narratives depicting real events

and issues. Charles McFadden, of the University of New Brunswick, suggests that science teaching may be enhanced if curriculum is presented first as an issue. For example, distinctions between living, nonliving and dead may be introduced with the issue of euthanasia; "...beginning instruction with a social issue or technological problem that is interesting to the students...(will increase) motivation, then, for acquiring the scientific understanding..." (McFadden, 1991).

A similar thesis is proposed by Edward Zielinski and D. Michael Sarachine. They suggest that students should have exposure to discrepant events and dilemmas. According to the authors, discussions and investigations around these issues allow students to grow morally and cognitively. They allow students to make informed judgments and test their knowledge. To this end, the authors advocate the use of case studies, particularly in bioethics (Zielinski and Sarachine, 1990).

Christopher Cratsley also argues for inclusions of problems in teaching science.

> Young students exhibit interest not in the discrete topics defined by modern high school science, but in particular aspects of the world around them....High school science must address real-life topics which span the traditional scientific disciplines and must allow for student imagination, experience and discovery. In order to do this, we must challenge students to find current issues in science that interest them and to use the scientific process to address these issues (Cratsley, 1991).

Richard Reif of the University of North Carolina and Gail Morse, an instructor at J.M.Alexander Junior High School, conducted a study whereby students in junior science were introduced to a program that incorporated cooperative learning with an interdisciplinary curriculum, a methodology with many similarities to case method teaching. Although the class was studying science, many activities were going on that would not be seen in a typical science classroom, such as magazine production. The class model emphasized activity and participation. Students perceived the curriculum as relevant, the teacher found an increased motivation in the students to learn and be part of the group and marks improved (Reif and Morse, 1992).

A new science program, Science-Technology-Society, is finding success in American high schools. The STS program for science teaching relies, according to Ogens (1991), on eight essential elements for a quality science curriculum:

1. Local and community relevance: Science study must be concerned with events and objects that can be seen, considered and studied locally.

2. Application of science: Technology has more relevance and is more easily seen and understood than the unifying ideas of pure science.

3. Social problems and issues: Science cannot be separated from the society which creates and uses it.

4. Practice with decision-making strategies: All persons must use evidence to reach decisions about daily living as well as decisions about the future of society.

5. Career awareness: If we live in a technological society, then careers related to that science and technology are an integral part of the society.

6. Cooperative work on real problems: Textbook problems and contrived exercises do not help students grow into responsible citizens able to tackle the future societal problems.

7. Multiple dimensions of science: Political, economic, psychological, sociological, or philosophical dimensions of science may be more important to some students than a content/discipline dimension.

8. Evaluation concerned with getting and using information (Ogens, 1991).

By providing programs which meet these criteria, Ogens believes students will be engaged in learning, will be more interested in pursuing science as a career and will be better able to make decisions in life dealing with issues of science and technology.

In a 1991 study of the use of case method teaching in a grade 11 Social Studies classroom, Maureen Adam found that case method teaching had a positive impact on the students' ability to meet the goals articulated in the Year 2000 document. Specifically, Adam asked students to examine their learning in relation to seven goals of the Year 2000 document. Her findings, based on student self-analysis, teacher analysis and researcher observation, indicate that students improved in the following areas:

1. the ability to examine issues critically

2. the ability to communicate their ideas clearly
3. the ability to make good decisions

4. the level of curiosity and general interest in learning

5. the level of respect they had for different views, attitudes and beliefs

6. the extent to which students were spurred on to read material beyond those presented in class

7. the extent to which students engaged in discussion of the issues outside of the classroom (Adam, 1991).

Adam found that students improved their decision-making and critical thinking skills as well as their ability to communicate and view issues from different points of view. Case method teaching, she contends, is a viable methodology for the teaching of thinking skills at the high school level in Social Studies.

Summary

Current perspectives on the teaching and methodology of science suggest that science should be taught in such a way as to promote student thinking, incorporate ethical issues, integrate material and concepts, and match objectives with methodology. There is evidence the case method teaching may satisfy these needs. Sykes and Bird, writing in the Review of Research in Education, suggest that:

> The future of the case idea, we suspect, rests more on development than research or perhaps on research in the context of development. We mean that the central task ahead is to create and use rich and interesting case materials in a variety of settings for a variety of purposes, while simultaneously studying these uses. To test an idea requires investment in development, training, and implementation across many sites and trials. To secure that investment requires advocacy for a bold idea before it has been tested (Sykes and Bird, 1992).

Chapter two has reviewed the literature by examining historical perspectives and support for case method teaching in science education. It has also looked at current thinking in science education and other disciplines, including perspectives in the education community and the connection between case method teaching and the goals of the Year 2000 program.

Chapter three will describe the process of case development.

CHAPTER THREE

DESIGN AND METHODOLOGY

Chapter three provides a description of the process used to research and develop the cases presented in this thesis. All cases were constructed using this process, but only the first case, A Shot of Reality, is discussed in detail. The description of the construction of the first case includes background information, the research and subsequent extraction of the big ideas and their synthesis with the goals of the Biology 12 course and the curriculum goals of the Year 2000, research into the theoretical framework of case narrative, consultation and editing, research into the formation of study questions and replay activities; followed by field testing, subsequent revision based on field test results, a list of the Biology 12 learning outcomes (Biology 11 and 12 Curriculum Guide, Ministry of Education, 1990) which are addressed by the case, and a summary. Through this description, the research methodology of synthesizing curriculum goals and objectives of biology and the educational goals of the Year 2000 document will become apparent, as will the placing of this synthesis into the theoretical framework of case narrative.

For greater simplicity of style in describing the process, I have broken with tradition for this chapter and written in the first person.

The Anatomy of the Development of Case One: A Shot of Reality

Background Information

In the fall of 1991, the problem of constructing content-based cases for Biology 11 was presented as a research possibility. The research problem presented several intriguing challenges. First, no content-based cases had been developed at the secondary level in the sciences. Would it be possible to develop case narratives around what was normally considered "factual" material? Or would the opposing pulls of "story" and "factual content" mitigate against such development? Second, the case narratives would have to reflect not just any good "science story," but concepts extracted from the grade level curriculum. How could such concepts be extracted and how could a synthesis be formed between science concepts and Year 2000 Graduation Program goals? These were the research challenges of this thesis. My initial choice was to focus on Biology 11 because it seemed to me that the provincial exam and the huge amount of content material at the grade 12 level made case writing more difficult.

After months of unproductive frustration, it became apparent that my "heart belonged to Biology 12." I therefore began to reflect on how cases could be written for Biology 12 despite what I had perceived initially as the obstacles involved in that undertaking.

Previous years of experience teaching Biology 12 convinced me that students tended to ask two types of questions in class. One type appeared to me as "content clarification" questions. These questions are usually asked when students have difficulty understanding a concept or process and are answered relatively easily. Questions in this category might be: What is the name of the sphincter that closes the stomach off from the duodenum? or How does the S-A node work? The second type of question appeared to me as "personal revelation" questions. These questions reflect problems or queries that have personal relevance for the questioner. When these types of questions are asked, other students in the class appear to become very interested and their personal involvement often generates lively discussion. Questions in this category might include: Why does your foot go to sleep if you sit on it? How come you get spots in front of your eyes? Why do you get that funny "falling" feeling just before you go to sleep?

In choosing to write content cases for Biology 12, it seemed advisable to relate cases to students' personal concerns as a way of engaging students' interest and

curiosity. Just how to do this was one of the challenges of case writing.

One way of proceeding was to seek advice from experts. A second method was to search the relevant literature on the writing of case study materials. In conversations with Professor C.R. Christensen at the Harvard Graduate School of Business, and Professor Selma Wassermann at the Faculty of Education at Simon Fraser University, I had learned that a framework for writing case narratives involved a process of extracting or identifying the big ideas, researching the relevant data, shaping an issue taken from real life into a narrative and working with colleagues to edit and refine the product.

This framework was confirmed in articles written by other experts in the field. Abby J. Hansen, an educational consultant and freelance writer, has worked with Professor Christensen in researching and writing cases for teaching seminars, and has written extensively on the topics of case teaching and case writing. In her article, "Reflections of a Case Writer: Writing Teaching Cases" (in Christensen, Hansen and Moore, 1987), Hansen discusses the theoretical framework of a case, as well as the process that she uses to research and write cases. She describes a case, from the point of view of a teacher, as "discussion fuel", a way to ignite the imagination and intellect of a group of people. From a writer's point of view, however, she warns that a case can mean "...weeks, even months, of gathering, analyzing, and

refining data, writing and editing drafts, and then trying to view the product from yet another perspective in order to write a teaching note." She goes on to define more precisely what a case is from the writer's point of view: "... an account of real events that seems to include enough intriguing decision points and provocative undercurrents to make a discussion group want to think and argue about them."

According to Hansen, case writing involves three major stages: gathering data, reassessing and reworking the material, and writing. In the first stage, the responsibility of the writer is to gather reliable information about the substance and content of the case. This may involve literature searches, interviews with individuals or other research. Hansen believes that accuracy and authenticity are crucial to a good case.

In the second stage, Hansen advocates submitting work-in-progress to an experienced reader who can make constructive suggestions in organization and style. This editing process is critical in order to scrutinize the case from different points of view.

Finally, the case is written using narrative style so that an account of a real life situation reads like a story. Hansen advocates character development, building tension through plot development and the inclusion of suggestive detail without editorializing. In summary, she states:

> To my way of thinking, case writing bears a closer relationship to journalism, short-story writing, and drama than to the bare sequential logic of, say, a scientific report. A case has characters, like a story or play, and it describes real - though disguised - events, like a news story. But its uniqueness lies in its special mission: to stimulate discussion (in Christensen, Hansen and Moore, 1987, p.269).

David Graf, of Iowa State University, also describes the process of case writing in the area of instructional design. His method is similar to Hansen's but is more detailed in that Graf articulates the need to have clear objectives in place before the case is written. The situation, issue or problem may have been identified earlier but the objectives, what Wassermann calls the big ideas, must be clear to both the writer and later to the reader. He sees the case writing process proceeding from data, to objectives, to background information (Graf, 1991).

Pearson Hunt of the Harvard Graduate School of Business, in a paper written in 1951, commented on both the process of writing cases and the planning of courses taught by cases. He suggests that material developed into cases must be of interest to the student. In choosing case materials, he advises care in the choice of topic so that the audience for which the case is being written is considered. He also points out that students' learning is enhanced when cases demand that students think for themselves and work through a muddle of real problems rather than ingest given solutions.

In preparing cases and courses using cases, Hunt warns that the writer/teacher must be aware that case method will change the order and emphasis in a subject and that this will have an impact on the flow of instruction in the classroom.

> Most subjects have been developed over the years to present through text and lecture the problem areas seriatum, usually preceded by definitions, and perhaps followed by problems where the partial analyses are used and integrated (Hunt, 1951, p.180).

Finally, in an editorial in The American Biology Teacher, a strong argument was made for the use of active voice in science. While the writer did not specifically mention case study or writing stories, the advice nevertheless was that science writing and biology writing in particular, would be strengthened by the use of active voice.

> Contrary to the implication of passive voice, science is a personal activity done by people, not machines. The belief that using "I" and "we" somehow makes science undignified is foolish and hobbles science.... Biology is the great adventure of our time. Let's not suffocate it with passive, abstract writing (Editorial, The American Biology Teacher, 1991, p.389).

Once the literature had been examined, I examined the Biology 11 and 12 curriculum guide (Ministry of Education, 1990), grade 12 textbook (Mader, 1985) and other reference books to extract the big ideas that would form the basis for the construction of the case. The concepts in the Biology 12 textbook are presented in discrete chapters with one chapter presenting information on one body system. One of the first chapters that I normally taught was the chapter on the

digestive system. The major topics in the chapter were the anatomy of the system, the physiology of digestion and absorption, the homeostatic mechanisms involved in digestion and absorption, the relationship of structure to function and the problems of some disorders of the digestive system. Presenting these big ideas in the form of a narrative seemed formidable. My first thought was to write a story of a poisoning that would address the big idea that "to understand and follow the process of digestion and absorption is possible by studying how a poison disrupts the processes." This case would encompass the major ideas in the chapter and would, I hoped, be engaging for the students. The case would then be developed to illuminate the big ideas and to provide information that would drive discussion and learning around the big ideas.

In each of several attempts to begin the case, I found I was unable to write the narrative, and stay within the constraints of the big idea. How could I write about the digestive system, I asked myself, when other systems kept getting in the way? The digestive system seemed to be just a small part of the story, while the circulatory, immune, and other systems began to overshadow the digestive system in importance. When I tried to change the focus of the case, to work with other story lines, the same problem kept cropping up. The big idea was being pushed out in a hodge-podge of other, related ideas. In the Biology 12 curriculum guide, learning outcomes for the digestive system were

listed in isolation from other body systems. This discrete separation of functions created major obstacles for narrative writing and would, I learned, have to give way to a more holistic emphasis.

Wrestling with the disparate pulls of story narrative and single science concepts began to seem like insurmountable obstacles until I realized that it wasn't necessary to keep within the constraints of a single big idea or even to follow the sequence of a textbook's chapters (Hunt, 1951). I could modify the big idea. I could alter the sequence. And if that meant other chapters of the textbook and other body systems would be woven into the case, so much the better. A case, after all, should reflect reality (Lawrence, 1953) and in reality, body systems work in concert not in isolation. Attempting to write this case had made me aware, not only on a cognitive level, but also on a practical level, that case method teaching and learning were integrated and experiential in approach. Such insight now seems simple; yet this awareness had to come from much cognitive turmoil and months of frustrated effort.

Once these restrictive and "old" expectations were unloaded, I was able to return to the job of constructing cases with a renewed vigour. The original case, based on a poisoning, took on an impossibly large number of big ideas. So many more involved big ideas would have to be added that studying the case in-depth, would mean students would be working for many months. The questions generated from a case

of poisoning would, I felt, move discussion and extend learning into too many and too diverse areas. It would be a difficult case to manage at the high school level given the time constraints of the course. Therefore, a further examination was made to extract new big ideas.

Articulating the Big Idea and the Prewriting Process

With the realization that cases are multi-dimensional came the need for more complex and comprehensive big ideas which were manageable in the high school classroom. In examining the curriculum guide and textbook again, the relationship between the circulatory and respiratory systems was noted. The two systems are so inextricably woven together that it is virtually impossible to learn one without incorporating the other. Yet, the two systems are presented in separate chapters of the textbook. In a case built on real life situations, this separation would be ridiculous. Therefore, the big ideas needed to include the interrelationship between the two systems and the connection that these systems had to other systems in the body. Homeostatic mechanisms needed to be considered as well. I synthesized the Biology 12 curriculum and the goals of the course and Year 2000 in shaping the following big ideas:

1. The functioning of the respiratory system and the circulatory system are closely related and dependent upon one another.

2. Body systems do not work in isolation but in concert with each other.

3. Homeostatic mechanisms work to restore balance in times of emergency.

These "roots" of the case provided me with the bare bones of the concept that the case would examine. Now a story was needed that would capture the essence of these big ideas set in the framework of case narrative (Hansen, in Christensen, Hansen and Moore, 1987). The idea for the narrative came as a result of working with a grade 12 class on the topic of pneumothorax. The case narrative could focus on a gunshot victim. Such a victim would experience shock and hemopneumothorax, both conditions which would serve to illustrate the problems that occur when healthy respiratory and circulatory systems are disrupted.

The idea for the narrative seemed a good one, but it was clear that once again the big idea would need to be reworked to accommodate the fact that an injured system would be studied rather than a healthy one. The big ideas were now reframed as:

1. Body systems work in concert to overcome the effects of an injury.

2. Emergency procedures will enhance the effects of the body's own homeostatic mechanisms.

3. Understanding the situations which occur during injury depends on an understanding of the healthy state of the body.

Once all the foregoing hurdles had been cleared, it was possible to begin to write the story about a young man who had been shot during a brawl and was taken to the emergency ward of an inner city hospital. To make the narrative more powerful, the case would be written from the point of view of a member of the trauma team to allow the reader insights into the procedures that would be used during the treatment process.

Remembering that cases should be gripping and emotionally engaging (Hansen, 1987), I included a certain amount of controversy in the case without taking away from the medical and physiological issues. Once again, a change was made, from a young man who had been shot, to a young child who had been accidentally shot by his friend when his father left a handgun unattended. This, I hoped, would add "value issues" to the science concepts, allowing for discussions in social dimensions of gun control, the medical

costs of treating gunshot victims, and human suffering resulting from them.

By adding the dimension of a wounded child to the case, I took further liberties in expanding the big ideas, but I felt that this was justified in view of the Ministry of Education's goals of integration of curriculum and social issues as outlined in the Year 2000, Graduation Program Draft (Ministry of Education, 1989). The focus of the discussion and replay of this case would be wider if the reader had a story that evoked responses on several levels. It also seemed that another big idea was necessary specifically to name the two major systems and their dependence on other systems. With this in mind, I added two more big ideas:

> 4. While injury may have direct impact on one or two body systems (in this case, the respiratory and circulatory systems), other systems will be involved and may also suffer injury indirectly or will be influential in returning to body to a balanced state.
>
> 5. Social issues, such as gun control, may have an impact on medical problems and costs.

With the big ideas finally, though perhaps not permanently in place, the prewriting process could evolve to

the next step. Accordingly, I sought out a consultant who could provide me with the data I needed in order that the case would be based in reality. Leigh-Anne McElgunn, a trauma nurse at the Royal Columbian Hospital in New Westminster, agreed to act as consultant. I presented her with the big ideas that I had generated and she began to walk me through the procedures that would be needed and undertaken by the ambulance attendants and the trauma team. I took extensive notes, stopping her at intervals to check my understanding of the reasons for the procedures and the people who would be involved in carrying them out. We discussed the type of dialogue that would be used, how the parents would likely respond, how the child would be feeling and responding, how long it would take to make an assessment of the child's situation and what that assessment would likely entail.

Elements of the Case Narrative

After the meeting with the trauma nurse, I needed to find a way to include the information she had shared with me in the case. The story needed to be gripping while at the same time providing the reader with enough material for a rich discussion of both the medical and physiological aspects as well as the social issues of the case.

Examining construction of other case narratives (Christensen and Hansen, 1987 and Bickerton, Chambers, Dart,

Fukui, Gluska, McNeill, Odermatt and Wassermann, 1991) I chose to open the case by introducing the reader to "Elizabeth." She is a new trauma nurse and her nervousness and apprehension at being asked to attend to a gunshot wound patient are evident. This mood, I hoped, would carry over to the reader. Immediately following Elizabeth's introduction, the narrative shifts to the patient as he enters the ward. Symptoms are enumerated and some of the treatments that had been started are shared with the reader. At the end of the second paragraph comes the revelation that the victim, Kevin, is a six-year-old boy. By incorporating the thoughts of a rather nervous first-time nurse and the surprise of finding that the victim is a six-year-old, I hoped that the reader would be "hooked" and want to read more.

For most of the rest of the story, the dialogue and action take the reader through the steps and process of assessing and treating a patient with hemopneumothorax and shock. The child's reaction to the situation is also revealed. Not until the end of the story does the reader once again face the issue of the youth of the victim. When the parents are confronted by Elizabeth with respect to the cause of the accident, the reader learns that the gun that shot Kevin was fired by a young friend when they were "playing cops." The horror of the wound is contrasted with the image of two little boys playing, as well as with the

guilt felt by the parents, all of which serve to heighten the emotional impact of the case.

Several times during the first writing, I consulted with the trauma nurse to clarify exact wordings or procedures used. When the first draft was completed, I used writing process guidelines (Hansen in Christensen, Hansen and Moore, 1987) and set the story aside for a number of days before returning to it to check for editorial work needed. At this point, I made a number of minor changes and then submitted the work to both my faculty advisors, Selma Wassermann and Allan Mackinnon, for further editing and feedback. Both were supportive in their comments while pointing out areas where the story could be improved. Most of the changes that they suggested were then incorporated into the next draft.

The second draft was sent to the trauma nurse for professional clearance and once again, the changes that she suggested were built in. It was now time to write the study questions for the case.

Formulating Study Questions and Replay Activities

Study questions for a case are designed to invite students to share their thoughts and ideas with each other. They are open-ended, rooted in thinking operations (comparing, analyzing, hypothesizing, interpreting data, providing examples etc.) (Raths, Wassermann, Jonas and

Rothstein, 1986), and encourage students' examination of the issues and big ideas. They lead students not to single correct answers but to thoughtful and respectful examination of issues.

Study questions are also designed to focus students on the issues surrounding the big ideas. Examination of the big ideas is guided by the careful construction and progression of questions which students will consider during the small group exercise. The series of study questions written for this case opens first with a general question, moves into specific queries about the case, pulls the material together by asking for personal experiences about situations that may have happened to students, and finally, works back to a very global question.

The art of framing questions that are inviting, that call for students' higher order thinking and examination of big ideas, that lead to increase understanding of the concepts has been described by Wassermann (1992). The sequencing of questions that move from analysis, to in-depth analysis and the making of personal connections, and to the generation of new ideas (Wassermann, 1990) is critical to students' productive examination of issues. The complex process of writing good study questions also requires several drafts and a process of fine-tuning similar to that of case writing.

The first draft of study questions for the case, A Shot of Reality, presented in chapter four of this thesis, is

shown below. Each is coded according to the higher order thinking operations on which it is based (Appendix, p. 169; Raths, Wassermann, Jonas and Rothstein, 1986).

1. What medical or physiological questions does this case raise for you? (This question is an invitation to share the questions that the case may have raised for them.)

2. When Kevin arrived in the trauma room, he was being given a clear fluid intravenously. What hypotheses can you suggest for the administration of this fluid? (This question calls for the student to form hypotheses.)

3. What is your understanding of the term "hemopneumothorax"? How might this condition be explained? (This question calls for students to interpret and analyze data.)

4. Elizabeth did a blood pressure and pulse reading shortly after Kevin arrived. How do you explain the results she got? What are you thoughts? (This question calls for students to interpret and analyze data.)

5. A catheter was inserted to collect urine. What hypotheses can you suggest for the need for this

procedure? (This question calls for the forming of hypotheses.)

6. Doreen "froze" Kevin's chest wall with a mixture of lidocaine and epinephrine. The epinephrine is not an anaesthetic but a vasoconstrictor. What reasons can you suggest for including it in the injection? (This question calls for students to form hypotheses.)

7. What theories can you suggest to explain the necessity of the chest tube? (This question calls for students to generate ideas and hypotheses.)

8. When Kevin's blood pressure began to drop further, the IV was changed to include packed cells. What hypotheses can you suggest for switching from clear fluid to whole blood? (This question calls for students to form hypotheses.)

9. Discuss with each other the types of physiological changes that might have occurred in Kevin's body immediately after the gunshot wound. Include in your discussion your thoughts on how these changes might overcome the results of the hemorrhage and the pneumothorax. (This question calls for students to generate ideas and apply ideas to new situations.)

10. Have you ever been in a major accident that required emergency care or hospitalization? If you feel comfortable doing so, share your experiences with your group. In what ways was your experience similar to Kevin's? In what ways different? What are your thoughts? (This question personalizes the issues and calls for the students to relate issues in the case to personal experience.)

11. What other issues does this case raise for you? Talk about them and be prepared to share your ideas during the debriefing. (This question invites the students to share new questions which may have arisen during the small group discussion.)

Follow-up or "replay" activities for a case are intended to direct student inquiry into areas of interest motivated by reading and discussion of the case. These activities allow students to examine content and issues more deeply and include choices that allow for the students to accommodate their individual learning needs (Gregore, 1982). An examination of follow-up activities listed in Evaluation Materials for the Graduation Program (Adam, Chambers, Fukui, Gluska and Wassermann, 1992) showed that many diverse activities were possible which would allow students to not only identify and learn content but understand concepts and

apply them to situations within and outside of the classroom.

The replay activities that serve as a follow-up for this case were designed to be student centered and to invite students to choose an activity that appealed to them. It is possible that not all students will choose to pursue the same area of study. For example, some students may find an interest in exploring the implications of gun legislation on medical costs and will choose to delve into this topic. Others may be more interested in the physiology of the circulatory system in overcoming the effects of the gunshot wound. The teacher still has the responsibility, of course, of determining which of the paths of inquiry should be explored by all students. All students would be exposed to all related activity areas however, as the teacher and students work together to set criteria for replay activities which encourage students to share their projects and information with each other and with members of the community.

When the list of activities is given to the students, choices are offered in the students' selection of the style of their presentation. Also, students are encouraged to go beyond the list in developing their own topics and methods of presentation in consultation with their teacher. By providing such choice for the students, different learning styles are accommodated. Students can approach a topic or issue from a perspective that is meaningful for them.

The first draft of the replay activities appears below.

1. Make a lifesize body diagram and show on the diagram all the systems which have been damaged and the mechanisms which the body uses to correct the situation.

2. Gather data about the causes and symptoms of hemopneumothorax. Present your findings in the form of a pamphlet which you can then send to your local health unit or trauma centre. Share your findings with the class.

3. Gather data about the reasons for hemorrhage, the methods used to treat it and the consequences of this condition on the rest of the body. Include the symptoms that a person with hemorrhage would experience. Prepare a multi-media presentation of your findings along with a short lesson on basic first aid for hemorrhage victims. Invite members of your local Fire Department to provide feedback at your presentation.

4. Interview a trauma physician. If possible, visit the physician in the emergency ward and take some notes and pictures of your visit. (This will need prior approval.) Prepare a presentation for the class which

documents your findings. Invite the physician to attend your presentation.

5. Gather data about the number of gunshot wounds and deaths in your city or area. To what do the police attribute the deaths? Gang related? Domestic? Alcohol? Combinations? Other? What type of gun controls are in place in your city? How do you suppose this influences the data you collected? What are your thoughts on gun control in your city? Prepare a letter to the editor which summarizes your findings. Submit it to the local papers in your area and present this along with your complete data and findings to the class.

6. Design an activity of your own, alone or with a partner or group. Work with your teacher to establish the criteria for the work and presentation of the finished product.

Editing

After the preliminary work in case and study question construction, it was time to try out the case with a group of grade 12 students. I was curious to hear their thoughts about the case and how they thought this type of instruction

would work in a classroom on a regular basis. While this was to be an informal gathering of data, I knew that information collected here would give me greater insight into how students saw the case and therefore, how successful I had been in writing the narrative and the questions. Unfortunately, the timing of this "field testing" was not good. The case was not ready to be tested until near the end of the semester. The pertinent material had already been covered in class and there was not enough time to spend in returning to this topic with the provincial exam facing students in a few short weeks time. I therefore decided to use the case with a small group (ten) of students who were meeting once a week to review and prepare for the scholarship exam. This was not a regular class with assignments or attendance requirements but a group which met voluntarily to improve their prospects for a scholarship. As such, this trial did not constitute a typical field test. The students were high academic achievers and self-motivated. Their perceptions would not, therefore, reflect those of a more homogeneous class.

The ten students read the case and spent about ten minutes discussing the study questions. I was disturbed that they were finished so quickly as I had hoped that the questions would generate much more discussion. It became apparent during the debriefing session that the study questions were not as open-ended as I had thought. In fact, it was clear from the students' responses in the debriefing,

that they had answered the questions in short, recall-of-information terms. With question #2, for example, (When Kevin arrived in the trauma room, he was being given a clear fluid intravenously. What hypotheses can you suggest for the administration of this fluid?), I had hoped to generate thought about the nature of the fluid, why it was being given at that particular time, why blood was not being given and what the physiological results of the administration of this fluid would be. Instead, students were steered by the question to respond only to the basic, immediate result, that of increasing blood volume. Once a student suggested the increase in blood volume, discussion stopped and the students moved on to the next question. I had set out to involve students in thinking deeply about the processes of physiology and instead, the students were working at a very superficial level of information recall.

These data necessitated a review of the study questions, which revealed that, although the questions were worded in respectful ways and appeared to call for higher order thinking, they were, in fact, leading the students to the responses, rather than calling for the examination of the issues and big ideas for themselves. If a case was to open discussion with students, the questions had to be more generative, calling for more of <u>their</u> thinking and ideas. The initial coding of the questions as higher order thinking questions (Raths, Wassermann, Jonas and Rothstein, 1986) was "wishful thinking." Instead, the questions, while appearing

on the surface to generate thinking, were worded in ways that led students to answers. Student thinking was stopped as soon as a single answer was generated. In order to open the questions more and have students generate more thought, questions needed to be formed in more open ways. This analysis led to revision of the questions as follows:

1. What medical or physiological questions does this case raise for you? (This question invites students to share questions that occurred to them as they read the case.)

2. When Kevin arrived in the trauma room, he exhibited a number of symptoms. Work with your group to identify and list these. What hypotheses can you suggest that might explain these symptoms? (This question calls for students to gather data and to interpret and hypothesize.)

3. The ambulance team had administered first aid to Kevin before he arrived at the emergency room. Talk together to identify some of the procedures they used. How do you see these procedures as being advantageous to Kevin's condition? (This question calls for students to gather data and hypothesize.)

4. The trauma team carried out a number of procedures on Kevin when he arrived. Work with your group to identify and list some of these. What hypotheses can you suggest for carrying out each of the procedures? How do you suppose they helped Kevin's condition? What are your thoughts? (This question calls for students to gather data, hypothesize and analyze.)

5. From your understanding of the functioning of the human body, identify body systems which might have been affected by the gunshot wound. In what ways might these systems have been affected? What are your thoughts? (This question calls for students to hypothesize and analyze.)

6. Brainstorm with your group to identify other body systems which may work to bring Kevin's body back to homeostasis. What theories can you suggest to explain the necessity of these systems? In what ways do you see these systems working to improve Kevin's condition? (This question calls for students to form hypotheses and apply them to new situations.)

7. Doreen "froze" Kevin's chest wall with a mixture of lidocaine and epinephrine. The epinephrine is not an anaesthetic but a vasoconstrictor. What reasons can

you suggest for including it in the injection? (This question calls for students to form hypotheses.)

8. What other issues does this case raise for you? Talk about them and be prepared to share your thoughts in the debriefing. (This question asks students to share thoughts and questions which may have arisen for them during the small group discussions.)

The original question #2, which had resulted in very short, simple answers, was now rewritten as two questions, #2 and #3. These questions did not provide the students with as much information as the original, instead they asked for the students to gather data from the case and to analyze, interpret and hypothesize using that data. The questions were formed in more open ways rather than leading to a single correct answer.

I did not assign replay activities to the scholarship students involved in the field test as they were not enrolled in a class and any assignment that I would have given them would have been over and above their already very heavy work load. Instead, I relied on feedback from my supervising committee as well as from various students and colleagues for the replay activities. From that feedback, the following modifications in the activities were made:

1. Make a lifesize body diagram and show on the diagram all the systems which would have been damaged and the mechanisms which the body uses to correct the situation. Present your findings to the class. Hang your poster on a bulletin board in the school.

2. Consult as many different sources as possible (encyclopedias, medical or biological books, computer searches, etc.) to find the causes and symptoms of hemopneumothorax. Present your findings in pamphlet form and send copies to your local health unit for feedback. Share your findings with the class.

3. Consult as many resources as possible to determine various reasons for hemorrhage, the methods used to treat it and the consequences of this condition on the rest of the body. Include the symptoms that a patient with hemorrhage would experience. Prepare a multi-media presentation of your findings along with basic first aid tips for the treatment of hemorrhage. Invite members of your local fire department or ambulance service to your presentation.

4. Interview a physician who works in an emergency ward. If possible, visit the physician in the ward and take some pictures or videos. (This will need approval from the physician.) Prepare a presentation for the

class which documents a "typical" shift in the emergency ward and which gives a snapshot of life in the ward. Invite the physician to your presentation.

5. Consult as many different sources as possible to determine the number of gunshot wounds and deaths in your city or area. To what do the police attribute the deaths? Gang related? Domestic? Drugs or alcohol? Combinations? Other? What type of gun controls are in place in your city? How do you suppose this influences the data you collected? What are your thoughts? Write a letter to the editor of local newspapers to share your results and be prepared to share your findings with the class.

6. Prepare a questionnaire which will help to track the opinions of people in your community about gun control and the right to carry firearms. Include in the questionnaire people's understanding of the relationship between guns and medical expenses. Tabulate your results and analyze them. Write to your member of Parliament and present your findings. Share your results with the class.

7. Design an activity of your own, alone or with a partner or group. Work with your teacher to establish the criteria for the finished product and presentation.

Relationship Between Biology 12 Learning Outcomes and Case #1

When the case narrative, study questions and replay activities were in final draft form, I analyzed the topics and issues of discussion generated from the case with the learning outcomes articulated for the Biology 12 course (Biology 11 and 12 Curriculum Guide, Ministry of Education, 1990). In making this analysis, it was possible to see that the case might extend thinking beyond the originally anticipated learning outcomes. Depending on the interest of students and teachers, many more areas of curriculum content and learning outcomes could be pursued using the case. Students or the teacher may wish to explore content in several of many areas that the case opens for discussion. While it is unlikely that all of the outcomes listed below would be addressed by one class in one lesson or unit, the opportunity for moving the discussion and subsequent study into any of these areas becomes possible for the case. Research, guest speakers, field trips, audio-visual materials and other strategies could be employed during the replay phase so that the content of the following learning outcomes is brought to light. Analysis of the curriculum and of the case material reveals that the following learning outcomes have been synthesized and may be addressed in the small group discussions, debriefing or replay activities.

From the case, students might extend their learning to:

* predict the effects of hypertonic, isotonic and hypotonic environments on plant and animal cells
* describe and differentiate between the five types of blood vessels
* identify the major arteries and veins in the body
* distinguish between pulmonary and systemic circulation
* distinguish between systolic and diastolic blood pressure
* define pulse, hypertension and hypotension
* describe the autonomic regulation of the heartbeat by the nervous system
* outline the factors which affect and regulate blood pressure
* outline the transport and exchange of oxygen and carbon dioxide by the blood
* describe the sequence of events that occurs during the formation of a blood clot
* describe the events that take place during an inflammation reaction
* given two examples of typed blood, discuss the physiological consequences of transfusion
* differentiate between the somatic and autonomic nervous systems with respect to locations and functions

* differentiate between the overall functions of the sympathetic and parasympathetic divisions of the autonomic nervous system
* identify and state the function of the medulla oblongata, the hypothalamus and the cerebrum
* explain five ways that drugs act at synapses
* indicate whether drugs stimulate or inhibit release of hormones in the brain
* list the structures of the respiratory system
* describe and distinguish between breathing, external respiration, internal respiration and cellular respiration
* explain how structure is related to function in the alveoli
* describe the functional relationship of the lungs to the pleural membranes and to the thoracic cavity
* describe the mechanisms of the processes of inhalation and exhalation
* explain how the nervous system controls the rate of breathing
* list and briefly describe the various ways in which water enters and leaves the human body
* identify and give the function of the parts of the nephron
* explain how the kidney regulates blood pH
* describe how ADH and aldosterone regulate urine composition

* state how the hypothalamus, posterior pituitary and collecting duct are inter-related in regulating water and solute levels in body fluids
* define hormones and state their functions
* support the assertion that the hypothalamus and pituitary are neuroendocrine control centers
* describe a negative feedback involving the endocrine system
* describe how each of the five types of white blood cells helps the body in defence against disease
* define and explain the role of macrophages, antigens and antibodies in the immune system
* distinguish between antibody-mediated and cell-mediated immunity

Summary of the Construction of Case #1

The first case, A Shot of Reality, represents a synthesis of Biology 12 learning outcomes and goals with Year 2000 Graduation Program goals. It provides a vehicle for the study of body systems, the interrelatedness of those systems, the homeostatic mechanisms associated with the healthy functioning of those systems and some of the social considerations that these medical issues encompass. The case was constructed through the analysis of course concepts that bear students' examination. This led to the articulation of big ideas which formed the basis for the

case narrative. These initial big ideas were not intransigent, but evolved as the case was written to take into account the fluid nature of the writing process and the need to include data and information to support the case. The process illustrates the non-linear, almost cyclical, nature of the process of analysis and generation.

Similarly, the case, study questions and replay activities also underwent several revisions following the field testing and feedback from informed colleagues. The narrative was scrutinized by an expert, a trauma nurse with experience of young gunshot victims, who could check the accuracy of the terminology, dialogue and atmosphere. Analysis of the study questions according to the Coding Sheet (Appendix, page 169) combined with an observation of a small group discussion, resulted in extensive changes in these questions. Replay activities were edited more conservatively as new ideas were incorporated.

The four cases which were written subsequently to this first one followed a similar process.

CASES TWO TO FIVE

PHANTOM

WATER, WATER EVERYWHERE

DO OR DIE

AN UNWELCOME REACTION

The four cases which were written after A Shot of Reality followed the same pattern of development. The experience of the first case provided the information necessary to extract the big ideas, generate the narrative, frame questions and replay activities for the subsequent cases. In each subsequent case, considerations of analysis of the factual content, emotional impact, controversy and reader appeal were important. A primary purpose was to write cases that were not only content-rich but also compelling. Cases needed to pique the curiosity of the reader and to stimulate a desire to know more while at the same time focusing student thought on the big ideas.

The second case, PHANTOM, incorporates the following big ideas, synthesized from an analysis of the Biology 12 curriculum learning outcomes and the goals of the Year 2000.

1. Neuron transmission is an electrochemical process.

2. Nervous sensation is carried from the sensory endings to the CNS and decoded in the brain.

3. Perception is a function of the brain and, though obviously related, it is not solely the effect of a sensory organ sending messages to the brain. Serious damage to the system can result in "misreading" incoming information.

The following big ideas of the third case, **WATER, WATER EVERYWHERE** have been synthesized from Biology 12 curriculum learning outcomes and the goals of the Year 2000.

1. Osmosis is a process that moves water between body cells and the media in which they live.

2. Water solutions that surround body cells must be isotonic to the cells. If the tonicity is disturbed, the body will attempt to normalize it.

3. In the event that the tonicity of solutions surrounding cells is too extreme for the body to stabilize, body functions will be disturbed.

The fourth case, **DO OR DIE**, is built around the following big ideas synthesized from Biology 12 curriculum learning outcomes and the goals of the Year 2000.

1. "Superhuman" acts are the result of body systems working in concert.

2. Recovery from extreme stress is also a result of body systems working together but more slowly than the preparation to act during stress.

Finally, the case, **AN UNWELCOME REACTION**, is based on these big ideas synthesized from Biology 12 curriculum learning outcomes and the goals of the Year 2000.

1. Allergic responses are caused by contact with an allergic agent to which individuals respond differently.

2. Symptoms of allergic responses vary according to the severity and type of allergic response.

3. Different people have different sensitivities that lead to allergic reactions.

CONCLUSION

Chapter three examined the processes of analysis, synthesis and generation used to develop content-laden cases for Biology 12. It provided an overview of how analysis of

curriculum content and synthesis of Biology 12 and Year 2000 learning goals are integrated in case narratives. It also followed the stages of writing and editing the cases, and the generation of the study questions and replay activities. It related the results of field testing to the revisions made necessary based upon that experience and, finally, compared the learning outcomes from the Biology 12 course with the content of the cases.

Chapter four presents five cases that were written for Biology 12.

CHAPTER FOUR

CURRICULUM MATERIALS

Chapter four presents the five cases that resulted from this research for Biology 12, including the "big ideas" presented in the form of teacher notes, study questions and replay activities. Teacher notes were constructed to provide teachers with the rationale underlying each case along with the connections of the case to the Ministry of Education learning outcomes for the course.

CASE ONE - A SHOT OF REALITY

TEACHER NOTES

The case, A Shot of Reality, was constructed to promote examination of the concepts of breathing and circulation. To understand the two processes and the relationship between them, the case describes a young boy who has been shot through the chest, resulting in a collapsed lung, hemopneumothorax, and shock. The symptoms of the boy when he is admitted to the emergency ward of the hospital as well as the treatment that he is given, will provide data for the reader.

During trauma such as hemorrhage, various parts of the body work together to try to keep the body in balance. Homeostasis is very important to the correct functioning of the body and if it is disturbed, the feedback systems will attempt to right the situation.

In this case, a severe hemorrhage has led to some serious problems. Students are asked to examine how the body functions in the healthy state, how the injury has disrupted that state and how the body and medical techniques attempt to compensate for the injury.

The big ideas that drive the case are:

1. Body systems work in concert to overcome the effects of an injury.

2. Emergency procedures will enhance the effects of the body's homeostatic mechanisms.

3. Understanding the situations which occur during injury depends on an understanding of the healthy state of the body.

4. While injury may have direct impact on one or two body systems (in this case, the respiratory and circulatory systems), other systems will be involved and may also suffer injury indirectly or will be influential in returning the body to a balanced state.

5. Social issues, such as the availability of guns and gun control, may have an impact on medical problems and costs.

The case, A Shot of Reality, was written to illuminate the big ideas of body systems working in concert, the physiological effects of injury and medical treatment and the social issues which impact on the physical well-being of people. The specific learning outcomes set out by the Ministry of Education which might be addressed by the case are listed below. This list contains outcomes identified by the Ministry of Education but does not identify other learning outcomes which may be a result of investigation

into the case. This list is not intended to limit the scope of the discussion.

Learning Outcomes - synthesized from the Biology 12 Curriculum Guide, Ministry of Education,1990 and the case narrative.

From the case, students might extend their learning to:

* predict the effects of hypertonic, isotonic and hypotonic environments on plant and animal cells
* describe and differentiate between the different types of blood vessels
* identify the major arteries and veins in the body
* distinguish between pulmonary and systemic circulation
* distinguish between systolic and diastolic blood pressure
* define pulse, hypertension and hypotension
* describe the autonomic regulation of the heartbeat by the nervous system
* outline the factors which affect and regulate blood pressure
* outline the transport and exchange of oxygen and carbon dioxide by the blood
* describe the sequence of events that occurs during the formation of a blood clot

* describe the events that take place during an inflammation reaction
* given two examples of typed blood, discuss the physiological consequences of transfusion
* differentiate between the somatic and autonomic nervous systems with respect to location and function
* differentiate between the overall functions of the sympathetic and parasympathetic nervous systems
* identify and give the functions of the medulla oblongata, the hypothalamus and the cerebrum
* explain five ways that drugs act at synapses
* indicate whether drugs stimulate or inhibit release of hormones in the brain
* list the structures of the respiratory system
* describe and distinguish between breathing, external respiration, internal respiration and cellular respiration.
* explain how structure and function are related in the alveoli
* describe the functional relationship of the lungs to the pleural membranes and to the thoracic cavity
* describe the mechanisms of the processes of inhalation and exhalation
* explain how the nervous system controls the rate of breathing
* list and briefly describe the various ways in which water enters and leaves the body

* explain how the kidney regulates blood pH
* identify and give the functions of the nephron
* describe how ADH and aldosterone regulate urine composition and water balance
* state how the hypothalamus, posterior pituitary and collecting duct are inter-related in regulating water and solute levels in body fluids
* define hormones and state their functions
* support the assertion that the hypothalamus and pituitary are neuroendocrine control centers
* describe a negative feedback involving the endocrine system
* describe how each of the five white blood cells helps the body in defence against disease
* define and explain the role of macrophages, antigens and antibodies in the immune system
* distinguish between antibody-mediated and cell-mediated immunity

A SHOT OF REALITY

Elizabeth joined the second nurse in the small trauma room of the emergency ward. They had had warning that a gunshot wound would be arriving in a few moments and the two worked side by side with the emergency physician and an intern to be sure that the correct supplies were at hand. This was the first time that Elizabeth had been involved with a gunshot wound in the emergency department and she hoped that her inexperience wouldn't slow or hold up the work. Everyone else seemed so calm.

The small group in the trauma room heard the commotion as the doors to the general ward banged open and the trauma team with the stretcher appeared in the doorway. Elizabeth took in the scene at a glance. The patient was conscious, sitting slightly propped on pillows to facilitate his breathing, his face obscured by an oxygen mask. His chest was bare and a blood stained dressing covered much of his space on the right side. An IV line snaked across his arm and up to the bottle of clear liquid that was draining slowly into his vein. But what struck Elizabeth with the force of an explosion was that the patient was a child, not more than six years old.

The trauma team moved to the side of the stretcher and lifted the child onto the trauma bed. An X-ray technician moved in to place an X-ray cassette into the space under the bed. She then positioned the X-ray machine over the boy's chest. One nurse began to insert a second IV line and also draw blood for cross-matching through this opening so that it would be ready when the lab technician came down to get the samples. A third person hooked the boy up to the ECG equipment in the trauma room and disconnected him from the portable unit that had been monitoring the child since he was picked up. A sphygmomanometer was wrapped around his little arm. Elizabeth read the name on the chart as she began pumping up the cuff. "You just relax, Kevin, everything will be all right. I'm sure you feel kind of scared but we're all your friends and we'll make you well." The boy did not really respond to her words, was instead focused elsewhere. He was not unconscious but was not really aware of his surroundings.

Elizabeth announced, "I've got a B.P. of 85/55 and a pulse of 100. Pretty strong." Elizabeth had time to call out the readings just as the X-ray technician called "clear" and the members of the team moved behind the screens in the room while the X-ray machine hummed for the second it took to make the picture. The cassette was removed and sent for developing as quickly as possible.

"We'll need a thoracic vascular surgeon and a pediatrician to have a look here. I'm not convinced that we should handle a wound like this here. He should probably go to Children's Hospital but let's get them down here to have a look." Doreen Harkin, the emergency physician, was studying the two wounds where the bullet entered and exited the body. "There is a hemopneumothorax of the right lung. I'll put a chest tube in. Do we have a cross-match on the blood yet?"

"Not yet but his pressure is holding pretty well." Elizabeth took a moment to push the boy's hair out of his eyes. Still conscious but not yet really taking in the situation, Kevin groaned, tiny whimpers coming from his throat without his knowing about them. He moved restlessly at times, at others he just lay still. She took the time to explain to him what they were going to do, but was not sure that he understood.

"Okay, let's get him anaesthetized and get that tube in." Doreen reached for the long needle with the lidocaine and epinephrine and was freezing an area of the chest when the door opened and Ross Fallows, the social worker, stuck his head in. "The parents have just arrived. What can I tell them?"

"Pneumothorax. B.P. is okay but we're watching it. The kid'll need surgery but we'll probably send him to Children's. We'll know more when the surgeon shows up. Tell the parents that the kid's life isn't in danger at this point." Doreen turned to Ross, her forehead wrinkled and with the needle deep in the small chest, and said, "Ask them how on earth this kid was in the way of a bullet."

Doreen was placing the chest tube. It was filled with a long metal rod that was used to push the tube into the chest through an incision that she had just made in the chest wall. When the tube encountered resistance, she gave a further push until she felt the resistance lessen and knew that she was in the pleural cavity. The metal rod was removed and the tube was attached to a system of bottles to collect the air and blood that was draining from the cavity. The tube ended in a bottle which was filled with water to prevent air from being sucked back through the tube and into the pleural cavity. Doreen asked the X-ray technician to take another picture to check the placement of the tube and, again, the team moved behind the screens while the machine took the second set of prints.

Meanwhile, Elizabeth had managed to insert a catheter into the tiny eurethra and attached a collecting bag to the tube to collect urine for measuring. The lab technician, Parween, arrived at that moment from the lab with bags of

packed cells and platelets which had been cross-matched to the boy's type. Kevin's blood pressure had dropped to 70/50 and it was decided to add the packed cells to the second drip.

Ron Parker, the thoracic-vascular surgeon and Leanne Chin, the pediatrician, walked into the trauma room right after each other. They looked at the X-rays and examined Kevin, noting the amount of blood that was draining into the bottles, the size of the two wounds, the low blood pressure and the rapid pulse.

"This is one for Children's Hospital, I think. Call the Infant Transport Team and let's get him over there as soon as we can. Elizabeth, will you come with me to talk to the parents?" Leanne and Elizabeth left while the rest of the team prepared to move Kevin to the specialty hospital fifteen miles away.

They found the parents in shock. They were pale and slumped in their chairs, but when they saw the two women walk toward them they stood and waited anxiously for news.

"Mr. and Mrs. Wright?" Nods confirmed the correct identity. "I'm Leanne Chin and this is Elizabeth Adams. Kevin is stabilized and we are sending him to Children's Hospital. They will be ready for him when he arrives and

they have much better facilities for him than we have - people who specialize in children's surgery and so forth."

The parents could do little but hold onto one another and nod. The reality of the situation was too much for them to comprehend and they seemed to be in a trance.

"Doctor, will he be all right? I mean, will he live?" Kevin's mother's voice was little more than a whisper as she plucked at the sleeve of the doctor's coat.

"Kevin is very badly injured, Mrs. Wright. We will all do our best and with luck he will be okay. At this point he is not in immediate danger."

Elizabeth was turning to leave but she couldn't contain herself any longer. She turned back to the Wrights and asked, "How could something like this have happened?"

Kevin's father collapsed into the plastic chair in the waiting room and held his head in his hands, propped on his knees by his elbows. "I left my gun out on the workshop bench when a neighbour came by to chat. We moved out to the back yard and didn't even see Kevin and his brother go into the workshop. They were playing cops...." His voice broke on a sob. "I just didn't see them go in." Tears were flowing down his face as his wife sat and put her arms

around her husband. She looked up at Elizabeth as if to say "Help us. We don't know what to do."

A SHOT OF REALITY

STUDY QUESTIONS

1. What medical or physiological questions does this case raise for you?

2. When Kevin arrived in the trauma room, he exhibited a number of symptoms. Work with your group to identify and list some of these. What hypotheses can you suggest that might explain these symptoms?

3. The ambulance team had administered first aid to Kevin before he arrived at the emergency room. Talk together to identify some of the procedures they used. How do you see these procedures as being advantageous to Kevin's condition?

4. The trauma team carried out a number of procedures on Kevin when he arrived. Work with your group to identify and list some of these. What hypotheses can you suggest for carrying out each of the procedures? How do you suppose they helped Kevin's condition? What are your thoughts?

5. From your understanding of the functioning of the human body, identify body systems which might have been affected by the gunshot wound. In what ways might these systems have been affected? What are your thoughts?

6. Brainstorm with your group to identify other body systems which may work to try to bring Kevin's body back to homeostasis. What theories can you suggest to explain the necessity of these systems? In what ways do you see these systems working to improve Kevin's condition?

7. Doreen "froze" Kevin's chest wall with a mixture of lidocaine and epinephrine. The epinephrine is not an anaesthetic but a vasoconstrictor. What reasons can you suggest for including it in the injection?

8. What other issues does this case raise for you? Talk about them and be prepared to share your ideas in the debriefing.

A SHOT OF REALITY

REPLAY AND EXTENSION ACTIVITIES

1. Make a lifesize body diagram and show on the diagram all the systems which have been damaged and the mechanisms which the body uses to try to correct the damage. Present your findings to the class. Hang your poster on a bulletin board in the school.

2. Consult as many different sources as possible (encyclopedias, medical or biological dictionaries, computer searches, etc.) to find the causes and symptoms of hemopneumothorax. Present your findings in the form of a pamphlet which you can then send to your local health unit. Share your findings with the class.

3. Consult as many resources as possible to determine various reasons for hemorrhage, the methods used to treat it and the consequences of this condition on the rest of the body. Include the symptoms that a patient with hemorrhage would experience. Prepare a multi-media presentation of your findings along with basic first aid tips for the treatment of hemorrhage. Invite members of your local fire department or ambulance service to your presentation.

4. Interview a physician who works in an emergency ward. If possible, visit the physician in the ward and take some pictures (this will need prior approval). Prepare a presentation for the class which documents a "typical" shift in the emergency room and which gives a snapshot of life in the ward. Invite the physician to your presentation.

5. Consult as many sources as possible (newspapers, magazines, statistical data etc.) to determine the number of reported gunshot wounds and deaths in your city. To what do the police attribute the deaths? Gang related? domestic? alcohol? other? combinations? What type of gun controls are in place in your city? How does this influence the data that you collected? What are your thoughts? Write a letter to the editor of local newspapers to share your results and thoughts and be prepared to share your findings and opinions with the class.

6. Prepare a questionnaire which will help to track the opinions of people in your community about gun control and the right to carry firearms. Include in your questions, people's understanding of the relationship between guns and medical expenses. Conduct the survey and tabulate the results. Write an analysis of your findings. Present this information along with your analysis to your Member of Parliament. Share your results with the class.

7. Design an activity of your own, alone or with a partner of group. Work with your teacher to set the criteria for the finished product and presentation.

CASE TWO - PHANTOMS

TEACHER NOTES

The case, Phantoms, was constructed to illustrate the functioning of the nervous system, especially the role of the peripheral nervous system and the brain in the perception of feeling and pain. To understand how the brain is implicated in perception, students are supplied with data in the form of the sensations that a young woman feels after the removal of her foot. How those sensations are possible is the focus of the case.

In some circumstances, a patient may experience a phenomenon called phantom pain after an amputation of a limb. To understand this, one must have a good understanding of the workings of the peripheral and central nervous systems, including how the brain perceives sensations.

The big ideas that drive this case are:

1. Neuron transmission is an electrochemical process.

2. Nervous sensation is carried from the sensory endings to the CNS and decoded in the brain.

3. Perception is a function of the brain and, though obviously related, is not solely the effect of a sensory

organ sending messages to the brain. Serious damage to the system can result in "misreading" incoming information.

Learning Outcomes - synthesized from the Biology 12 Curriculum Guide, Ministry of Education, 1990 and the case narrative. The list below is derived from the Ministry of Education and is not intended to be complete or to limit discussion to only these concepts and issues.

From the case, students might extend their thinking to:

* define homeostasis and describe at least three examples of homeostatic mechanisms
* describe the fluid mosaic model of the membrane and the role that each component plays in the movement of molecules through the membrane
* explain why the cell membrane is described as selectively permeable rather than semi-permeable
* compare, and give examples to illustrate diffusion, osmosis, facilitated transport and active transport
* predict the effects of hypertonic, isotonic and hypotonic environments on animal cells
* describe endocytosis and contrast it with exocytosis
* describe the physical relationship between an enzyme and its substrate using the "lock and key" theory
* describe the role of enzymes in biochemical reactions
* relate the structure of the ATP molecule to its role as the energy currency of cells

* using examples describe the four major tissue types of the human body and give their functions
* draw and label a simple motor neuron and state the functions of the parts
* distinguish between sensory, motor and interneurons and give the function of each
* explain how a nerve impulse is transmitted through a neuron
* explain why the transmission across a synapse occurs in one direction only
* describe the structure of myelinated nerve fibres and relate this to the efficiency of impulse conduction
* identify the major components of a synapse and explain how impulses travel across the synaptic cleft
* differentiate between the central nervous system and the peripheral nervous system
* identify and state the functions for the cerebrum
* list the four lobes of the cerebrum and state their functions
* describe the location and function of chemoreceptors, mechanoreceptors, proprioreceptors, and radioreceptors

PHANTOMS

I felt like I was walking but, oh, so slowly - one foot pulled sucking from the sand and falling heavily just a few inches in front of the other. Jerking, in slow motion, I moved through the thick heat toward the light.

Dry.

My mouth was so dry - my tongue felt swollen and unable to move. My lips were cracked and hard.

Water.

The word formed in my mind and splashed in my consciousness until I could walk no more. I must tell someone. I must get water.

Wa-ter. I moaned, "Wah." Even to my ears the sound had no form, no meaning. I know my lips and tongue did not move. Everything was so still and heavy. But I was so thirsty, I had to try again. Try again.

"Wah-ter." This time the sound came more clearly and my lips moved. "Water." This is better. Surely someone

will understand this time. I'll try again, louder. "Water."

Did I hear a voice? It seemed far away but I'm sure it was there. What was it saying? Listen!

"Jennifer?" the voice said, faint but there. Thank God! Someone can hear me! "Water." I want to say "please" but there is no energy. Do they hear me?

"Jennifer, you are out of surgery and everything went just fine. I can't give you any water yet, Jennifer, but I'll sponge your lips." I can feel the cool water on my lips and open them to pull some into the desert of my mouth. There is so little of it! I can hardly taste it or feel it. Please, please, I want some more!

"Jennifer, can you tell me where you are? Tell me what this place is," the voice spoke in an insistent tone. Maybe if I can tell her where I am, she will give me some water. I didn't know, did I? I thought hard. Yes! "Hospital," I said. "I'm in hospital. Water. Please."

"I'm sorry, Jennifer. I can't get you any water yet but I will bring you an ice chip in a moment. Can you open your eyes?"

Could I? I think so. I'll try. The lids must be glued together, they feel so heavy. I'll try one eye. There. The voice had a face and it was smiling. "Good girl. Good for you. I'll tell your parents and Dr. Mitchell that you're awake. I'm sure they'll be in to see you soon."

"Can I have some water?" I really don't need the doctor or my parents right now. I need water.

"I'll get you that ice." The voice and the face disappeared but returned immediately with the ice chip. It feels wonderful! But...oh! It's gone! I want more! I look around for someone to ask but I'm alone.

I wonder why I'm here and for the first time think about my leg. A squirt of fear snakes through my gut. Thirst is forgotten. My heart begins to pound and sweat breaks out on my forehead. The surgery was to try to save my leg. Was it still there? Was my leg still there?

Please God, let my leg be there. I'll do anything, just let my leg be there! I'm going to wiggle my toes now. When I wiggle my toes I'll know that the leg is there. I'm going to wiggle them now, God. Please, let them be there. Please!

They're there! Thank-you, thank-you! My toes are there. I can feel them scraping on the sheet and wiggling against each other. I didn't lose my leg! The relief pours through me like sweet syrup through my veins. Thank God.

In the waiting room, Dr. Mitchell is sitting with a man and a woman, both very obviously distressed. They are crying and clutching at each other and the doctor, searching for comfort. A nurse approaches and says, "Jennifer is awake. She's asking for water."

"Thank-you, Ellen. I'll be in right away." Dr. Mitchell turns to Jennifer's parents. "Will you come with me or shall I tell her before you come in?" His voice is compassionate and supportive. Sometimes parents couldn't take the strain, no matter how much they had prepared for it. He could tell Jennifer that she had lost her leg but it would be better to hear it if her parents were there.

Holding tight to his wife's hand, Jennifer's father says, "We'll come with you."

PHANTOMS

STUDY QUESTIONS

1. What medical or physiological questions does this case raise for you?

2. What hypotheses can you suggest to explain how neurons are able to transmit information from a foot to the brain? Discuss your thoughts with your group.

3. What role do you suppose the brain might play in the perception of sensations? What are your thoughts on it?

4. From your understanding of the functioning of neurons and the brain, develop some hypotheses which might explain why Jennifer could still feel her foot after it had been amputated.

5. You may have had a local anaesthetic when you had stitches or dental work done. What theories can you suggest to explain why the doctor can still push a needle through your skin or a dentist drill your tooth and yet you feel no pain? What are your thoughts?

6. What other issues does this case raise for you?

PHANTOMS

REPLAY ACTIVITIES

1. Consult various resources to find how nerve impulses are transmitted from foot to brain and back again. Use a body diagram to show the path of the neurons through the nerve and the spinal cord to the brain and back. On the diagram, show the electrochemistry that causes the nerve impulse to move along the neuron and show how the impulse moves from one neuron to another. Present your diagram with an explanation to the class.

2. Consult various resources to find how pain is perceived and transmitted. Prepare a pamphlet which shows the method of pain transmission, the part the brain plays in the perception of pain, and possible methods of blocking pain. In your pamphlet, explain the functioning of pain killers such as morphine. Send your booklet to your local health centre or physician for feedback. Present your pamphlet to the class. Invite a health official or physician to your presentation.

3. Use as many different resources as possible to research the incidence, mechanism and treatment of phantom pain. In

your account, relay some specific examples of individuals who have experienced phantom pain. Present your material in a form that you can share with sufferers and their families. Send a copy of your material to an orthopedic surgeon, a neurologist or a psychologist or psychiatrist for feedback. Present your findings to the class.

4. Consult as many sources as possible to find information on patients who have had lesions to various parts of their brain or spinal cord. Discuss how these injuries have affected the functioning of the body. Include injuries that have involved different areas of the brain or spinal cord and describe how these different injuries cause differing symptoms. Present your findings to the spinal cord unit of a hospital for feedback and to your class.

5. Design an activity of your own, alone or with a partner or group. Work with your teacher to set the criteria for your production and presentation.

CASE THREE - WATER, WATER EVERYWHERE

TEACHER NOTES

The case, Water, Water Everywhere, was constructed to promote examination of the process of osmosis and its importance to the functioning of the human body. The death of one shipwreck victim who had ingested salt water and the survival of a victim who ingested urine supplies the data which the students can use to begin their study of osmosis.

Many of the processes necessary for life depend on the process of osmosis. Transfer of water between cells and the media in which they live is essential for the metabolic reactions that comprise life. Disruption of the process can lead to serious consequences.

The big ideas that drive this case are:

1. Osmosis is a process that moves water between body cells and the media in which they live.

2. Water solutions that surround body cells must be isotonic, or nearly isotonic, to the cells. If the tonicity is disturbed, the body will attempt to normalize it.

3. In the event that the tonicity of solutions surrounding cells in too extreme for the body to stabilize, body functions will be disrupted.

Learning Outcomes - synthesized from Biology 12 Curriculum Guide (Ministry of Education, 1990) and the case narrative. This list is not intended to limit discussion of other concepts and issues which may arise from the case but reflects the connection between the case and ministry goals.

From the case, students might extend their learning in the following areas:

* define homeostasis and describe at least three examples of homeostatic mechanisms
* diagram examples of homeostatic control through positive and negative feedback in human systems
* describe and give examples of the properties of water that account for its importance in biological systems
* describe the fluid mosaic model of the cell membrane and the role that each component plays in the movement of molecules through the membrane
* explain why the cell is described as selectively permeable rather than semi-permeable
* compare and give examples of diffusion, osmosis, facilitated transport and active transport
* predict the effects of hypertonic, isotonic and hypotonic environments on animal cells

* outline the transport of oxygen and carbon dioxide by the blood
* list and briefly describe the various ways in which water enters and leaves the body
* compare and contrast the composition of urine and blood plasma
* describe how ADH and aldosterone regulate urine composition
* state how the hypothalamus, posterior pituitary and collecting duct are inter-related in regulating water and solute levels in body fluids
* identify and give the function of the parts of a nephron
* define hormone and state the functions of hormones
* identify and give the functions of the endocrine glands
* support the assertion that the hypothalamus and pituitary are the neuroendocrine control centers
* describe a negative feedback system in the body

WATER, WATER EVERYWHERE

Elham Fasihy picked up the last file on her desk and with a heartfelt sigh, scanned the preliminary report of the attending officer. One man dead and a woman in critical condition in the hospital. Thirteen days at sea in a dingy without food or water. The man: 30 years old, had been dead for two days when rescuers finally arrived. The woman: 31 years old, was delirious when she had been airlifted to the nearest hospital. No one had been able to speak to her to find out what had happened.

Elham turned to her partner, Jon Adams. "This case bothers me, Adams. I don't like it. There's something weird about it," said Detective Fasihy as she put down the report and reached for the tepid cup of coffee next to the desk blotter.

"What case is that?" Jon looked up from his word processor but continued to type as he spoke.

"This new one. The shipwreck. A big, apparently healthy, young man dies after eleven days in a boat but the woman is still alive. It doesn't add up. Shouldn't she have gone first?"

"You suspect foul play?" Adams asked. The younger of the two, Adams looked to Elham Fasihy for advice. She had seen more and stranger things than Jon had in his two years on the force.

"Naw, I don't think so. There's just something strange about a big, healthy guy dying of dehydration out in that lifeboat while that little slip of a female is still alive and likely to recover. It doesn't figure." Fasihy's brow was furrowed in concentration as she attempted to reconcile these two disparate pieces of information.

"Maybe he gave her all the water they had. You know, sort of the martyr thing," Adams speculated.

"No evidence of any water or water containers on board."

"Guess we'll just have to wait for the autopsy or until the woman can tell her story." Jon turned back to his computer to continue his report.

"I'm going down to the morgue now. I want to hear what they have now. Coming?" she asked Adams.

The morgue was a busy place that afternoon with two autopsies going on and a backlog that would keep the pathologists busy for awhile. One of the men working on the first cadaver looked up at Elham and Jon as they walked in.

"Haven't seen you guys around for some time. Something up?" the pathologist, Travis Wong, smiled at the two detectives as he waved a gloved and bloody hand in greeting.

"Hiya, Dr. Wong. We're anxious to hear about the shipwreck. Got anything on him yet?" Jon moved toward a row of government issue, plastic chairs but did not sit down. It was enough to be out of the line of sight of the stainless steel trough that held the body.

"Great timing, guys. Got him on the table right now. What's bugging you?" asked Dr. Wong, squinting at something he had uncovered.

"You figured the cause of death yet? We're puzzled about how a man could have died of dehydration while a much smaller female stayed alive two days longer. Got any ideas?" Elham asked as she moved closer to the trough to see the body.

The man in the trough had been a large man in life but was an emaciated corpse. Sunken, plaster white cheeks were

covered with a thick, scruffy, growth of beard. HIs skin was pulled taught over protruding bones and had a chalky, bluish tinge. Elham averted her eyes from the great gashes that the pathologist had cut into the chest and abdomen. A rib spreader, blood spattered, lay beside the body.

Dr. Wong looked over at Jon who had taken a seat and was gazing with great interest at his shoes. "I don't see anything suspicious yet but I haven't really gotten a lot done here. We'll need a workup of the body fluids to determine more. I'd guess this guy died of simple dehydration."

"Give us a call when you have anything definite, will you please? It may be a few days before we can speak to the woman." Elham moved toward the door.

Thirty-six hours later, Adams and Fasihy left a hospital room together. Adams spoke, "God, that is disgusting! How could anyone do that? She drank her own urine! It's enough to make you hurl!"

The older woman looked at the pale face of her partner and nodded. "Not too appetizing, I guess, but, hell, she's alive to tell about it and he's dead."

"Yeah, guess that drinking urine gave her an edge. I wonder why he didn't do the same?" Adams replied.

Elham was about to reply when her beeper went off and she checked the number on the display. "That's the morgue. Maybe Wong has something for us." She moved to the desk and borrowed the phone to call the doctor's number. Jon watched the expressions cross her face as she listened to the report from the pathologist. Concentration, disbelief, anger.

Returning to Jon after hanging up the phone, she filled him in on the autopsy results. "Stupid guy should've followed his girl friend's's example. Apparently the stomach contents were full of salt. Our victim tried to save himself by drinking salt water."

WATER, WATER EVERYWHERE

STUDY QUESTIONS

1. What medical or physiological questions does this case raise for you?

2. What hypotheses can you suggest to explain the death of the man in the lifeboat? What are your thoughts on it?

3. What hypotheses can you suggest to explain the survival of the woman? Share your ideas with your group.

4. During their ordeal at sea, the body systems of the two shipwreck victims would have attempted to maintain homeostasis in the face of lack of water and food. How do you suppose various body feedback systems would try to counter the lack of each? What are your thoughts on it?

5. Have you ever had occasions when you have been extremely thirsty? If you feel comfortable doing so share your experience with the group. What were the circumstances that led to the thirst? Discuss with your group your thoughts on the possible causes of thirst from a physiological point of view.

6. Read the ingredients on a soft drink bottle or can. What hypotheses can you suggest for including salt as one of the ingredients? What are your thoughts?

7. What other issues does this case raise for you?

WATER, WATER EVERYWHERE

REPLAY ACTIVITIES

1. Investigate the process of osmosis. Consider the process when hypotonic, isotonic and hypertonic solutions are involved. Design a demonstration that will illustrate the situations above and present this along with your research to the class. Relate the situations to situations in the case.

2. Design a pamphlet for the coast guard that will alert sailors to the dangers of dehydration. Include a list of supplies that all lifeboats should carry to help avoid the affects of dehydration. Include symptoms of dehydration and the treatment of dehydrated victims. Submit your pamphlet to the local coast guard station or emergency clinic. Invite a member of the coast guard or clinic to attend or be part of your presentation to the class.

3. Investigate the mechanisms in the human body which regulate the amount of water in your blood and cells. How do these controls attempt to balance your fluid levels during periods of dehydration? Discuss how the control mechanisms would be affected by drinking salt water or

urine. Prepare a multi-media presentation of your findings to the class.

4. Investigate shipwrecks and the consequences of them. In cases where there were survivors, what circumstances do you see that were valuable in saving the lives of shipwreck victims? What commonalities, if any, did you observe in the accounts? In cases where there were deaths, in your opinion, what circumstances led to the deaths of victims? What did the accounts of the deaths have in common? Prepare a list of safety rules based on your research and present them, along with your data, to a local radio or TV station and to the class.

5. You are the producer of the "Phil Donahue Show." The survivor of this case is being invited to be a guest on the show. What questions would you want Phil to ask her? Who else would you want on the show? Why? What information would you hope they would be able to provide? Work with a group to set up a simulation of the "Phil Donahue Show." Have the "survivor" and the "experts" on the panel. Present this show to the class, allowing time for questions from the "audience."

6. Design an activity of your own, alone or with a partner or group. Work with your teacher to set the criteria of the production and presentation.

CASE FOUR - DO OR DIE

TEACHER NOTES

The case, Do or Die, was constructed to promote examination of the capabilities of the human nervous and hormonal systems in the face of extreme emergencies. The data for the case are supplied in the story of a young woman who lifts a car off her baby sister after the car rolls onto her. Students who study the case will find information to drive further study of the functioning of adrenalin and the sympathetic nervous system.

During times of extreme emergency, the human body can perform acts that would be impossible at any other time. How the body responds to extreme stress is the focus of this case.

The big ideas that drive the case are:

1. "Superhuman" acts are the result of body systems working in concert.

2. Recovery from extreme stress is also a result of body systems working together but more slowly than the preparation to act during stress.

Learning Outcomes - synthesized from Biology 12 Curriculum, Ministry of Education, 1990 and the case narrative. The list below is not intended to limit discussion of concepts or issues but rather reflects the goals of the ministry.

From the case, students might extend their learning in the following ways:

* define homeostasis and describe at least three examples of homeostatic mechanisms
* diagram examples of homeostatic control through positive and negative feedback
* describe the fluid mosaic model of the cell membrane and the role that each component plays in the movement of molecules through the membrane
* describe the physical relationship between an enzyme and its substrate using the "lock and key" theory
* differentiate between the sympathetic and parasympathetic divisions of the autonomic nervous system
* define hormone and state the functions of hormones
* distinguish between peptide and steroid hormones in terms of composition and mode of action
* identify the endocrine glands
* describe a negative feedback involving the endocrine system

* state the hormone produced, primary action and target organ of the adrenal cortex and adrenal medulla
* support the assertion that the hypothalamus and the pituitary are neuroendocrine control centers

DO OR DIE

"Come on Megan, don't be a drag." Ryan stood in front of Megan, blocking out the sun and twirling a frisbee on the end of his finger.

Megan squinted up at him and shook her head. "I don't wanna play. Besides I gotta watch Lindsay."

"Party poop." Ryan shouted over his shoulder as he ran out onto the hard packed sand of the wide beach. Megan rolled over onto her side and watched Lindsay push her little shovel into the sand and transfer the load to a pile she was building on the blanket. She smiled at the sight of her diapers hugging her chubby body, dimples winking at the well-padded joints. It was hard to believe that she really had a sister. For years she had wished for a baby sister and now that she had one she found that she often felt more like her mother or aunt. She loved Lindsay more than just about anything in the world, but with sixteen years between them it was sometimes hard to think of her as a sister.

Rolling onto her back, Megan thought about leaving home at the end of the year to attend university and felt the now familiar squirt of fear in her abdomen. It would be so

scary to be away from the protection of her family and friends; to be completely responsible for herself. Not for the first time she wondered if she was making the right decision. Maybe she should stay at home and go the college nearby. At least if she did she would get to know Lindsay as she grew up.

Lindsay was squealing and talking away in her own language as she turned her attention to a clam shell that she had found in her excavations. "Pretty shell, Lindsay," Megan said. "Pretty shell."

"Itty ell," Lindsay mimicked. Megan grinned at her, and turned on her stomach to see where Ryan, Ted and Andrew had gotten to. They were way down the beach, barely discernible from her vantage point. Snuggled into a cove carved into the sand dunes, Megan and Lindsay had found a sheltered spot in which to spread their blanket. The spring sun warmed her skin and, protected from the wind, she was beginning to feel more at peace with her decision to go away. She felt drowsy and lethargic. What could possibly go wrong?

Shading her eyes against the glare, Megan watched the frisbee game so far down the beach. The three friends were getting really good with the saucer. Their moves were much more sophisticated than even two weeks ago. Megan knew she

couldn't play with them much longer if she didn't get out and practice with them some more. Maybe she could take Lindsay down to the beach and they could all keep an eye on her. She turned to find Lindsay. She wasn't there!

Jumping up, she called Lindsay's name. "Lindsay! Lindsay! Where are you?" She knew that the baby couldn't have toddled away to the beach because she would have seen her so she must have made her way up over the miniature dunes toward the parking lot. Megan ran up over the dunes to the lot and called again. "Lindsay! Come on sweetie, where are you?"

The lot was empty of people and only a few cars were parked. It was still early in the season and the crowds were not in evidence. Megan was about to turn back to the dunes when she noticed that one of the cars seemed to be in a weird position. Something was wrong. One car was jammed up against another, as if it had crashed into it.

Megan ran over to the car and found a dog in the front seat, barking and pawing at the driver's window. No one else seemed to be around. How could the car have crashed? Where was Lindsay? Megan ran around to the other side of the car and stopped short before a sight that caused her heart to leap into her throat and her mouth to open in a

silent scream. Her face lost all colour. Lindsay was under the right front tire of the car!

The weight of the car seemed to rest fully on Lindsay's back. Her tiny little head was turned on its side facing away from Megan and she was absolutely still. "Oh God! She must be dead!" thought Megan, paralyzed from the fear she felt on seeing her precious baby sister lying under the huge black tire. "I've got to get the car off her!"

Megan tried the car door but it was locked. The dog inside barked even louder, baring his fangs at the intruder. "I'll get her out! I will!" Pale and shaking, she ran to the front of the car, reached under the bumper at the front and took a deep breath. With a tremendous lunge, she lifted the car off the little, unmoving body and with her foot, pushed Lindsay out of the way. The car fell back down, scrapping the second car with a garish sound. Megan didn't even notice.

With trembling hands, she reached down to touch the baby's neck. Was there a pulse? She couldn't trust herself but she thought there was. She tried to feel for her breath coming from her nose. Yes! She was alive! She had to get help! Reaching for the baby, she stopped herself. Somewhere she had heard that it was better to move an injured person as little as possible.

Megan ran to the road, waving her arms and screaming. Within minutes a car pulled over and stopped. "My sister, she's been hit by a car! We need help!" Megan was sobbing her story to the stunned young couple in the car. "Please, please, help me!"

Within six minutes, the emergency response team of the fire department was there. The police and the medics followed minutes later. Megan waited with the couple who had phoned in the 9-1-1 call on their cellular phone. Lindsay appeared so tiny, so helpless and still. Surrounded by so many people, Megan felt cold and alone. This was her fault. If Lindsay died, it would be her fault.

"Miss?" Megan looked blankly up at the tall man in the firemen's coat. "Your sister is going to be taken to hospital. We need your parents' phone number and we need to know what happened here. Let's sit over here and you can give us the details."

Megan shook her head. She wasn't going to leave Lindsay's side, even if she couldn't get close to her, she wasn't going to leave her. "I can talk right here," she replied. Giving her parents' number, Megan went on to recount what had happened. As she finished, she looked up

into the faces of the fireman and a policeman. They were staring at her with disbelief.

"You lifted the car off the baby?" one asked.

Megan nodded. "Is Lindsay going to be okay? Will she live?"

"We think so. She'll need to be assessed but she appears to be pretty good. Are you sure the car was resting right on her? Did you really lift that car by yourself?"

When Megan heard that Lindsay was probably going to be okay, a rush of relief swept through her leaving her weak and trembling. The last question the officer asked was lost in a blur of buzzing as blackness swam around her and Megan fell sideways, unconscious.

DO OR DIE

STUDY QUESTIONS

1. What medical or physiological questions does this case raise for you?

2. How might you explain Megan's sudden ability to lift a car? Discuss what you believe are the physiological changes in the body that would be necessary to accomplish this. What are your thoughts?

3. What hypotheses can you suggest to explain why Megan lost all colour as she prepared to lift the car?

4. After learning that her sister would likely live, Megan fainted. What hypotheses can you suggest that might explain her reaction?

5. If you feel comfortable doing so, share an event in your life when you experienced a stress-induced energy "rush". What were the circumstances? Discuss how you felt during the "rush" and how you felt after the "rush" had ended. Relate your experience to Megan's.

6. What other issues does this case raise for you?

DO OR DIE

REPLAY ACTIVITIES

1. Investigate the functioning of adrenalin and the sympathetic nervous system during stress. Discover the affects that the "fight or flight" system has on various body systems. How do these systems respond to help you deal with stressful situations? Present your findings on a body tracing diagram and share this with the class.

2. Investigate feats of "superhuman" endeavors. What do you see as common to these events? Prepare a multi-media display to describe the stories. Share these with the class.

3. Prepare a pamphlet for your local health centre that details how stress affects the body and how the body then recovers from stress. Suggest ways to deal with stress. Include examples of positive (happy events such as weddings) stress and negative (threatening events such as Megan encountered) stress. Send your pamphlet to your local health centre for feedback and present it to the class.

4. The editor of your city newspaper asks you to write a story about Megan's experience for the next edition.

Determine who you would like to interview (those people who could help you and your readers understand what happened). Using good journalistic technique, write the story including quotes from these individuals (make up names). Present your article to the class and send it to the local newspaper for feedback.

5. The producer of the evening news asks you to interview Megan and any other people who would be interesting to viewers about her experience. With a group, set up a role playing situation where one person acts as the interviewer and others take on the role of Megan and various experts. Perform your interview/discussion for the class and video the process.

6. Design an activity of your own or with a partner or group. Work with your teacher to set the criteria for the production and presentation of your activity.

CASE FIVE - AN UNWELCOME REACTION

TEACHER NOTES

The case, An Unwelcome Reaction, was constructed to promote examination of the process of allergic response, especially of severe anaphylactic shock. The data are contained in a story of a young man who experiences anaphylactic shock when he ingests a cookie which supposedly is free of nuts but is not. His symptoms and the treatment that he receives at the emergency ward will provide information for students to use in their study.

In extreme cases of allergic response, anaphylactic shock may lead to death. The mechanisms underlying this situation are complex. In most cases, people with severe allergic responses have a "window" of time when they can seek treatment but in rare cases, the reaction is immediate.

The big ideas that drive this case are:

1. Allergic responses, caused by contact with an allergic agent, take different forms.

2. Symptoms of allergic responses vary according to the severity and type of allergic response.

3. Different people have different sensitivities that lead to allergic reactions.

Learning Outcomes - synthesized from Biology 12 Curriculum, Ministry of Education, 1990 and the case narrative. The list below is not complete and is not intended to limit discussion of concepts or issues generated by the case. Rather the list reflects the goals of the Biology 12 course.

From the case, students might extend their learning in the following areas:

* describe the fluid mosaic model of the cell membrane and the role that each component plays in the movement of molecules through the membrane
* list the major vessels and organs of the lymphatic system and their functions
* state the major components of plasma
* outline the transport and exchange of oxygen and carbon dioxide by the blood
* describe the events that take place during inflammation
* list the structures of the respiratory system and briefly describe the function of each
* describe how each of the five types of white blood cells helps the body in defence
* define and explain the role of macrophages, antigens and antibodies in the immune system

* describe the nature of the antibody-antigen complex
* distinguish between primary and secondary immune responses
* explain how immunization may prevent a person from contracting a disease
* distinguish between passive and active immunity
* define allergy and describe the physiological responses associated with mild and severe allergic responses

AN UNWELCOME REACTION

"Wanna cookie?" Gwen asked, steering Rod toward the counter in the mall's Food Fair. The choices displayed in the case were succulent - huge chunks of chocolate and nuts snuggled in with mouthwatering, moist cookie.

Rod slipped his arm around Gwen's waist. "You buying?" he asked. When she nodded, he agreed. "I'll have a double chocolate chunk."

Gwen stepped up to the counter and placed the order. "There aren't any nuts in these cookies are there? My boyfriend is allergic to nuts."

"These ones just have chocolate in them, no nuts," replied the young man behind the counter. He placed two enormous chocolate chunk cookies in a bag and handed it over to Gwen. "That'll be $3.00."

Gwen paid for the cookies. "Let's eat them in the car on the way. If we don't hurry we'll be late." They walked out to the new Honda Prelude and Rod got behind the wheel. Gwen waited until he had backed out of the parking spot and they were out on the main road before handing him a cookie. She bit into hers and was enjoying the sweet and chewy taste, squishing the chocolate on her tongue, when she heard

Rod gasp. She looked over at him and saw a cookie crumb hanging on his lip. He was still watching the road but his face looked strained and pinched.

"Gwen, I feel weird," his voice was slurred and thick, as though he were drunk. Air rasped through his lips. "Gwen, I..." The rest of the sentence was lost as Rod turned to Gwen, his eyes huge in his rapidly swelling face. He was gasping now just to pull tendrils of air into his lungs.

"Oh my God," whispered Gwen. A thousand bits of information raced through her brain at once. Rod was choking. He was swelling and turning all blotchy. The cookie crumb was still stuck on his bottom lip. His hands were frozen to the wheel. The car...My God, the car was careening all over the road! Horns were honking. As Gwen grabbed for the wheel, Rod grabbed for Gwen. "Help me," his eyes pleaded but no sound came from his throat. He was dying.

Gwen remembered what happened next as if it were a dream or a movie that she saw. The details were sharp but the episode seemed to have happened to someone else. Through gritted teeth she muttered, "Hang on, Rod. We're going to make it."

She pushed him over to the side of the driver's seat and moved over onto the seat herself, half sitting on him and half on the console. Grabbing the wheel, she pulled the car back into the lane, leaned one hand on the horn and stomped on the gas pedal. "Get out of my way, you bastards. I'm coming through."

The Honda screamed through the first intersection on a green light. There were only a few cars in front of her and two of them had pulled over to get out of the way. She felt Rod clutching at her, as she maneuvered past three pedestrians who had stepped off the curb and then jumped back in fright as they saw the car thundering toward them. Gwen ignored the increasingly frantic grabbing at her as the panic rose in Rod. With tunnel vision concentration, she swing the car into the oncoming lane to pass a truck that was lumbering along in front of them. Back in her own lane, she barely registered that Rod was now still.

Three blocks to the hospital. Up a hill, around the corner and into the parking lot. They were going to make it! From a driveway, a car pulled out in front of them. Again, Gwen turned the racing Honda into the oncoming lane and barely missed hitting the bus that was pulling out into the traffic.

The corner was negotiated on two wheels but as they

bounced back down on all fours, Gwen heaved a sigh of relief. There was the hospital emergency ward. She hit the horn with loud, spiking hits to draw attention to them. How long had Rod been without air? Time seemed to have expanded for her. She had lost touch with reality.

At the door to the emergency ward, Gwen slammed on the brakes. Both she and Rod were thrown onto the steering wheel. She cut her forehead but didn't even notice the blood on her face. Rod's lip was cut.

The driver's side door was blocked by Rod's inert form so she wriggled over to the passenger door and was opening it when a gurney and two attendants appeared through the doors of the hospital and ran to meet her.

"He's over here," she gasped as she ran around to the driver's side. "He ate a cookie. It must have had nuts in it. They said it didn't but it must have. Is he going to be okay?" All the time she was talking, the two attendants were removing Rod from the car and placing him on the gurney. They placed a number of pillows under his feet and wrapped a sphygmomanometer cuff around his arm. Pushing him into the ward, they called to the triage nurse and a doctor who joined them, "Anaphylactic shock, B.P. 70/50, pulse 120 and thready."

"Get an airway and IV lines in stat. Start epinephrine." The young doctor issued orders as the gurney disappeared into the treatment room.

Gwen felt an arm hug her and heard a voice say, "I'm sure he's going to be okay. Let's sit down over here and you can catch your breath. Someone will be along to look at your head in a moment."

Gwen put a hand to her head in surprise. She hadn't realized that she had been injured. The woman's voice continued, "You should be proud of yourself. It appears that you saved that young man's life."

AN UNWELCOME REACTION

STUDY QUESTIONS

1. What medical or physiological questions does this case raise for you?

2. What hypotheses can you suggest to explain how certain agents such as nuts are able to cause such extreme responses in the body? Discuss your ideas with your group.

3. Discuss with your group the symptoms that Rod exhibited after ingesting the nuts. From your understanding of allergic responses, develop some hypotheses to explain Rod's symptoms. What are your thoughts on it? Share these with the group.

4. How might you explain the fact that Gwen showed no symptoms of allergic response even though she ingested the same "allergen"?

5. Discuss with your group the treatment that Rod received immediately upon arrival at the hospital. In what ways do you see his treatment improving his condition? What are your thoughts?

6. How do you suppose a cookie which was supposed to be nut-free, produced these allergic responses? How might this be explained?

7. Suggest some homeostatic mechanisms in the body that might be working to return Rod's systems to normal. How do you see these mechanisms countering the effects of the allergens?

8. Have you ever had, or been with someone who has had, a mild or severe allergic reaction? If you feel comfortable doing so, share your experience with the group. In what ways do you see allergic responses as being similar? What differences do you notice? How might you explain the differences?

9. Take a straw poll in your group to determine how many are allergic, to what they are allergic, what form those allergies take and how severe their allergies are. What do you suppose makes different people allergic to different things? How might you explain differing reactions to allergens?

10. What other issues does this case raise for you?

AN UNWELCOME REACTION

REPLAY ACTIVITIES

1. Do some investigative work to improve your knowledge of allergic response and anaphylactic shock. What do you see as common to these events? Prepare a pamphlet for use by community health unit in your area which will provide the citizens of your community with concise information about

- -agents which commonly cause allergies
- -how allergies are caused
- -symptoms of allergies
- -treatment of mild to severe allergies

Present your pamphlet to the health unit and to the class in a presentation. Invite someone from the health unit to your presentation.

2. Use as many sources as possible to find out about cases of unusually extreme anaphylactic shock. If possible, interview someone with extreme allergies and find out how the allergies have affected their lives. Present your findings to the class and invite the person you interviewed to be part of the presentation.

3. Prepare a survey of your neighbourhood to determine the types, severity, and incidence of allergies in your community. Include questions on peoples' understanding of the cause and treatment of allergies. Submit your findings to the class, the local health unit and the local newspaper. Invite health officials or newspaper reporters to your presentation.

4. The editor of the local newspaper asks you to write an article about the incident in this case. Determine who you would want to interview and what questions you would want to ask to better inform your readers. Write the article using quotes from your fictitious experts.

5. Investigate the laws and regulations regarding the listing of ingredients in food and the specific problems caused by allergens. Interview someone from the Department of Health in your province or state to discover what steps are taken to protect allergic individuals. Invite them to be part of your presentation to the class.

6. Visit an allergist and spend some time interviewing the allergist about the diagnosis (determination of the agents that cause an individual to respond), treatment (over-the-counter and prescription drugs, therapies etc which alleviate the symptoms) and possible cures (complete removal

of the allergic response) for allergies. Prepare an audio or video tape of your interview and the information that you gathered. Present this to the class. Invite the allergist to your presentation.

7. Design an activity of your own, alone or with a partner or group. Work with your teacher to set the criteria for the production and presentation.

Chapter four presented the cases constructed for the study of human physiology from a synthesis of the goals of the Biology 12 curriculum and the Year 2000 goals. Each case was accompanied by teacher notes, learning outcomes derived from the Biology 12 curriculum guide, study questions and replay activities.

Chapter five will present findings and implications for further research and development.

CHAPTER FIVE

FINDINGS, LIMITATIONS AND IMPLICATIONS

Findings

This study reviewed the historical development of case method teaching and examined the literature for support for case method teaching as a means of meeting the goals of both Biology 12 and the Year 2000 Graduation Program. An analysis of the literature on current thought in science teaching, particularly the teaching of biology, indicated that methodologies which increase student thinking and involvement are necessary to promote student interest, achievement levels and to reduce drop-out rates in the sciences.

Many educators at the high school and university levels identified problems with current practice in science classrooms. According to researchers, too much emphasis is being placed on recall of factual information and too little on critical thinking skills, integration of curriculum, and minds-on engagement of students (Wassermann and Ivany, 1988; Rau, 1991; Schamel and Ayres, 1992). There is a need, according to the Ministry of Education's Assessment of Science Report (1990) for science teaching to move away from

the traditional methodology of lecture/lab to more innovative and student-centered methodologies.

Support for case study from practitioners and researchers suggests that this method may meet the needs of both the science curriculum and of the Ministry of Education's Year 2000 Graduation Program. Evidence was presented that case method teaching improves students' abilities to think critically, cooperatively and independently (Hunt, 1951; Christensen, Garvin and Sweet, 1991). The researchers found that case method teaching increased students' abilities to analyze from data and to interpret and apply knowledge to new situations. These skills, they found, are not as easily achieved through more traditional forms of delivery, such as lecture or textbook readings.

Research suggests that integration of material and subjects in ways which are meaningful and reflective of society is more possible in case method teaching structures that in more traditional classroom situations (Hansen and Gottlieb, 1991; Lipson and Tobias, 1991).

Students are more able to recognize different points of view and respect others' opinions (Christensen and Hansen, 1987; Adam, 1991). In a landmark study of grade 11 Social Studies students, Adam found an increase in students' abilities to listen and respect others and to examine issues from different sides.

One of the major strengths of the case method, according to Christensen at the Harvard Business School, is the increased ability of students to apply general concepts to specific situations. Graduates of a case method program are able to move into action in the face of complex situational problems while training of other types does not prepare students as well (Christensen and Hansen, 1987; Christensen, Garvin and Sweet, 1991). In this way, case method teaching is perceived to connect theory to practise so that experience in the classroom translates more readily to the world beyond.

Tedlock (1981), Adam (1991) and Elmore (1981) all report significant improvement in students' abilities to make informed decisions, ask pertinent questions and communicate clearly after experience with case method teaching.

An exhaustive analysis of the curriculum content of Biology 12 identified numerous big ideas which underlie the learning outcomes for the course. Learning outcomes are listed primarily as behavioural outcomes, couched in terms of what students should be able to do or explain (Ministry of Education, 1990). The big ideas, on the other hand, are derived from the learning outcomes, the goals of the Biology 12 course and the textbook and establish the major concepts or issues which are contained within the course but not explicitly recognized. These big ideas, then, form the framework of case narratives which address student learning

in content as well as conceptual understanding. Synthesizing the big ideas with the goals of the Year 2000 and the data extracted from further literature searches, led to the construction of case narratives and the production of five completely new curriculum packages.

Five cases were researched and produced which simultaneously addressed the needs of the Graduation Program and of the Biology 12 course. These cases synthesized the curriculum goals and Year 2000 goals to meet both the requirements of the curriculum and of the Year 2000 Graduation Program. The cases developed are anticipated to meet the following goals:

1. to develop the ability of students to analyze critically, reason and think independently and acquire basic learning skills and bodies of knowledge

2. to develop in students a lifelong appreciation of learning, a curiosity about the world around them and a capacity for creative thought and expression

3. to develop in students a sense of self-worth and personal initiative

4. to develop a sense of social responsibility, and a tolerance and respect for the ideas and beliefs of others

5. to provide opportunities for students to develop scientific attitudes, and to develop positive attitudes towards science

6. to provide opportunities for students to acquire the skills and understand the processes of science

7. to provide opportunities for students to increase their understanding of the basic concepts and principles of biological science

Limitations

A number of limitations have constrained this study. Firstly, the amount of material developed does not constitute a complete course. More cases would be needed to cover all the content of the current Biology 12 course. The number of cases that would be needed to address the full program is unknown.

Secondly, although the material was introduced to a small group of grade 12 scholarship students, the cases have not been extensively field tested. There are two major reasons for this.

1. There were, at the time of writing, no Biology 12 teachers trained in case method teaching in British Columbia. While the author is trained to teach with cases, she did not have a grade 12 class at the time when the field study could have been carried out.

2. The sheer amount of content knowledge that Biology 12 students are expected to memorize militates against taking time from a course to experiment with a new methodology. Teachers are very reluctant to release their classes for a study when they have to prepare their students for a content-based final exam.

Implications

The development of content-rich cases in bioscience has implications for other areas of the curriculum. The data from the analysis of the literature and of the curriculum and goals of the senior biology course and the Year 2000 suggest that case method teaching and case narratives are viable vehicles for motivating students to examine and learn in other content-rich science courses.

While the cases that were constructed in this thesis were in the field of human physiology, the data support case development in other areas of science. For example, applying methods developed in this thesis, case development

in chemistry, physics, mathematics, technology and other "hard" sciences should be possible.

This thesis developed procedures that allowed for the construction of five cases for Biology 12. The application of this procedure should allow for the development of other cases that could ultimately address all, or most of the senior biology course, and, therefore the construction of a complete course which would be taught with case narratives and through case method teaching.

From the research into and the construction of these cases, questions are raised for further research. For example:

1. Will field testing of the cases support the data in the research?

2. Will the cases and case method teaching lead to the realization of the learning outcomes from the Biology 11 and 12 curriculum guide?

3. Will the cases and case method teaching contribute positively to student interest in biology and the sciences?

4. Will the cases and case method teaching increase students' ability to meet the goals of the Year 2000 Graduation Program?

5. Does the introduction of case method teaching in the Biology 12 course change the type of assessment and evaluation used in the classroom and on the provincial exams?

Concluding Comments

The findings of the study indicate that it is possible to construct curriculum materials that meet both the goals of the Year 2000 and the Biology 12 course and the learning outcomes of Biology 12. The primary finding of this study reveals that synthesis of curriculum content and learning goals is feasible, even in content-rich science areas such as senior biology.

APPENDIX

Coding Sheet

A. Responses that Inhibit Thinking

a. Responses that bring closure:
- Agrees/disagrees with student's idea
- Doesn't give student a chance to think
- Tells student what teacher thinks
- Talks too much/explains it
- Cuts student off
- Other closures

b. Responses that promote fear:
- Heckles/is sarcastic/puts down ideas

B. Responses that Limit Student Thinking
- Looks for single correct answer
- Leads student to "correct" answer
- Tells student what to do
- Gives information

C. Responses that Encourage Thinking

a. Basic responses that encourage re-examination of the idea:
- Saying back the idea to student
- Paraphrasing
- Interpreting
- Asking for more information, e.g. "Tell me a little more about that," or "Help me to understand what you mean."

b. Responses that call for analysis of the idea:
- Give me an example
- What assumptions are being made?
- Why do you suppose this is good?
- What alternatives have you considered?
- How does that compare with this?
- How might that data be classified?
- What data support your idea?

c. Responses that challenge:
- What hypotheses can you suggest?
- How do you interpret that?
- What criteria are you using?
- How would those principles be applied in this situation?
- What predictions can be made based on that data?
- How would you test this theory?
- What new scheme/plan can you envision for that situation?

d. Accepts students idea non-judgmentally:
- I see
- Thank-you

D. Responses unrelated to debriefing the big ideas
- Classroom/behaviour management responses
- Speech mannerisms
- Other

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