THE UNIVERSITY OF MANITOBA

CONTRACT TEACHING
1968 BSCS BLUE VERSION BIOLOGY

by

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CHAPTER I

I INTRODUCTION

In recent years much writing has been done in education on the topics of student responsibility, individualized instruction, programmed learning and continuous progress. These areas of emphasis have come about largely as a result of an awareness of individual differences in the learning abilities of the children. Rather than cater to the average student, the teacher now finds it necessary to direct his teaching techniques towards the needs of the individual by providing the student with the variety of learning experiences that are best suited to his needs.

It has been suggested that one of the ways of meeting the challenge of individualizing instruction is by using the method of contract teaching. The appeal of this method lies in the fact that it allows the teacher to "custom tailor", to a degree, learning experiences for his students. This study has been undertaken to compare the efficacy of the contract method to methods used in the "traditional classroom" situation.

II STATEMENT OF THE PROBLEM

Two groups of students were used in this study.

One group, the experimental group, learned by the contract method. The second group, the control group, learned by the more traditional teacher-centered, teacher oriented approach.

The purpose was to determine if the experimental group receiving one treatment would perform better on a test after the treatment than would the control group.

In an attempt to monitor a number of factors that were difficult to control, a Monitoring Contract Survey was administered twice during the study. The instrument was used to give immediate feedback on students' frequency of performing certain tasks of the contract. An Opinion Questionaire was administered to the students at the end of the study to indicate their attitude toward the contracts. The answers in the questionaire were to give some indications as to how the contracts could be improved in the future. Both instruments were administered to the experimental group only.

III DEFINITION OF TERMS

Control group was the group of students who were taught in a traditional teacher-centered atmosphere.

Traditional teaching method was the method by which the teacher presented material by exposition,

demonstration, questioning, use of chalkboard, film-strips, discussion and giving of assignments. More specifically, the teacher dealt with content using the lecture-discussion method with the aid of chalkboard and/or overhead projections to explain the more difficult concepts of each topic. In presenting filmstrips the teacher read the captions and added explanations where it was deemed desirable. Questions assigned on a section of the work were discussed in class in order to pinpoint areas of difficulty and to apply individual help where required.

Experimental group referred to the group which was placed on contract for the duration of the study.

The term contract in this study was a series of behavioral objectives dealing with a topic in Biology and a series of procedures which the student was to follow in order to satisfy these objectives.

Learning on the part of the student was accomplished by the student actively searching out the material according to the prescribed format with the teacher acting as a resource person and a guide. The actual functions of the teacher in this case varied from providing any technical assistance in setting up the different media to instructional assistance. The

in-school tasks that students were expected to perform included filmstrip viewing, laboratory work, and listening to tapes in the classroom or library; wherever the equipment was available. Reference work and text-book reading were allowed to be done outside the school.

The contracts in this study were designed so that all students could make use of the tapes and filmstrips on the same topic. The idea being that a variety of media could be selected to promote most efficient learning for a particular student.

The contract on Excretion (Appendix B) can be used as one example to illustrate the use of several media alternatives.

IV SIGNIFICANCE OF RESEARCH

Although much of the literature fails to provide us with conclusive evidence as to the effectiveness of contract teaching, Departments of Education, School Boards, administrators and teachers continue to invest much time and money in adopting this system for their area.

This controlled study on the effectiveness of contract teaching in Grade XII Biology was designed to

help give educators more of an insight into evaluating this method of instruction for possible use in their schools.

V THE METHOD OF THE PROPOSED RESEARCH

All the Grade XII students who were taking the Grade XII Blue Version Biology program at Glenlawn Collegiate for the first time took part in this study. Since there were about 50 students (two classes), it was decided that one class work on contracts and the other class be treated as the control group.

A deliberate attempt was made to control the variable factors which could have influenced the research. These were as follows:

(1) Same instructor - Since a teacher plays an important role in the learning process it would be impossible to do any conclusive research by using several teachers in such a study unless each teacher worked with both a control group and an experimental group or unless the population studied was quite large.

(2) Same topic of study - Some topics in Biology seemed to be more easily contracted than others and if one group were given a different topic of study than another group, a new variable would have been introduced.

In this study, Unit VI of the 1968 Blue Version, Molecules to Man was selected. The reasons for choosing this particular unit were: (a) More time was provided for classes to stabilize. Most class transfers, course changes and late comers had been handled. The study covered the period between November 1970 and February 1971. (b) More time was provided to develop a teacher-pupil relationship. Students began the Grade XII course at Unit V, and therefore had covered one unit. (c) Practice was provided by doing a "dry run" contract in chapter 17 to acquaint the students as to what the contracts would be like. (See Appendix A.) It should be noted that the students had had experience in working on contracts with a different instructor the previous year for a period of several months. It is assumed that this previous experience could tend to reduce the halo effect somewhat. (d) Time was available to gather data on students in the study. (e) Materials for laboratory work and visual aids were readily available for this unit at the school in which the experiment was performed.

(3) The same behavioral objectives were operational for both groups.

(4) The same administrative environment was applied to both groups. The same policy as to attendance,

discipline and evaluation was in effect. It would not have been possible to obtain valid results if parts of this experiment were carried on in different schools because it was not known how great an effect a small administrative environmental difference would have made on students. The school was administered as open-campus. That is; students could leave the school premises when they had free time. In this study attendance was expected in the control and experimental groups.

(5) The same testing devices - The Unit Six Multiple Choice Test consisted of forty multiple choice questions. (See Appendix C) The questions were of the following types: (a) recall and reorganization, (b) showing relationships, (c) application type or (d) testing for use of scientific skills. This classification is used in materials published by BSCS.

The study had several limitations because certain variables were not controlled. Some of these were:

1. Neither the instructor nor the students had any control to which group the students would belong. All available students were used as they had been timetabled. Students were not selected at random.

2. The instruments used in collecting data were

not standardized.

3. The same instrument was used in the post-test as in the pre-test.

VI TREATMENT OF THE RESEARCH DATA

Prior to the study, the students' November Biology marks were collected and a Unit Six Multiple Choice Test (pre-test) was administered. These two scores formed the covariates of the statistical analysis. A Unit Six Multiple Choice Test (post-test) given at the end of the study formed the dependent variable in the analysis.

The Monitoring Contract Survey (Appendix D) and the Opinion Questionaire which were given to the experimental groups of students were used to provide some possible explanations for the results of the test data.

VII SUMMARY

This chapter has described the purpose and outline of the study of contract teaching using the 1968 BSCS Blue Version Biology. The definition of terms and references to the literature in this chapter will be expanded in chapter II. Chapter III contains a detailed description of the basic design and implementation of

the study. A statistical analysis of the data collected to accept or reject the null hypothesis will be found in chapter IV. The last chapter contains the conclusion to the study and a description of the results of the survey and questionaire.

CHAPTER II

REVIEW OF THE LITERATURE

I INTRODUCTION

In this chapter a review will be made of some of the literature as it affected the development of the study. Two topics will be researched, the first of which is the individualization of instruction. This section will begin with representative comments made about individualization generally and will move to contemporary attempts made at individualization in science instruction, particularly the area of Biology. The second topic, contracts as vehicles for individualization, will deal with the components of the contracts, namely; (a) the behavioral objectives, (b) the introductory lecture, (c) the reading assignments, (d) the tapes, (e) the filmstrips, (f) the laboratory and (g) the evaluation.

II INDIVIDUALIZATION

There have been three major efforts in trying to refine the meaning of individualized instruction, these range from curriculum remaking to computor programmed instruction and finally to desegration efforts of the

schools in which focus was on the "disadvantaged child".

This study uses the same curriculum, the same instructional materials without segregating the students. Howes[1] makes the point that very little consensus has been reached on the meaning of individualized instruction. In this study, individualization took place to the extent that students were given several sources from which to obtain information. They could choose from those sources what they were going to study and how they were going to study. Two basic premises of the research were that (a) students learn at different rates and (b) there is no one best way for all learners but there are best ways for each learner which may be different from those of others.

Some reasons to individualize were listed by Keuscher[2] in Howes' book on individualization that (a) it is more democratic (b) it teaches critical thinking (c) it teaches self-direction (d) it nurtures creativity (e) it develops one's self-confidence.

[1]Virgil M. Howes, Ed., Individualization of Instruction, A Teaching Strategy, (The MacMillan Company, London, 1970), p. 71.

[2]Ibid., pp. 6-18.

Keuscher wrote of prominent men like Rogers, Fromm, Maslaw and Combs who support the concept of individualization. Combs stated that:

> individualized instruction supports the development of strong people which are necessary in a society that is becoming rapidly more relativistic and ambiguous.[1]

Howes edited a set of three books containing writings on individualization supporting comments of the above nature in the areas of mathematics, science, reading and social studies.

Esbenson quoted Bright, the Associate Commissioner for Research in the United States office of Education, that:

> within another ten years almost the entire academic portion of the instruction will be on an individualized basis in most schools.[2]

The factor which has hindered the movement towards individualization has been that:

> many teachers view themselves as the dispensaries of knowledge and as a person in charge of the educating that goes on in the classroom. They find it very difficult to view their role as one of

[1] Ibid., p. 83.

[2] Thorvald Esbenson, Working with Individualized Instruction: The Duluth Experiment. (Fearon Publishers, Palo Alto, California, 1968), p. IX.

> producing the climate, providing the resources, stimulating students to explore, investigate and seek answers. In a rich pregnant environment the teachers' role becomes one of guiding and facilitating rather than directing.[1]

Literature on individualized instruction is generally related to administrative topics such as flexible schedules, large group - small group instructional practices, multi-track plans, team teaching, continuous progress and similar manipulations of the time schedule or curriculum. These do not in themselves guarantee individualization. Keuscher points out that:

> very little has been done in varying the sequence of content, the objectives or the paths to objectives that students have to follow. The self-concept of the learner, individualized learning style, cultural influences and student responses to various styles of learning have been ignored.[2]

Several attempts have been made at employing the concept of individualization in science instruction. Clayton Public Schools in Clayton, Missouri[3] opened the physics laboratory and physics center to students all

[1]Howes, Op cit, p. 17

[2]Ibid., p. 15

[3]Louis Deall, Development and Implementation of a New Type Program of Secondary School Physics, A Four Year, Independent, Individualized Modular Program, Final Report 1969, (U.S. Department of Health Education and Welfare).

day. The four phases offered in the new physics program ranged from structured to unstructured programmes. The course provided students the option to choose to do the minimum or be enriched by doing levels within the phases. The program allowed for student variation in individual learning style, mathematical aptitude and topical interests.

De Rose[1] reported a study (ISSP - Independent Science Study Program) which based individualized learning on two assumptions, namely; (a) that learning results only from students own effort and (b) that learning how to learn is a primary ingredient for an education. In De Rose's study, the students were picked by the teachers where the emphasis was on attitude and work habits rather than on high marks. Listing major topics, chapter and sections in the text with questions to be answered did not produce desired results so behavioral objectives were produced and test items based on the behavioral objectives were given. Students who were selected for the ISSP scored considerably higher than those of two control groups.

[1]James V. De Rose, "The Independent Study Science Program at Marple Newton High School". The Science Teacher, May 1968, Vol. 35, No. 5, pp. 48-49.

Since the students were picked for the experiment, no conclusions were made about the value of the methodology per se. However, it was noted that students in the experiment did develop some of their own procedures and solutions in solving problems. They learned to come to grips with the problem, that is; they learned how to learn.

The literature contained a number of studies done on individualization using specific use of BSCS materials. These approaches using the different BSCS versions shows somewhat the type of individualization attempted in this study. Richard did research with the Grade X students using BSCS Green Version Materials. In phase three of his experiment, which was a refinement of phase one and two he reported that:

> during phase three I was teaching one class traditional BSCS Biology and guiding the second class in individualization. I was positive that my students were learning more under my traditional methods, since I was explaining terms and concepts more clearly during the class discussions and doing all those fine things which one does as he helps and leads an inquiry class. When the achievement tests (BSCS Achievement Test) revealed a slightly higher means score for the individualized class I was taken aback.[1]

[1]Paul W. Richard, "Experimental Individualized BSCS Biology", The Science Teacher, FEbruary 1969, Vol. 36, No. 2, pp. 53-70

Richard's individualization consisted of a syllabus of two sections. The first one required activities which included text reading, text guide questions, problems, films and laboratory activities. Students were allowed to do these in their own sequence and at their own rate within a certain allotted time. The second one, enrichment activities, were optional and included laboratory exercises and audio activities, invitations to enquiry, BSCS pamphlets and others. Students could also design their own enrichment program provided their topic was related to the topic being studied.

In his experiment, Richard cited three tentative findings. They were tentative because he had only two classes of thirty students each on which to make his observations. (1) Biology could be individualized in a purposeful manner. (2) Biology achievement was not reduced by individualization. (3) Individualized biology benefitted the learners in several ways not measured by the achievement tests. These included a greater enjoyment, better laboratory techniques and development of greater self-direction.

In Manitoba, Keating[1] conducted an experiment based on the BSCS Yellow Version. His two classes were "very similar in almost every way". One class acted as a control group in which lecturing was the basic method of instruction while the other was given a contract. His research consisted of (a) Behavioral Objectives and (b) Procedures and Resources. The Procedures and Resources instructed students to:

1. Listen to a tape on heredity.
2. Read chapter 30 in the text.
3. Study the filmstrip on heredity.
4. Read from four listed references.
5. Complete work sheets containing genetic problems.

An exam containing fifteen multiple-choice questions on genetics was administered to both classes. Keating's conclusion was that there is no significant difference obtained when using the lecture method or the programmed (contracted) method.

Fulton[2] used an individualized approach with students at the eighth grade level using the BSCS Blue

[1]Neil Keating, "Programmed Instruction Assignment No. 4", Unpublished assignment for Prof. Hoare, University of Manitoba, April 1971.

[2]H.F. Fulton, "Individualized vs Group Teaching of BSCS Biology". American Biology Teacher, May 1971, Vol. 33, No. 5, pp. 277-291.

Version materials. His sample consisted of twenty students in 1967-68 taught by group instruction and twenty students in 1968-69 taught by an individualized approach. The 1968-69 students progressed at individual rates by verbal agreements made between the student and teacher. The analysis of covariance results revealed greater gains by the class working individually than by the class getting group instruction as measured by the BSCS Comprehensive Final Examination.

Oak Grove High School science department individualized instruction in their science courses. Eastman reported that in BSCS Blue Version Biology learning packets were developed following the format of I.D.E.A.'s Unipac. Each packet consisted of the following pages:

> Page 1: Cover. This is an attention-getter. It is illustrated and contains a statement about the concepts covered in the packet.
>
> Page 2: Essential objectives. All the specific behavioral objectives are listed here under two or three concepts. The activities and the references in aid of them are listed alongside each objective.
>
> Page 3: Essential investigations. Since the investigations do not always cover any one specific objective, we list these separately. They are considered essential to the concepts of the packet and thus should be recognized as an essential part.
>
> Page 4: Quest. The essential objectives and investigations are minimum requirements that all biology students must meet. Throughout the biology curriculum there are other investigations

> and ideas that carry the students above the minimum requirements. These are called "quests". The students are told to complete these at their own discretion, in addition to the essential requirements.
>
> A post-test accompanying each packet is written directly from the behavioral objectives.[1]

Although it was too early to do a formal evaluation on their program, both students and instructors reacted very positively because greater individualization "humanized" their program.

III CONTRACTS

Different vehicles have been developed in an attempt to individualize instruction. These include programmed instruction,[2] audiotutorials[3] and grade contracts.[4,5,6] In grade contracts students commit

[1]S.W. Eastman, "Biology In An Individualized School", American Biology Teacher, December 1970, Vol. 32, No. 9, pp. 533-536.

[2]P.C. Lange, Programmed Instruction: Sixty-sixth Yearbook, National Society for the Study of Education, Part II, (University of Chicago Press, 1967).

[3]S.N. Postlethwait, et al, The Audio-Tutorial Approach to Learning, Second Edition, (Burgess Publishing Company, Minneapolis, Minn.) 1969

[4]William D. Romey, Inquiry Techniques for Teaching Science, (Prentice-Hall, Inc., Englewood Cliffs, New Jersey, 1968), pp. 77-86.

[5]S. Amsden, "Have You Ever Tried Contracting For Grades?" English Journal, Vol. 59, No. 9, December 1970, pp. 1279-82.

[6]Jack R. Frymier, The Nature of Educational Method, (Charles E. Merrill Books, Inc., Columbus, Ohio, 1965), p. 262.

themselves to completing a certain number of tasks for a certain grade. Contracts used in this study were based on the models developed in Grand Forks, North Dakota.[1,2]

In-service sessions provided by the Faculty of Education and personnel from Grand Forks culminated in the type of contracts used in this study. Although the research described by De Rose, Richard, Keating, Fulton and Eastman did not mention "contract" it did contain common aspects with contracts as we have defined them.

The contracts used in our study fit Jenkin's and Russell's[3] sphere of individualized instruction which include five kinds of student involvement considered for individualized instruction. These are as follows: (1) tangibles, (2) audio input, (3) human interaction, (4) visuals, (5) printed materials. These are necessary because:

> Students differ in their responsiveness to different media. Some learn best through reading; others learn more from pictures and

[1]J.H. Schieffer, "A Proposed New Instructional Program", (Educational Service Center, Grand Forks, North Dakota, July 1968), Unpublished proposal.

[2]Harold Bergquist, "A Basic Operational Learning System", Educational Technology, Vol. XI, No. 11, November 1971, pp. 29-30.

[3]J.R. Jenkins and J.D. Russell, "Involving Students in Individualized Instruction", American Biology Teacher, Vol. 33, No. 8, November 1971, pp. 489-492.

> films; and still others must hear in order to understand. Some students need to get their hands on the object being studied. Most benefit from human interaction and its associated reinforcement. A multisensory unit on flowers would allow the student to read about flowers, to hear about flowers via audio tape, to see them, to handle them, and to smell them. Individualized instruction should provide an opportunity for the subject matter to be covered--perhaps a better term would be "uncovered"--in a variety of ways and allow each student to select the medium through which he is reached most directly and effectively. In fact, a combination of media might be the best "mix" for most students.[1]

(a) Behavioral Objectives

In our study behavioral objectives formed the first part of the contract. Glasser claimed that:

> Knowledge of objectives by the student gives him a goal to attain; such knowledge is instructive and motivating. It permits the student to monitor his partial successes and failures and to adjust and organize learning resources for himself.[2]

According to Kutrz,[3] Glasser[4] and Sharpe[5] behavioral objectives seem to be the heart of any individualized program. Atkin stated that:

[1] Ibid., p. 491.

[2] H.W. Anderson, Ed., Readings in Science Education for the Secondary School, (The MacMillan Company, New York, 1969), p. 147.

[3] Ibid., pp. 142-142

[4] Ibid., pp. 145-149.

[5] Ibid., pp. 152-153.

> The behavioral objective people are now near the center of curriculum decision making--in fact, delineating instructional objectives in terms of identifiable student behaviors or performances seems essential in 1968 for assessing the output of the educational system. Currently accepted wisdom does not seem to admit an alternative.[1]

The effect of behavioral objectives has been researched to a limited extent. McNeil[2] cited three experiments (using student teachers as subjects) designed to collect evidence as to whether or not supervision by objectives produced better student-teacher and better student achievement. The data indicated that the assessment of teachers by their supervisors was more favorable when the supervisor and student-teacher agreed to assess certain specific behaviors of the teacher. Pupils taught by teachers working with behavioral objectives achieved more than those taught by teachers in a control group.

Little evidence exists about whether instructional objectives in behavioral terms pays off in better lessons

[1]M.J. Atkin, "Behavioral Objectives in Curriculum Design: A Cautionary Note". The Science Teacher, Vol. 35, No. 5, May 1968, p. 27.

[2]Richard C. Anderson, et al., Ed., Current Research on Instruction, (Prentice-Hall, Inc., Englewood Cliffs, New Jersey, 1969), pp. 47-53.

but what there is seemed to suggest the affirmative.[1]

Behavioral objectives for each of the chapters were developed following the techniques presented by Mager[2], Romey[3] and Esbenson (see Appendix H). Adaptations of behavioral objectives for biology were made from Barnum[4] and Alkin[5].

Montague and Butts[6] described behavioral objectives as doing three things: (1) They should state the action or behavior desired. (2) They should be a description of the situation in which the behavior is to be observed. (3) They should state the extent to which the student should exhibit the behavior.

[1]Ibid., p. 44.

[2]Robert F. Mager, Preparing Instructional Objectives, (Fearon Publishers, Inc., Palo Alto, Calif., 1962).

[3]Romey, Op. Cit., pp. 77-86.

[4]Marvin R. Barnum, et al, Audio-Tutorial Introductory Biology: Principles, (Glencoe Press, A Division of the MacMillan Company, Beverly Hills, 1969).

[5]Marvin C. Alkin, Instructional Objectives Exchange: Biology 10-12, (UCLA Graduate School of Education, Los Angeles, California, 1970).

[6]Earl J. Montague and David P. Butts, "Behavioral Objectives", The Science Teacher, Vol. 35, No. 3, March 1968, p. 34.

In this study the behavior desired was stated very simply. "Upon the completion of this contract you will be able to answer questions relating to:
1. - - - - - - 2. - - - - - 3. - - - - etc."

(b) Lecture

The large group introductory lecture was intended to familiarize students with the contract and thus give an overview of the content which was to be covered. Studies in familiarization indicated that if the familiarization points out the important features to be learned and it is done immediately prior to the task there is positive value in it.[1]

This period also gave students opportunity to ask questions about the contracts.

(c) Reading Assignments

Each of the contracts contained additional reading material. Several of the texts were College level and others could be used in Junior High School. A multi-reference approach to teaching biology was found to produce greater gains in understanding.[2]

[1]N.L. Gage, Ed., Handbook of Research on Teaching, Rand McNally & Company, Chicago, 1963, p. 642.

[2]Gregor A. Ramsay and Robert W. Howe, "An Analysis of Research on Instructional Procedures in Secondary School Science Part 1 - Outcomes of Instruction", The Science Teacher, Vol. 36, No. 3, March 1969, p. 63.

Students could choose the references they thought would best meet their needs. Students were expected to answer certain questions from their text or on a question sheet.

(d) Tapes

Each of the chapters had an audio tape for students to use. (See Appendix F)

Postlethwait feels that:

> audio should not be a "lecture on tape"; rather, it should be a medium that allows the teacher to tutor an individual student. The student can control the pace of his instruction.[1]

Although Audio instruction has been used fairly extensively in the study of a foreign language no controlled research was available.[2]

(e) Filmstrips

Filmstrips with captions explaining the diagrams or charts were provided in each contract. A student in the experimental group was able to study the frames at his own rate. Students who had difficulty reading some of the references were able to spend more time studying a pictorial presentation.

(f) Laboratory

Laboratory work is an integral part of most

[1]Jenkins, op. cit., p. 491.

[2]Gage, op. cit., p. 607.

modern biology programs. The laboratory approach has been considered important because it emphasizes direct experience with the materials pertinent to the study. Recent research at the college level has yielded contradictory results.[1] Gennaro used a "laboratory block" approach supplemented with assigned readings and found no significant difference to the "traditional" approach using BSCS Yellow Version materials.[2,3] Each laboratory block deals with a specific biological subject through a series of sequencial laboratory investigations. A six-week "block" of time is recommended for each of the blocks.

(g) Evaluation

Testing provides the student and teacher with an index of progress. Tests have been used as motivating devices.

> Students are conditioned to recognize that examinations constitute their "reward", in this case a grade, for classroom performance. Despite the fact that the teacher may feel strongly that the processes of science, the inquiry approach,

[1] Ibid., p. 483.

[2] Ramsey, op. cit., p. 63.

[3] Ibid., p. 1041-2.

> the laboratory orientation, the open-endedness and the other values contained in the curriculum are of great importance, and despite the fact that he may emphasize these in his classroom behavior, nonetheless, if the examinations given ask for lists of order of insects, names of the bones of the wrist, or simple recall of similar facts the students soon learn to pay little attention to what is said and concentrate instead upon what the examinations emphasize.[1]

For this reason end of chapter tests and Unit Six Multiple Choice Test contained questions of different cognitive levels as described in chapter three.

IV DISCUSSION

The research has tended to isolate one pair of items at a time. For example; lecture vs discussion or laboratory-centered versus lecture demonstration-centered instruction. That type of research is not really that relevant because some of the aspects in the experimental group were also operative in the control group albeit not necessarily to the same degree. Controlled research providing a similar mix of mode and media as in the contract of this study was not available.

[1]Biological Sciences Curriculum Study, Test Booklet for High School Biology, (The Regents of the University of Colorado, Boulder, Colorado, 1966) Preface - i.

V SUMMARY

Although the research into the literature did not yield any simple definition of individualization, many have tried to individualize in various ways. A study of individualization has led to the realization that one needs to realize one is dealing with the whole person and his total set of learning styles. The literature emphasized the importance of individualization in today's world.

Research that has been done has shown that the gains made by students, as measured by various types of achievement tests, are equal to or greater than those not receiving individualized instruction. The researchers often stated that gains were made in behavior changes not measured by achievement tests.

A multiplicity of ways to individualize was evident in the literature but the contract, as defined in chapter one and included in the Appendix, contained the main basic required ingredients for individualization generally.

CHAPTER III

RESEARCH PROCEDURES

I BASIC DESIGN

The study was designed to compare two methods of instruction at the Grade XII Biology level. The experimental group was given instruction by means of contracts. The control group was instructed in a more traditional manner. A description of the treatment given to both groups is given more attention later in this chapter. The purpose of this study was to determine whether students learn as well using contracts as those taught in a "regular" classroom situation, based on the results of Unit Six Multiple Choice Test.

II THE SETTING

For this study Unit Six "Multicellular Organisms: Energy Utilization" from Biological Science: Molecules to Man, Revised Edition[1] was used. The study covered four topics; "Transport Systems" Chapter eighteen,

[1]Claude A. Welch, et al, Biological Science: Molecules to Man, Revised Edition, Blue Version Biological Sciences Curriculum Study, Houghton Mifflin Company, Boston 1968, pp. 464-553.

"Respiratory Systems" Chapter nineteen, "Digestive Systems" Chapter twenty and "Excretory Systems" Chapter twenty-one. These chapters represented eight weeks of study in the Grade XII Biology program.

All the Grade XII students who were enrolled for the first time in the Grade XII Biology course were involved. The experimental group consisted of twenty-six students of which thirteen were female and thirteen were male. The control group consisted of sixteen students of which eleven were female and five were male. Due to the other course options the students were involved in it was not possible to have both groups of equal size.

III THE FACILITIES

The classroom - laboratory setting was a single room containing cupboards, a demonstration table with a sink and eighteen student tables with electrical outlets, an over-head projector and screen, one tape recorder, one filmstrip projector, one filmstrip viewer and all the necessary laboratory equipment required to do the assigned investigations of Unit Six of the BSCS Blue Version Second Edition. The room thus equipped could accomodate thirty-six students. All the filmstrips and

tapes that were available came from the library for classroom use.

IV CONTRACT "DRY RUN"

Just prior to the research study the experimental group was given a contract to use as a "dry run". (Appendix A) This was to familiarize the students with the different components of a contract which they were going to use in subsequent chapters. Students were shown how to handle the audio and video equipment. The "dry run" contract also gave students the chance to get used to working more on their own.

V IMPLEMENTATION OF THE STUDY

The Unit Six Multiple Choice Test (Appendix C) was administered as a pre-test at the beginning of the study to the control group and experimental group.

The Unit Six Multiple Choice Test was a teacher made test. It constituted forty multiple choice items. Ten items were prepared on each of the four topics to be covered in the study. The test items were developed to test four kinds of outcomes that are relevant to BSCS Biology. These outcomes are described in the

Biology Teachers' Handbook Second Edition.[1]

(1) The ability to recall information and to make minor reorganizations of materials learned.

(2) Ability to show relations between different bodies of knowledge learned at different times or in connection with different topics.

(3) Understanding of materials learned as demonstrated by ability to apply knowledge in new situation.

(4) Ability to use cognitive skills involved in an understanding of scientific problems.

Unit Six Multiple Choice Test, being teacher made, did not have any reliability or validity scores. The items were chosen or adapted from basically two sources. The Test Booklet For Molecules To Man[2] was produced by the Biological Sciences Curriculum Study (BSCS) to provide a source of questions consistent with BSCS philosophy. Items from all four cognitive levels were incorporated into the Unit Six Multiple Choice Test. Another valuable source of test items was Dressel's and Nelson's Questions and Problems in Science, Test Item

[1]Evelyn Klinckmann, Supervisor, Biology Teachers' Handbook, Second Edition, (John Wiley and Sons, Inc., New York, 1970), pp. 407-408.

[2]Biological Sciences Curriculum Study, Test Booklet for Molecules to Man, (Biological Sciences Curriculum Study, Boulder, Colorado, 1966), pp. 21-1 to 24-3.

Folio Number 1[1] in which the items are all keyed to Bloom's Taxonomy of Instructional objectives.

VI TREATMENT OF CONTROL GROUP

The control group was treated in a somewhat traditional sense as shown by the patterns of behavior exhibited by the teacher. The teacher taught mainly by lecture and overhead projections of examples and illustrations were used extensively. Logical development of the lecture was maintained by writing the main points of the lecture on the chalkboard. Questions were directed to the students throughout the lesson. Normally, the first thirty minutes of the periods were used for the presentation of the new content material while the remaining twenty minutes of the time was left to do related assignments. Specifically the assignments consisted of doing some reading and/or answering several questions from the text or from a work sheet which were then taken up the following day.

Prior to a laboratory investigation the teacher presented a pre-lab in which suggestions to overcome possible points of difficulty were discussed. The

[1]Paul L. Dressel and C.H. Nelson, Questions and Problems in Science, Test Item Folio Number 1, (Cooperative Test Division, Educational Testing Service, Princeton, New Jersey, 1956), pp. 65-146.

students were assigned to work in small groups.

When visual materials such as films and filmstrips were used the teacher again assumed the dominant role in selection and discussion.

The treatment of the control group was "traditional" in the sense that it was teacher oriented, teacher controlled and teacher paced to a large degree.

Tests were administered to the control group at the end of each chapter. They contained a mixture of matching, multiple choice and long answer questions. These tests were administered to the experimental group on the same days as the control group. The times when tests were administered to both groups was determined by the speed at which the teacher was able to teach the material to the control group. The tests appear in Appendix B.

VII TREATMENT OF EXPERIMENTAL GROUP

Due to the similarity in the contracts the procedure for each chapter was basically the same. Students were given their contract on the first day at which time the behavioral objectives were read and the student procedures explained. This was referred to as the introductory lecture in the student procedures.

Tuesdays and Thursdays were usually set aside for performing the laboratory investigations. This cleared the laboratory to be used for reading, filmstrip viewing and listening to tapes on Mondays, Wednesdays and Fridays.

During the course of their work the experimental group encountered two basic tasks; the laboratory experiment and the work with resource materials. The students were provided with equipment and were allowed to work in groups of two in the laboratory sessions. The role of the teacher was that of a resource person who could guide students to the solution of their problems if the student so requested. Students were allowed to leave the laboratory whenever they had enough information to complete the assignment indicated in the contract.

The students used the classroom as a resource centre on alternate days. References were kept in the library on a separate shelf so that access to these could be gained at any time the students were free. The tapes and filmstrips were studied in the classroom where the teacher was available to discuss pertinent problems.

Contract Monitoring Surveys were given to the students of the experimental group at the end of

chapter nineteen and twenty. (See Appendix D) The purpose of these surveys was to obtain immediate feedback from the students on the extent to which they were following the procedures set out for them in the contracts. A brief discussion relating to the surveys is given in chapter four. The same chapter tests were administered at the end of each chapter as indicated previously.

VIII COMPLETION OF STUDY

Upon completion of Unit Six both groups were administered the Unit Six Multiple Choice Test as a post-test in the same manner as when given as a pre-test described earlier in this chapter. (Appendix C)

An Opinion Questionaire (Appendix E) was administered to the experimental group at the end of the study. The students were asked to respond to the questions and include their comments which will be discussed in chapter four.

IX SUMMARY

Students of the experimental group and control group were administered the Unit Six Multiple Choice test as a pre-test and as a post-test. The Grade XII

November Biology mark of both groups was also available.

The Monitoring Contract Survey and the Opinion Questionaire were administered to the experimental group only.

CHAPTER IV

DATA ANALYSIS

I DESCRIPTION OF DATA COLLECTED

The collected data consisted of three different scores: (a) November Biology mark, (b) pre-test and (c) post-test marks. The November Biology mark was an average of three chapter tests and a unit test given between September and mid-October. Each of the four tests consisted of forty points. They were made up of thirty multiple choice questions, each worth one point and two long answer questions, the addition of which was worth ten points. The November Biology mark was assumed to be indicative of a general capacity of the students. The pre-test and post-test were the Unit Six Multiple Choice Test administered just prior to the study and immediately after the study respectively.

II TREATMENT OF DATA

An experimental design must ensure that the observed results may be attributed to the treatment variable and no other circumstances. In chapter one some of the controls and limitations of the experimental design were given. The analysis of covariance was the

statistical method used to adjust for the effects of uncontrolled variables. As Ferguson states:

> A statistical, rather than an experimental method may be used to "control" or "adjust for" the effects of one or more uncontrolled variables, and permit, thereby, a valid evaluation of the outcome of the experiment. The analysis of variance is such a method.[1]

The uncontrolled variables having been accounted for, the null hypothesis was tested. The null hypothesis: - for students learn equally well using contracts (referred to as the experimental group) - as those taught in a "regular" classroom situation (referred to as the control group) - as measured by the Unit Six Multiple Choice Test. This resulted in a two group problem with the post-test as the dependent variable, the pre-test and November Biology mark were the two covariates. Three types of statistical computations resulted. (a) Correlation Matrix (b) Regression Analysis and (c) Analysis of Covariance. Raw scores for the three test results appear in Appendix G.

[1]George A. Ferguson, Statistical Analysis in Psychology and Education, Second Edition, (McGraw-Hill Book Company, New York, 1966, p. 326.

(a) Correlations

TABLE 4 - 1

Correlation Matrix

	Post Test	Pre Test	November Biology Mark
Post test	1.00		
Pre test	.42	1.00	
November Biology	.44	.31	1.00

The correlation between the pre-test and post-test was .42 and between the November Biology mark and the post-test the correlation was .44. With numbers of this magnitude it could be assumed that the pre-test and November Biology marks were high predictions of post-test results.

(b) Regression Analysis with two covariates

TABLE 4 - 2

Step-wise Regression to Analyze the Contribution of each independent variable.

Adding	d.f.	F.	P	Per cent
Pre-test	1	8.20	.0068	17.38
Biology mark	1	5.82	.0208	10.98

Table 4 - 2 indicated that the Pre-test scores accounted for 17.38 per cent of any variance that may

have occurred in the Post-test and similarily that the Biology mark accounted for 10.98 per cent of any variance in the Post-test scores.

(c) Analysis of Covariance

TABLE 4 - 3

Univariate Analysis of Variance

d.f.	MS.	F.	P
1	9.5908	.6241	.4345

The probability for the difference between the experimental group and the control group was .4345. Such a high probability resulted in the acceptance of the hypothesis that students learn equally well using contracts as those in a regular classroom.

TABLE 4 - 4

MONITORING CONTRACT SURVEY RESULTS*

	Performed more than once		Performed once		Did Not Perform	
	Ch. 19	Ch. 20	Ch. 19	Ch. 20	Ch. 19	Ch. 20
1. Attended introductory lecture	-	-	19	21	4	4
2. Read chapter in text	11	11	12	13	-	1
3. Did assigned questions	-	-	11	11	12	14
4. Read references	5**	4**	7	12	11	9
5. Listened to tapes	2	3	7	8	14	14
6. Viewed filmstrips	1	1	15	14	7	10
7. Performed laboratory exercises	-	-	11	12	12	13

* See Appendix D for Survey.
** Read more than one reference book.

III MONITORING CONTRACT SURVEY (See Appendix D)

Students responded to the survey immediately after completion of the contract for chapter nineteen and again after chapter twenty. The frequency of responses for each of the items are shown in Table 4 - 4. Twenty-three out of thirty-two students responded to the survey after chapter nineteen and twenty-five students responded after chapter twenty. The survey was given on one set day so that not all the students were present. Illness and more pressing assignments in other subjects were reasons given for being absent.

Several observations were made on the basis of the results. (1) When a greater emphasis was placed on reference work (see chapter 19 and 20 contract, Appendix B) more students read references. That is; twelve read references in chapter nineteen as compared to sixteen in chapter twenty. (2) Students generally did work in the same pattern on the two chapters. That is; the individual responses showed that the same group of students would listen to tapes in chapter nineteen as in chapter twenty as an example.

IV OPINION QUESTIONAIRE

At the end of the study twenty-seven students

out of a possible thirty-two responded to an Opinion Questionaire. (See Appendix E) The results of their responses are summarized in the following tables.

OPINION QUESTIONAIRE RESULTS

	Positively	Negatively
1. How students felt about contracts before study. (After practice contract.)	14	13
2. How students felt about contracts after study.	19	8

The raw scores indicated that five of the students who responded negatively to the first question responded positively to the second question. There were no students responding positively to question number one and negatively to question two.

In question three students were asked to indicate the value of each of the following items was to them.

3. Indication of the value to the student of the following parts of the contract.

	V.G.	G.	F.	P.	Not Worthwhile*
(a) Behavioral objectives	12	8	3	-	4
(b) Tapes	9	10	1	-	7
(c) Filmstrips	5	9	5	4	4
(d) References	8	9	5	-	5
(e) Laboratory	4	8	1	4	10

*Not worthwhile was indicated in the questionaire as "did not use or not worthwhile".

	V.G.	G.	F.	P.	Not Worthwhile
(f) Text assignment	4	11	2	3	7

(g) Testing -
(1) timing - no complaints
(2) types of questions - there should be long answer as well as short answer questions on tests.

Students found some aspects of the contract more valuable than others. For example, twenty students indicated that the behavioral objectives were good and very good, three thought they were fair and four students either did not pay any attention to them or found them of no help. On the other hand, twelve students indicated that the laboratory work was good or very good but fourteen indicated that the laboratory work was poor or of no value. The Monitoring Contract Survey results show that in chapter nineteen, twelve students did not do the laboratory work required and in chapter twenty, thirteen students did not perform the laboratory exercises assigned. Some students indicated that they used the behavioral objectives as their basic outline for study. Others used the behavioral objectives for review purposes. Students were evaluated in this study on their performance using multiple choice tests. This probably contributed to concentrating on

activities which would give the highest results. Performance in the laboratory was not perceived to provide those returns.

Item 3 (g) referred to the timing of tests to which the students did not have any major comments except that it would have motivated some of them to work faster if they could have written the tests as soon as they were finished the contract. Students reacted positively to the chapter tests in that they contained both short answer objective test items as well as long answer subjective test items.

Question four on the Opinion Survey was open-ended. It read as follows: "Give any comments, particularly how contracts may be improved." Fourteen students provided comments which are quoted in Appendix E. The comments about improving contracts can be summarized by the following statements:

(1) Students would have preferred more large group instructional time. For some this time should be made mandatory.

(2) Students prefer to work from their textbooks although many felt the references were of value.

(3) Some students felt uncomfortable with the

amount of freedom they had. Of these, some developed self-discipline, others continued to have lack of direction.

(4) Some students would have been motivated to work faster in Biology if they could have written the chapter tests when they were ready rather than on a teacher-assigned date.

(5) Students were unable at times to obtain the books, filmstrips and tapes when they wanted them.

CHAPTER V

I SUMMARY

The purpose of this study was to determine whether or not two groups of biology students who were exposed to two different treatments in a common unit of study would perform equally well on a common test. A control group was compared to an experimental group. The students in the experimental group were placed on contracts for the duration of one unit of study.

Research into the literature indicated that individualization of instruction was an important emerging concept although this meant different things to different people.

The vehicle for individualization used in this study was the use of contracts. The types of contracts used in this study consisted of a statement of behavioral objectives, a set procedure and a means of evaluation. The components of the procedures included filmstrips, lectures, audio-tapes, reference readings, laboratory investigations and assignments. The literature relevant to the components of the procedures in the contract (lecture, assignments, tapes, filmstrips, laboratory) did not yield any conclusive results.

Detailed accounts were given in chapter three as to the treatment of the control and experimental groups. The environment in which the students worked and a description of the Unit Test was presented in chapter three. The difference between the treatment of the control group and the experimental group could be summarized as that of independence. Students in the experimental group worked through certain procedures, as indicated in the contracts, more independently than the students in the control group. The statistical treatment of the collected data was given in chapter four. The predictability of the November Biology mark and the pre-test on the post-test was considered fairly high. Regression analysis indicated that the pre-test scores and the Biology mark would account for nearly forty per cent variance on the post-test scores. The analysis of covariance indicated no significant difference in the two groups on the post-test scores.

The Monitoring Contract Survey indicated that, on the two chapters surveyed, students tended to perform generally in the same manner. The Opinion Questionaire results indicated that certain parts of the procedures in the contract were not perceived to be as valuable as others.

II CONCLUSION

The statistical treatment of the data showed that there were no significant differences between the gains of the two groups. That is; the null hypothesis expressed in chapter one, that students learn equally well using contracts as those taught in a "regular" classroom situation was accepted.

III DISCUSSION

The reason there was no significant difference may have been partly due to the reliability and/or validity of the tests used. There was no monitoring system developed to determine the total time students of both groups spent in the study of Biology. That is; students on contracts may have spent less total time involved in Biology than those who came to class each day. Several of the comments in the Opinion Questionaire tend to support this view. It could be stated that students who are placed on a contract system do not score more poorly than those who come to class regularly.

More students "liked" using contracts after they had done the unit than before they did the unit. Those students in the experimental group who scored poorly

tended to accept the blame for leaving the work to the last minute. The reasons why more students liked the contracts was probably due in part to the freedom they obtained in use of time, the variety that the contracts provided and the help that was available if and when they needed it. A different response may have resulted if the students were on contract in all subjects for the whole year.

Students generally worked on the procedure items of the contract which they felt would yield them greatest gains or tests. For example nearly all the students read the chapter assigned once, nearly half of them read the chapter more than once as illustrated by Table 4 - 4. Also it should be noted that only half of the students performed the laboratory investigations. This indicates the students' perception of the relationship of the work to be done to the type of evaluation they will face.

Students kept to the same pattern from chapter to chapter unless a deliberate attempt was made to change their pattern. For example, more emphasis was placed on reference work in chapter twenty (see Appendix B) than in chapter nineteen. It may be possible to conclude that students have been taught to

go to one source for information. (A sad commentary on teaching). Yet it is possible to change student behavior towards using several resources.

IV RECOMMENDATIONS FOR IMPROVEMENT OF CONTRACTS

During the course of the study several improvements in developing further contracts could be made. It would be more helpful to the student if there were more behavioral objectives stated specifically. This could lead to tests which are more closely tied in with the specific behavioral objectives. About half of the students of the experimental group did not perform the laboratory investigations. (See Table 4 - 4) There There will need to be more behavioral objectives developed relating to the investigations as well as an evaluation based on those behavioral objectives. Possibly different investigations which have a higher interest factor should be developed.

Students who completed their work on the contract had to wait until the set date of the test. Several students commented that they would have preferred to write the tests when they were ready instead of having to wait. It would seem reasonable to allow the students to write the tests when they are ready so that they can

move through the whole course at their own rate.

The contracts could further be improved by providing for enrichment on the topic studied. This enrichment could take several forms such as; field trips, investigations into a problem by interviews or questionaires, essays, and filming.

V RECOMMENDATIONS FOR FURTHER STUDY

One unit of work may provide variety within a course which may affect test scores differently than if the treatment was given for a whole year. Several teachers using a contract system similar to the one outlined in this study for the duration of a whole year would provide more substantial information on the effectiveness of contracts.

Use of standardized tests as pre-test and post-tests with high validity and reliability scores would be recommended in any further research. In this study students' Biology marks were used as one of the covariates. Standardized Achievement test scores would be a helpful covariate to include.

It would also be of great value to develop a system of monitoring the total time used in studying. The conclusion of this study did not reflect in any way

which group spent more time in studying. That is, although the students on contract scored equally well as those in class, they may have done so with less time spent preparing for the tests.

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APPENDICES

APPENDIX A

ORIGIN OF NEW SPECIES CHAPTER XVII

A. Behavioral objectives - upon completion of this contract you will be able to:

1. give reasons why Drosophila are used extensively for genetic studies.
2. list and explain 3 ways by which mutation rates may be increased.
3. define, using the Watson-Crick model, what a mutation is.
4. state assumptions upon which the Hardy-Wienberg principle is based.
5. state 3 factors which invalidate these assumptions.
6. state the meaning of p and q in $p + q = 1$ and $p^2 + 2pq + q^2 = 1$.
7. work out problems using the above equations.
8. state at what stage of evolution two gene pools are considered to belong to separate species.
9. list the factors that operate to isolate a population and explain how each of the factors do isolate the population.

ORIGIN OF NEW SPECIES CHAPTER XVII

B. Student procedures - to be able to complete the behavioral objectives of this contract you should do the following activities:

1. attend introductory lecture which will explain how the contracts will function.
2. read charter 17 of the text and answer the following questions on page 460- number's 1, 2, 4, 7, 9, 10, 12, 13, 15, 16, 20, 21, 22, 26, 28.
3. listen to the tape on Genetics. (Explanation of how tape recorder works.)
4. do experiment 17-6. Substitute 2 coins for beans and boxes and modify table 17-1 on page 441 replacing W with H and R with T - Tuesday answer the six discussion questions pertaining to the laboratory exercise.
5. do lab 17-10 in groups of four, appoint one member to be the recorder to answer the six discussion questions on page 449. - Thursday.
6. come to class Tuesday to take up questions which should be helpful for test purposes.
7. Write test on Wednesday and score over 70%.

APPENDIX B

CONTRACT CHAPTER XVIII

TRANSPORT SYSTEMS BLUE VERSION 1968

A. Behavioral objectives - upon completion of this contract you will be able to answer questions relating to:

1. tissues involved in transporting food, minerals, and water in plants.
2. the forces involved in transporting water and materials in plants.
3. the part played by the leaf in aiding transportation.
4. the transport systems in the paramecium, hydra, planaria, earthworm and grasshopper.
5. the functions of the circulatory system in man.
6. the cellular components of blood and their respective functions.
7. the main components of blood plasma in relation to their specific functions.
8. the path of blood through the heart.
9. how the various blood vessels are adapted to perform their function(s).
10. how the transport system helps in keeping a homeostatic condition within the body.
11. the primary function of the lymphatic system.
12. how the heart structures are adapted to perform their functions.
13. the laboratory investigations dealing with transportation.

CONTRACT CHAPTER XVIII

B. Student procedures - to be able to complete the behavioral objectives of this contract you should do the following activities:

1. attend an introductory lecture which introduces you to this contract, the equipment to be used, the facilities available and the times these are available.
2. read:
   a) your text. Chapter 18. Answer the following questions on page 498--number's 10,12,14,19,20,22.
   b) approved section(s) from a library book or books dealing with the transportation systems of paramecium, hydra, planarian, earthworm and grasshopper. This reading to be approved.
3. listen to a tape on "Circulation" using the 1963 BSCS Yellow Version as your guide.
4. see at least one of the two film strips on circulation. "The Heart and Circulation".
5. do labs 18-5, part B. Answer questions 1-5 on page 476. Do labs 18-12 parts A & B. Answer discussion questions on page 491. Do lab 5-12 and answer discussion questions on page 770.

The times when labs are set up will be posted.
Note: It is advisable that lab work be done in pairs.

6. Write a test on circulation on Tuesday, December 1st and score over 70 per cent.

CHAPTER XVIII TEST--CIRCULATION

Place the correct answers on the answer sheet provided.

PART A Choose the phrase you think best defines the term and place the letter of your choice in the space provided.

1. ____Valves	A. Composes 45 per cent of the volume of man's blood.
2. ____Platelets	B. Mechanisms that keep the blood moving in one direction within blood vessels.
3. ____Pulmonary artery	C. Muscles of the lungs.
4. ____Cardiac muscle	D. That part of the blood which attracts oxygen.
5. ____Hemoglobin	E. Tissue unique to the heart.
6. ____Flatworm	F. An animal that has a heart in each leg to insure blood circulation.
7. ____Leucocytes	G. "Red blood cells".
8. ____Formed elements	H. The "main" circulatory pattern of man.
9. ____Aphid	I. An animal that has a branching gastrovascular system, which extends to all parts of the body.
10. ____Systemic	J. Defensive mechanisms of the blood.
	K. Vessel that carries blood from the heart to the lungs.
	L. Blood-clotting mechanisms.

PART B

11. The annual growth ring consists of
    a) an inner layer of spring wood and an outer layer of summer wood.
    b) a single layer of annual wood.
    c) a single layer of spring wood.
    d) an inner layer of summer wood and an outer layer of spring wood.

12. The vascular rays serve to
    a) store food manufactured in the leaves and delivered to the rays.
    b) prevent water loss in extreme temperatures.
    c) transport food and water across the tree trunk.
    d) transport food and water from the leaves to the roots, where they are expelled.

13. One effect of girdling is
    a) the stem below the girdle grows.
    b) the tree dies from the root upward.
    c) the bark above the girdle flakes off.
    d) both a and c.

14. Which of the following best defines the process of transpiration?
    a) the actual movement of materials within a plant.
    b) the intake of carbon dioxide and the expulsion of oxygen by the leaf.
    c) the loss of water from a leaf.
    d) the exchange of food and water for waste materials in the plant cells.

15. Placing the end of a piece of celery in a dark-blue liquid solution is a simple method of locating
    a) the xylem.
    b) the phloem.
    c) the heartwood.
    d) both a and b.

16. The reason for the smallness of hydra and the flatness of planaria is that
    a) they live in water and cannot get enough nutrition to grow larger.
    b) they do not have a circulatory system.
    c) they have no digestive juices.
    d) they have too many predators.

17. The least complex animals to possess a circulatory system are
    a) grasshoppers.
    b) man.
    c) segmented worms.
    d) fishes.

18. The chief distributing vessel in the body of man is
    a) aorta
    b) inferior vena cana
    c) superior vena cana
    d) pulmonary artery

19. The blood cell which loses its nucleus is
    a) hemoglobin
    b) white blood cell
    c) platelet
    d) red blood cell

20. Two gases involved in respiration are
    a) O_2 which is used and CO_2 which is given off.
    b) H_2 which is used and CO_2 which is given off.
    c) CO_2 which is used and O_2 which is given off.
    d) O_2 which is used and H_2 which is given off.

21. If the blood flow and blood pressure decreased the capillary pressure probably.
    a) would decrease with less fluid leaving the capillaries to the tissue spaces.
    b) would decrease with more fluid leaving the capillaries to the tissue spaces.

22. Leeches which suck blood from vertebrates produce a substance, hirudin which inhibits blood clotting. Preparations containing hirudin might be used to treat a person suffering from
    a) malaria
    b) coronary thrombosis
    c) anemia
    d) nemophelia

23. Blood leaving the right side of the heart is carried to the
    a) lungs
    b) atrim
    c) aorta
    d) the whole body

24. What is lymph?
    a) another name for blood
    b) blood plasma
    c) blood plasma minus some proteins
    d) blood minus red blood cells.

25. Which of the following statements about arteries and veins is not true?
a) the wall of the artery is thicker.
b) the veins have valves.
c) the artery carries blood away from the heart.
d) the veins always carry blood which is high in oxygen content.

26. The main function of the white blood cells is
a) fight bacteria
b) acid in blood clotting
c) carry oxygen
d) carry carbon dioxide

27. The grasshopper is said to have an open circulatory system because
a) it has only one heart.
b) blood is not always in the vessels.
c) there are no veins in his system.
d) it is a cold blooded animal.

28. The function of the plateletts in the blood is
a) fight disease.
b) carry oxygen.
c) produce antibodies
d) to start the clotting mechanism.

29. The theory of circulation of the blood was postulated by
a) Harvey
b) Galen
c) Malpighi
d) Aristotle

30. What type of blood would you expect to find in the pulmonary veins?
a) blood rich in oxygen.
b) blood poor in oxygen and rich in carbon dioxide.
c) blood rich in hemoglobin.
d) blood under great pressure.

PART C Essay questions.

1. Why does nicotine (found in cigarettes) affect a person's athletic ability as determined by the lab using goldfish?

2. Which ventricle has the thicker wall? Why?

3. Compare and contrast the circulatory systems of the earthworm and grasshopper.

4. In what three (3) ways does the human transport system keep a homeostatic condition within our body?

CONTRACT CHAPTER XIX

RESPIRATORY SYSTEMS BLUE VERSION 1968

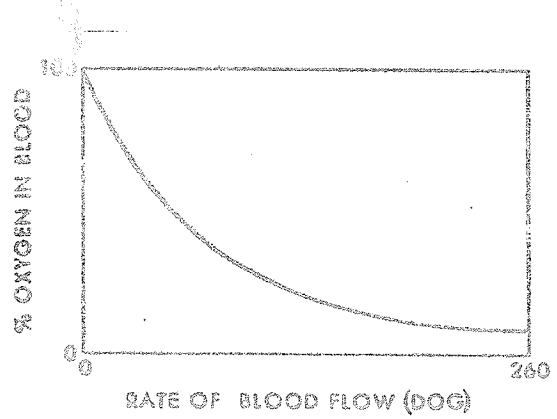
A. Behavioral objectives - upon completion of this contract you will be able to answer questions relating to:

1. the contributions of Lavoisier, Priestly and Boyle to understanding respiration.
2. the metabolic rates of cold-blooded and warm-blooded animals.
3. the factors that affect the rate of respiration.
4. the process of gas exchange in single-celled organisms, planarian, earthworm, fish, frog and grasshopper.
5. the relationships between hemoglobin and (a) oxygen (b) carbon dioxide.
6. the function of the HCO_3 - ion and H+ ion.
7. the evolution of respiratory organs.
8. the major structures associated with the human gas exchange system.
9. the data obtained from the laboratory investigations.

CONTRACT CHAPTER XIX

B. Student procedures - to be able to complete the behavioral objectives of this contract you should do the following activities:

1. attend an introductory lecture in which you will be introduced to the contract, the eqipment, and the times during which facilities will be available.
2. read:
   a) your text. Chapter 18. Answer the following questions on page 517--number's 2,6,7,10,13,16,17.
   b) one of the following:
      Biology Kimball, J.W.--page 209-214 and page 236-238 (O_2 & CO_2 transport).
      Biology Smallwood and Green--page 413-421 or an approved section in some other book which deals with invertebrate respiration more fully than your text.
3. listen to a tape on respiration.
4. see the filmstrip, "Mechanics of Breathing".
5. do an alternate lab to 19-2. Answer questions and hand them in.
6. do investigation 19-9. Hand in your own results. The results will be coalated into group results so that you can answer the discussion questions on page 516.
7. write a test on December 15th and score over 70 per cent.



KEY
A. A logical hypothesis based on the data
B. A hypothesis inconsistent with the data
C. A restatement of the results
D. A false statement, an erroneous reporting of the results
E. There is insufficient evidence to judge this statement.

1. The rate of blood flow in the dog progressively increases as the oxygen level in the blood decreases._____
2. The rate of blood flow in the dog progressively increases as the oxygen level in the blood increases._____
3. Oxygen lack causes contraction of blood vessels and thus reduces blood flow._____
4. Oxygen lack causes marked dilation of blood vessels and increases blood flow._____
5. Which is (are) characteristic of the respiratory organs of all organisms? _____
   A. The respiratory membrane is moist.
   B. The respiratory membrane is thin.
   C. There is some way of transporting oxygen and carbon dioxide to and from the membrane to the cell.
   D. Two of these.
   E. All of these.
6. Two persons, weighing the same, produce different quantities of CO_2. The best explanation for this is that
   A. one smokes an occasional cigarette.
   B. one is more active than the other.
   C. one is more active than the other.
   D. one has not eaten for some time.

The planet earth has just been visited by creatures from outer space. These creatures have brought some of their domesticated animals as gifts to us. These animals, however, exhale a chemical which very rapidly ties up a large percent of the free oxygen in our atmosphere. Assume that the outer-space creatures and their animals are friendly to us. However, they do present a problem to the living organisms on earth.

7. Which of the human bodily systems would be affected first by

by the tie-up of free oxygen in our atmosphere?
A. Circulatory
B. Muscular
C. Respiratory
D. Skeletal
E. Digestive

8. Which group of living organisms would likely be disturbed least by the tie-up of a large portion of our free atmospheric oxygen?
A. Fish
B. Mammals
C. Plants
D. Insects
E. Mollusks

9. Which would best describe the way in which the human body would react to the situation posed?
A. Increased vigor
B. More rapid breathing due to increased CO_2 built up within lungs
C. Weakening of the skeletal system
D. General over-all fatigue
E. Increase in circulation rate

10. Which situation, possibly encountered quite naturally on earth would have parellel effects on the body to those expected from the tie-up of much of our atmosphere's free oxygen?
A. A walk in the country
B. Watching a thrilling western movie
C. Climbing the last 100 meters of Mt. Everest
D. Dancing the twist
E. Taking a bicycle ride

11. Oxygen exchange of the typical terrestrial insect is effected by which of the following?
A. diffusion through the exo-skeleton
B. highly vascularized gills, suspended in an air sac
C. tracheae opening into lungs
D. trachae running directly to the tissues
E. trachea surrounded by a vascular network.

12. As exhaled air is bubbled through bromthymol blue the color of the solution changes. This provides evidence that
A. the body produces carbon dioxide
B. the body produces oxygen
C. there is carbon dioxide in the exhaled breath
D. there is oxygen in the exhaled breath
E. the lungs remove carbon dioxide from the blood.

Key: A. external respiration
B. tissues of the body
C. diaphragm relaxed
D. breathing
E. diaphragm contracted.

13. What is the exchange of gases called between the air and blood in the lungs? _____
14. What are the movements called which are associated with getting air in and out of the lungs? _____
15. Where does the carbon dioxide of the blood come from? _____
16. When the lungs are full of air, in what condition is the diaphragm found? _____
17. During which condition is the diaphragm dome-shaped? _____
18. The concentration of oxygen in the pulmonary vein is
A. greater than
B. less than
C. same as the concentration of oxygen in the pulmonary artery.

19. In mammalian respiration air enters the lungs as a result of
    A. a series of rhythmic tracheal contractions
    B. oxygen debt accumulations
    C. diffusion through a moist membrane
    D. a partial vacuum created by the action of the diaphragm
    E. increased thoracic pressure by lengthening of the intercostal muscles.

20. Which of the following best describes what normally occurs in man's lungs?
    A. the oxygen of the inspired air is completely removed by the lungs and is replaced by carbon dioxide
    B. the blood filters out of the capillaries of the lungs into the lymph vessels where exchange of products occurs, after which the blood re-enters the lungs capillaries
    C. Oxygen and carbon dioxide exchange occurs in the capillaries of the air sac in response to differential diffusion gradients.
    D. The squeezing action of the lungs in breathing is solely responsible for the oxygen-carbon dioxide exchange.
    E. Scientists do not yet understand how the gaseous exchange takes place in the lungs.

CONTRACT CHAPTER XX

DIGESTIVE SYSTEMS BLUE VERSION 1968

A. Behavioral objectives - upon completion of this contract you will be able to answer questions relating to:

1. intracellular and extracellular digestion by relating these to examples from plants, protists and/or animals.
2. the structures of digestive systems of hydra, planaria, earthworm, birds and termites.
3. how the structures of digestive organs are adapted to their respective functions in man's digestive tract.
4. the enzymes from (a) mouth (b) stomach (c) pancreas (d) small intestine--what they act on and where.
5. the role of bile in digestion.
6. the role of hormones in their control of the digestive process in man.
7. the formation of hypothesis in experimental design.

CONTRACT CHAPTER XX

B. Student procedures - to be able to complete the behavioral objectives of this contract you should do the following activities:

1. attend an introductory lecture to become acquainted with the contract.
2. read!
   a) your text. Page 519-536. Answer the following questions on pages 536-7. Number's 3,4,11,12,18,19,20.
   b) one book from Group A and one book from Group B.

Group A

(i) BSCS Yellow Version Chapter 20 (1968)
(ii) BSCS Green Version Chapter 14 (1963)
(iii) Elements of Biology - Weisz Chapter 11
(iv) Life - Introduction to Biology - Simpson Chapter 10
(v) Principles of Biology - Buffaloe Chapter 6

Group B

(i) Biology - Villee Chapter 19
(ii) Biology - Kimball Chapter 10
(iii) Science of Biology - Weisz Chapter 14
(iv) Biological Science - Galbraith Chapter 9

3. listen to a tape on Digestion.
4. See at least one film strip on digestion. "Man's Digestive System" or "Digestion of Foods".
5. do the following lab exercises: 20-1--fill in table 20-1 and 20-2 and answer discussion questions number's 1-4. s-15 on page 772. Answer discussion questions number's 1-5 after completing the lab.
6. take a test by December 22nd and score over 70 per cent.

If you score below 70 per cent an additional assignment will be forthcoming.

CHAPTER XX TEST--DIGESTION

Place the correct answers on the answer sheet provided.

PART A Choose the phrase you think best defines the term and place the letter of your choice in the space provided.

1. ____Amino Acids	A. Famous for his observations of human digestion.
2. ____Beaumont	B. Lubricant in human digestive tract.
3. ____Colon	C. End products of protein digestion.
4. ____Digestion	D. Process of making food available to cells.
5. ____Emulsification	E. Process of building up large molecules.
6. ____Gastrin	F. Another name for the large intestine.
7. ____Hydrochloric Acid	G. Wavelike contractions of the small intestine.
8. ____Mucus	H. Means the same as chewing.
9. ____Peristalsis	I. A hormone that is a control in human digestion.
10. ____Reaumur	J. Acts upon food in the stomach.
	K. Discovered and named gastric juice.
	L. Process of breaking fat into small droplets.

PART B

11. Chemical digestion in all organisms is accomplished by means of
    a) enzymes
    b) stomach acids
    c) synthesis
    d) microorganisms

12. Division of labor in cells generally leads to
a) smaller cell size.
b) chaos.
c) greater efficiency.
d) rapid mitosis.

13. One way nature cares for the internal cells of all multicellular organisms is through
a) a flow of water.
b) speciation.
c) digestion.
d) a transport mechanism.

14. Bile is produced by the
a) stomach
b) small intestine
c) pancreas
d) liver

15. The cells of the hydra that ingest food particles are located in the
a) cavities of pore cells.
b) ectoderm.
c) endoderm.
d) spicules.

16. The extent to which a cell can grow and survive is governed by a ratio of
a) intake to synthesis.
b) reproduction to digestion.
c) plasma membrane to volume.
d) reproduction to death.

17. A simple organism exhibiting "one-way traffic" for food in its digestive tube is the
a) sponge
b) hydra
c) human
d) earthworm

18. In any organism, the process of digestion always involves
a) chewing.
b) breakdown of large molecules to small molecules.
c) making foods insoluble in water.
d) all of the above.

19. The ring of muscle fiber that separates the human stomach from the small intestine is a muscle known as
a) peristalsis
b) duodenum
c) sphincter
d) colon

20. The leaf traps of a Venus's-flytrap do not secrete enzymes that digest
a) insects other than flies.
b) protein.
c) carbohydrates.
d) insects.

21. In humans, most chemical digestion is accomplished in the
a) stomach
b) small intestine
c) large intestine
d) appendix

22. The embryo of a seed cannot begin to grow until the seed has begun
a) fertilization
b) photosynthesis
c) digestion
d) peristalsis

23. Dr. Beaumont observed that digestion slowed whenever Alexis St. Martin produced large amounts of what we know as
a) gastrin
b) gastric juice
c) peristalsis
d) adrenaline

24. If it were necessary to remove the gall bladder of a human, he would be advised to reduce his intake of
a) fats
b) sugars
c) proteins
d) enzymes

25. Which of the following terms does not closely relate to the other three?
a) sucrase
b) gastrin
c) pepsin
d) lipase

26. A major function of man's large intestine is
a) absorption of digested foods.
b) absorption of water.
c) digestion of cellulose.
d) to contain the villi.

27. The stomach is to the human as which of the following is to the earthworm
a) crop
b) gizzard
c) intestine
d) anus

28. Which of the following does not relate closely to the other three?
a) fatty acid
b) simple sugar
c) hydrochloric acid
d) amino acid

29. Venus's-flytraps grow in areas where most plants cannot. The growth of most noncarnivorous plants in such areas is hindered by the absence of soil bacteria involved in
a) photosynthesis
b) nitrogen fixation
c) denitrification
d) the carbon cycle

30. One pint of whipping cream and one ounce of bile are placed into each of two flasks. One gram of substance A is added to flask #1, and one gram of substance B is added to flask #2. After 24 hours there is no change in flask #1, but the cream in flask #2 becomes clear. Substance B was most likely
a) bile
b) lipase
c) hydrochloric acid
d) amylase

PART C Long anwer questions

1. Trace proteins through man's digestive system. Name the enzymes, their origin and where they act. How are the end products of protein digestion absorbed efficiently?

2. Compare and contrast the digestive systems of the grasshopper and bird.

3. In what ways does digestion depend on
   a) circulation?
   b) hormones?
   c) respiration?
   d) the liner?

4. Briefly, but clearly, explain what conclusions you arrived at in the experiments dealing with dialysis tubing.

DIGESTION - EXTRA WORK

1. Trace proteins through man's digestive system. Name the enzymes, their origin and where they act. How are the end products of protein digestion absorbed <u>efficiently</u>?

2. Trace fats through man's digestive system. Follow through as in question #1.

3. Trace carbohydrates through man's digestive system. Follow through as in question #1.

4. Compare and contrast the digestive systems of:
   a) earthworm and grasshopper.
   b) earthworm and man.

5. Distinguish (and give examples of) between:
   a) intracellular digestion.
   b) extra cellular digestion.

6. State some adaptations of:
   a) bird digestive systems.
   b) termite digestive systems.

7. What part do hormones play in regulating enzyme production in man?

8. Describe a villers. Why is it important?

CONTRACT CHAPTER XXI

EXCRETION IN ANIMALS BLUE VERSION 1968

A. Behavioral objectives - upon completion of this contract you will be able to answer questions relating to:

1. how plants solve the problem of excretion in paragraph form.
2. the 3 forms of nitrogenous wastes produced by animals.
3. differentiation between excretion and elimination.
4. defining the term HOMEOSTASIS and illustrating the concept by using human kidney function as an example.
5. comparing and differentiating the excretory processes of the Amoeba, Paramecium, Hydra, Planaria, Earthworm, Grasshopper and Man.
6. the process of Urea formation in the human body.
7. the primary structures of the excretory system of man.
8. how man can produce urine which is more concentrated than blood.

CONTRACT CHAPTER XXI

B. Student procedures - to be able to complete the behavioral objectives of this contract you should do the following activities:

1. attend a large group introductory lecture.
2. read:
   a) your text. Chapter 21. Answer the following questions on page 553- number's 20, 21, 23.
   b) the Scientific American article "The Kidney" and answer the question sheet.
3. listen to a tape on excretion, using the 1963 Yellow Version as your guide.
4. see the filmstrip "Your Kidneys--Living Filters".
5. do lab 21-5. Answer questions on page 546.
6. write a test on December 15th and score over 70 per cent.
7. if you score less than 70% you will get an assignment to help you become familiar with the material.

CHAPTER XXI TEST--EXCRETION

Place the correct answers on the answer sheet provided.

PART A

1. In which of the following are the structures listed in order of increasing complexity?
   a) contractile vacuole, flame cell, kidney, nephridium.
   b) contractile vacuole, flame cell, nephridium, kidney.
   c) flame cell, contractile vacuole, nephridium, kidney.
   d) flame cell, contractile vacuole, kidney, nephridium.
   e) nephridium, kidney, flame cell, contractile vacuole.

2. One of the waste products of protein metabolism is
   a) pepsinogen
   b) trypsin
   c) amino acid
   d) urea
   e) urine

3. The primary function of the sweat glands is to
   a) secrete oils which lubricate the skin.
   b) regulate the body temperature.
   c) discharge urea from the body.
   d) secrete the waste products of metabolism.

4. The concentration of which one of the following is not decreased when blood passes through the normal kidneys of a person?
   a) protein
   b) glucose
   c) urea
   d) other nitrogenous wastes
   e) all decrease in concentration when passing through the kidneys.

5. What happens to most of the water that passes into the filtrate in the kidneys?
   a) it is excreted in the urine.
   b) it is given off in the form of perspiration.
   c) it is utilized in carbohydrate synthesis.
   d) it is reabsorbed into the blood.
   e) it is converted into digestive fluids which serve as vehicles of transport for enzymes.

6. It is believed that contractile vacuoles serve mainly to
   a) discharge nitrogenous wastes.
   b) digest food.
   c) transport non-digestible materials in an anal pore.
   d) regulate water content.
   e) aid respiration, mainly by the discharge of CO_2.

7. Which of the following structures is not directly associated with the urinary system in man?
   a) renal capillaries
   b) ureter
   c) urethra
   d) renal tubule
   e) gall bladder

8. Some substances pass through the capillary membranes of the glomeruli while other substances do not. These capillary membranes are, therefore, considered to be
   a) osmotically abnormal.
   b) functioning improperly.
   c) differentially permeable.
   d) more than one of the above.
   e) none of the above.

9. Indicate which is the correct sequence of the path of excretory wastes in man from the body to the outside.
   a) bladder, blood, kidney, ureter, urethra.
   b) blood, kidney, urethra, bladder, ureter.
   c) blood, bladder, urethra, kidney, ureter.
   d) blood, kidney, ureter, bladder, urethra.
   e) blood, bladder, ureter, kidney, urethra.

10. There is a decrease in concentration of which of the following in the blood after exercise as compared to the concentration before exercise?
   a) oxygen
   b) carbon dioxide
   c) lactic acid
   d) two of these
   e) all of these

11. As urine passes through the ureters, bladder, or urethra
    a) no change occurs in the urine.
    b) urea is reabsorbed.
    c) water is absorbed.
    d) additional nitrogenous waste products are added.

12. In a normal healthy man the passage of urea through the sweat glands is
    a) equal in quantity to that passed through the kidneys.
    b) greater in quantity than that passed through the kidneys.
    c) insignificant in quantity compared to that passed through the kidneys.
    d) equal in quantity to that amount present in the blood.

13. One of the most important functions of the human kidneys is to
    a) assist in the elimination of indigestible wastes from the digestive tract.
    b) store amino acids.
    c) store glycogen for emergency use.
    d) excrete nitrogenous substances produced during protein metabolism.
    e) eliminate carbon dioxide from the body.

14. Some of the waste products produced by the metabolic activities of an amoeba are
    a) oxygen and nitrogenous wastes.
    b) oxygen and carbon dioxide.
    c) carbon dioxide and nitrogen.
    d) urea and carbon monoxide.
    e) nitrogenous products and carbon dioxide.

15. The liquid which collects in the cavity of Bowman's capsule is
    a) urine in concentrated form.
    b) freshly aerated blood.
    c) blood plasma minus the plasma proteins.
    d) used bile ready to be excreted.
    e) adrenalin secreted by the adrenal glands located adjacent to the kidneys.

16. The glomeruli are most closely related to the system involved in
    a) digestion.
    b) excretion.
    c) reproduction.
    d) reaction to stimuli.
    e) support and movement.

17. Which of the following has no relation to excretion?
    a) nephridium.
    b) nephron
    c) hair cell
    d) flame cell
    e) all of these

18. The liquid which filters through the capillary walls into the cavity of Bowman's capsule is
    a) venous blood minus the cells and plasma proteins.
    b) urine in concentrated form.
    c) used bile to be excreted.
    d) whole blood freshly oxygenated.
    e) insulin for emergency use.

19. The lowest concentration of nitrogenous waste is likely to be found in blood passing through which of the following vessels?
    a) renal vein
    b) vena cava
    c) hepatic vein
    d) pulmonary artery
    e) renal artery

20. Which of these is the first to break the proper sequence?
    a) kidney
    b) urethra
    c) bladder
    d) ureter
    e) none of these

21. Urea is mainly excreted from the body by
    a) skin
    b) lungs
    c) kidneys
    d) liver

22. The organ within which the proportions of the inorganic salts in the blood is regulated is the
a) kidney.
b) liver.
c) parathyroid.
d) adrenal cortex.
e) wall of the small intestine.

23. The elimination of metabolic wastes from the body is called
a) egestion.
b) oxidation.
c) assimilation.
d) excretion.

24. Normally, concentrations of wastes, such as urea, are
a) high in urine in comparison to plasma.
b) high in filtrate but low in urine.
c) trace amounts in urine and high in blood.
d) the same in blood, filtrate and urine.
e) low in filtrate most of the time.

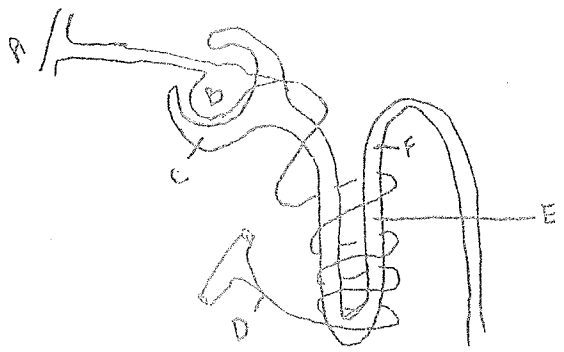
25. Normally, concentrations of proteins are
a) high in plasma and usually absent in glomerular filtrate and urine.
b) high in plasma and glomerular filtrate but absent in urine.
c) high in plasma, glomerular filtrate and urine.
d) high in plasma, absent in glomerular filtrate but present in urine.
e) low in plasma but high in glomerular filtrate and urine.

26. Which circulatory mechanism is characteristic of all organisms?
a) flame cell.
b) gastro-vascular.
c) xylem-phloem.
d) diffusion.

27. Normally, concentrations of metabolically important substances are
a) high in glomerular filtrate but high in urine.
b) low in glomerular filtrate but high in urine.
c) high in both glomerular filtrate and urine.
d) low in both glomerular filtrate and urine.
e) none in glomerular filtrate and a little in urine.

28. A biologist had two solutions labelled I and II. One of these was salt water, with a concentration of salts just greater than that of a living cell. The other solution was distilled water. He wished to find which each solution was, so he placed several fresh-water protozoa in each solution. The animals in solution I swelled and burst; those in solution II shrank and disintegrated. Which is distilled water?
a) I
b) II

29 - 32



29. Which substances can be found in A but not in C?
a) blood proteins
b) water
c) carbonic acid
d) mineral salts

30. In order for glucose molecules to pass from C to D, which must be true?
a) the glucose must first by hydrolyzed.
b) ATP must be used.
c) ionization must occur.
d) C must receive a stimulus from the cerebrum of the brain.

31. The structure above is the unit of the human
a) liver
b) kidney
c) lung
d) spleen

32. The liquid in E normally differs from that in D in that the liquid in E has a much greater concentration of
a) glucose.
b) urea.
c) albumin.
d) water.

33. Flame cells are part of the excretory system of
a) the hydra.
b) the planarian.
c) the earthworm.
d) man's kidneys.
e) the grasshopper.

34. In man, most nitrogen waste is excreted as urea, $CO(NH_2)_2$. It is formed
a) by a small amount of ammonium nitrate being excreted.
b) by the combining of two amino groups with carbon and oxygen.
c) by ammonia molecules being combined with CO_2.
d) by means of the ornithine cycle.
e) by a combination of a least three of these.

PART B

(5) 1. Describe the mechanism that prevents the buildup of a high concentration of ammonia (NH_3) in the human body. Where does it occur?

(5) 2. Describe how an earthworm nephridium works.

(10) 3. Outline the <u>evolution</u> of excreting systems including Paramecium, Planaria, Grasshopper, Earthworm, and Man.

i.e. How does the system become more specialized and more dependent on other systems?

EXCRETION - EXTRA WORK

1. What is deamination? What are the 3 forms of nitrogenous wastes?

2. What is the function of the Contractile vacuole in protozoa?

3. What is the function of the liver as applied to excretion? Describe the Ornithine cycle.

4. How is the earthworm adapted to excretion? Compare and contrast the workings of an earthworm nephridium to that of the human nephron.

5. How do Malphigian tubules function?

6. What is the relationship between the amounts of wastes excreted and the pH of the blood?

7. What happens to the urine after it reaches the pelvis of the kidney?

8. Outline the EVOLUTION of excretory systems including Paramecium, Planaria, Grasshopper, Earthworm and Man.

   i.e. How does the system become more specialized and more dependent on other systems?

APPENDIX C

Pre-test ___
Post-test ___

UNIT 6 - MULTIPLE CHOICE TEST ANSWER SHEET

NAME _____ Section A, B.

	Ch. 18	Ch. 19	Ch. 20	Ch. 21
Recall & Reorganize	1* ___	11 ___	21 ___	31 ___
	2 ___	12 ___	22 ___	32 ___
	3 ___	13 ___	23 ___	33 ___
Show Relationships	4 ___	14 ___	24 ___	34 ___
	5 ___	15 ___	25 ___	35 ___
	6 ___	16 ___	26 ___	36 ___
Application	7 ___	17 ___	27 ___	37 ___
	8 ___	18 ___	28 ___	38 ___
Use of Skills	9 ___	19 ___	29 ___	39 ___
	10 ___	20 ___	30 ___	40 ___

*Numbers in columns represent test item number.

BSCS Unit 6 MULTIPLE CHOICE TEST

1. What is the function of blood platelets?
   A. Aid in the coagulation of blood.
   B. Carry hemoglobin.
   C. Ingest bacteria.
   D. Transport carbon dioxide.

2. A vein that carries blood with a high concentration of oxygen is the
   A. pulmonary vein. B. subclavian vein.
   C. hepatic vein. D. vena cava.
   E. renal vein.

3. Water necessary for photosynthesis enters the green plants mainly through
   A. the stomates. B. the roots.
   C. the root hairs. D. the xylem.
   E. intercellular spaces.

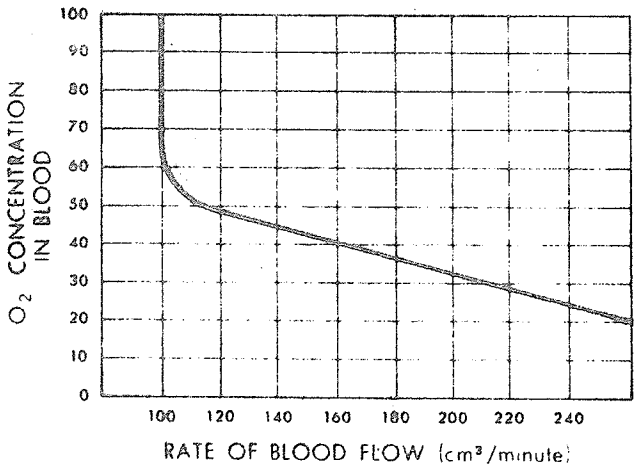
4. For item 4, after the exercise number on the answer sheet show which designates the most similar structure, condition, or process.

   The action of the liver on old red blood corpuscles:
   A. The action of the enzyme in the saliva on starch.
   B. The act of changing the oil in an automobile engine.
   C. The action of chlorophyll in photosynthesis.
   D. The action of an acid in dissolving a metal.
   E. The action of patriotic individuals in salvaging the rubber in worn-out tires.

5. The open circulatory system of a grasshopper has NO functional structure corresponding to
   A. arteries.
   B. veins.
   C. capillaries.
   D. lymph vessels.

6. Which of the following would characterize blood that is flowing through the pulmonary veins?
   A. It contains more CO_2 than blood in any other part of the body.
   B. It is purplish red rather than scarlet red in color.
   C. It has been freshly oxygenated.
   D. It contains more red corpuscles per cc. than blood in any other part of the body.
   E. Its composition is no different than that of blood in other parts of the body.

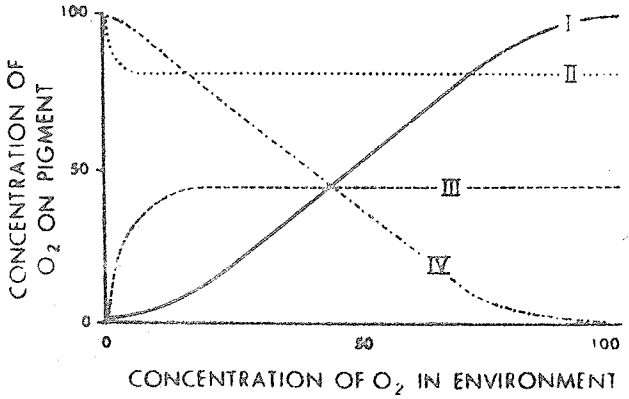
Questions 7 & 8 are based on the following graph which shows the effect of the concentration of oxygen on blood flow through a dog's leg not under nerve regulation.



7. An interpretation of the data presented in the graph suggests that a decrease in oxygen causes blood flow to
   A. increase and the blood vessels to dilate.
   B. decrease and the blood vessels to contract.
   C. decrease and the blood vessels to dilate.
   D. increase logarithmically.

8. Where the oxygen concentration line of the graph drops sharply the blood is most likely to be passing through.
   A. a vein.
   B. an artery.
   C. a capillary.
   D. the heart.

9. Questions 9 & 10 are based on the following graph in which the oxygen concentration on four different pigments is plotted against oxygen concentration in the environment.



9. Which pigment would be the most effective for transporting oxygen in man?
   A. I B. II C. III D. IV

10. If one of the curves represents the hemoglobin of a fish, the section of the curve where oxygen concentration is low would represent hemoglobin is
   A. a vein from the gill.
   B. an arteriole in the tail.
   C. an artery in the head.
   D. a vein in the fin.

11. Oxygen enters the cells of Hydra by
   A. cyclosis. B. hydrolysis.
   C. osmosis. D. diffusion.

12. Oxygen is carried by the blood of man mainly
   A. in the form of biconbonate ions.
   B. dissolved in plasma.
   C. as oxyhemoglobin.
   D. by white blood cells.

13. The exchange of gases in human lungs takes place at the
   A. trachea. B. bronchi.
   C. diaphragm. D. air sacs.

14. For flying at 30,000 feet it is necessary to supply nearly pure oxygen to the occupants of the plane. Usually a small amount of CO_2 is added to the oxygen. Why is this done?
   A. the CO_2 is used to partially dilute the oxygen--breathing pure oxygen will tend to cause a burning sensation in the chest.
   B. A small amount of CO_2 is used in cellular respiration.
   C. CO_2 is used in the formation of carbonic acid which is essential in certain reactions.
   D. CO_2 stimulates the respiratory center in the medulla.
   E. CO_2 is used in carbohydrate synthesis.

15. Which is (are) characteristic of the respiratory organs of all organisms?
   A. The respiratory membrane is moist.
   B. The respiratory membrane is thin.
   C. There is some way of transporting oxygen and carbon dioxide to and from the membrane to the cell.
   D. Two of these.
   E. All of these.

16. Two persons, weighing the same, produce different quantities of CO_2. The best explanation for this is that
    A. one smokes an occasional cigarette.
    B. one is a woman.
    C. one is more active than the other.
    D. one has not eaten for some time.

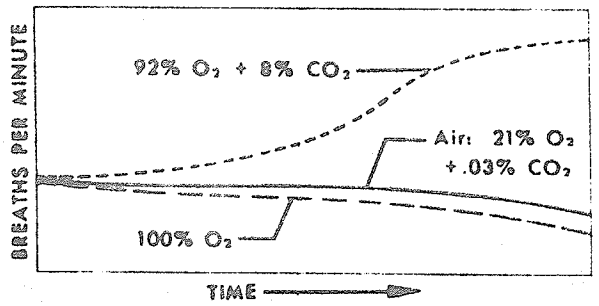
The planet earth has just been visited by creatures from outer space. These creatures have brought some of their domesticated animals as gifts to us. These animals, however, exhale a chemical which very rapidly ties up a large percent of the free oxygen in our atmosphere. Assume that the outer-space creatures and their animals are friendly to us. However, they do present a problem to the living organisms on earth.

17. Which of the human bodily systems would be affected first by the tie-up of free oxygen in our atmosphere?
    A. Circulatory B. Muscular
    C. Respiratory D. Skeletal
    E. Digestive

18. Which group of living organisms would likely be disturbed least by the tie-up of a large portion of our free atmospheric oxygen?
    A. Fish B. Mammals C. Plants
    D. Insects E. Mollusks

19. & 20.

Using the right experimental setup a human subject can be checked as to rate and depth of breathing while inspiring various precisely determined gas mixtures. The subject begins the experiment while breathing pure air. The experiment is repeated using 100% O_2 and repeated again with a gas mixture of 92% O_2 and 8% CO_2.



Key for questions 19 & 20.

A. A logical hypothesis based on data
B. A hypothesis contradictory to the data
C. A hypothesis for which there is no evidence
D. A restatement of the data

19. The depth of breath increases markedly in 92% O_2 and 8% CO_2. _____

20. There is no marked change in depth or rate of breathing under any conditions. _____

21. Bile is produced by the
A. stomach. B. small intestine.
C. pancreas. D. liver.

22. A major function of man's large intestine is
A. absorption of digested foods.
B. absorption of water.
C. digestion of cellulose.
D. to contain the villi.

23. Which of the following terms does not closely relate to the other three?
A. sucrase. B. gastrin.
C. pepsin. D. Lipase?

Key for questions 24, 25, 26.
A. Extracellular digestion
B. Intracellular digestion
C. Not digestion

24. Starch in the carrot root becomes glucose. _____

25. Glucose is converted to starch in the leaf of the geranium plant. _____

26. An ameba in the digestive tract of a termite converts cellulose to a sugar. _____

27. Venus's-flytraps grow in areas where most plants cannot. The growth of most noncarnivorous plants in such areas is hindered by the absence of soil bacteria involved in
A. photosynthesis.
B. nitrogen fixation.
C. denitrification.
D. the carbon cycle.

28. One pint of whipping cream and one ounce of bile are placed into each of two flasks. One gram of substance A is added to flask #1, and one gram of substance B is added to flask #2. After 24 hours there is no change in flask #1, but

the cream in flask #2 becomes clear. Substance B was most likely
A. bile. B. lipase. C. hydrochloric acid.
D. amylase.

Minced eggwhite, a protein, was placed in test tubes containing 10 cc of water. Each tube was left for 12 hours.

Tube	Treatment (substance added)	Peptides Present	Results
A	pepsinogen	no	egg pieces
B	pepsinogen and acid	large amounts	clear
C	nothing	no	egg pieces
D	acid	trace	egg pieces
E	pepsinogen (boiled) and acid	no	egg pieces

Use F as a key for None of these.

29. What is the control for the entire experiment? _____

30. Which tube gives evidence that acid has the ability to break down proteins? _____

31. One of the waste products of protein metabolism is
A. pepsinogen. B. trypsin. C. amino acid.
D. urea. E. urine.

32. Which of the following structures is not directly associated with the urinary system in man?
A. Renal capillaries. B. Ureter. C. Urethra.
D. Renal tubule. E. Gall bladder.

33. Indicate which is the correct sequence of the path of excretory wastes in man from the body to the outside:
   A. bladder, blood, kidney, ureter, urethra.
   B. blood, kidney, urethra, bladder, ureter.
   C. blood, bladder, urethra, kidney, ureter.
   D. blood, kidney, ureter, bladder, urethra.
   E. blood, bladder, ureter, kidney, urethra.

Key for questions 34, 35, 36.

Substance	Tissue fluid of a limb (mg./100cc.)	cell (mg./100cc.)
A. Carbon dioxide.	60.0	61.0
B. Oxygen.	10.0	9.0
C. Glucose	50.0	49.0
D. Nitrogen wastes and urea.	38.0	39.0
E. Amino acids.	2.0	1.8

34. There is more of this (these) substance(s), which is (are) characteristic of protein metabolism, in the cell than in the tissue fluid. _____

35. There is more of this (these) substance(s), which is (are) characteristic of all kinds of metabolism, in the cell than in the tissue fluid.

36. There is more soluble, diffusible carbohydrate in the tissue fluid than in the cell.

37. An excretory organ might be essential to plants if plants
   A. produced any waste products.
   B. digested food.
   C. had an excess of water.
   D. produced ammonia.

38. A biologist had two solutions labelled I and II. One of these was salt water, with a concentration of salts just greater than that of a living cell. The other solution was distilled water. He wished to find which each solution was, so he placed several fresh-water protozoa in each solution. The animals in solution I swelled and burst; those in solution II shrank and disintegrated. Which is the distilled water?
   A. I B. II

Questions 39 & 40 are based on the following results from experiments on a kidney.

SUBSTANCE	CONCENTRATION OF SUBSTANCE	
	IN BOWMAN'S CAPSULE	IN URINE
I	0.1 g/liter	0.1 g/liter
II	0.1	1.0
III	0.1	0.0

39. Substance I was probably
   A. reabsorbed in the tubules.
   B. not reabsorbed in the tubules and not secreted by tubule cells.
   C. reabsorbed in the tubules and secreted by tubule cells.
   D. secreted by tubule cells and not filtered through the glomerulus.

40. Substance II was probably
   A. reabsorbed in the capsule.
   B. secreted by tubule cells.
   C. not secreted by tubule cells.
   D. not filtered through the glomerulus.

APPENDIX D

MONITORING CONTRACT SURVEY

Chapter 19 ___
Chapter 20 ___

NAME _____

This, in no way will be used to determine your mark. Please answer each question.

Check which of the following you did.

	YES	NO	2 or more times
1. Introductory lecture.			
2. Read chapter in text.			
3. Did assignment questions.			
4. Read references.			(more than one)
5. Listened to tape.			
6. Viewed filmstrip.			
7. Performed laboratory exercises.			

APPENDIX E

OPINION QUESTIONAIRE

NAME _____

1. How did you feel about contracts before you started this study?

2. How do you feel about them now?

	POSITIVE			NEGATIVE
	V.G.	G.	F.	P.	USELESS or DID NOT USE

3. Of what value did you find each of the following?
   - (a) Behavioral Objectives
   - (b) Tapes
   - (c) Filmstrips
   - (d) Reference Material
   - (e) Laboratory
   - (f) Assignment in text
   - (g) Testing
     1) testing
     2) types of questions

4. Any comments, particularly how contracts may be improved.

COMMENTS-QUOTES - OPINIONAIRE

- Tests should be written when I am ready, not when the control group is ready.

- Opportunity to go into course to the depth you wish. i.e. 95 per cent, 85 per cent, 55 per cent.

- Improvement can only be made on my part. My work improved from last term so I feel it is good.

- A few mandatory classes to tie the material together. This would have made the work much easier. The laboratory mate ial seemed irrelevant and not worth the time.

- Tapes should make more reference to our text rather than to another reference book.

- Human element needs to be improved. I wasn't self-disciplined enough. Now I am more disciplined. I think I'll be able to cope with them better.

- Contracts should be available for the rest of the chapters in order to finish the chapters in the shortest possible time.

- I left things to the last. I don't feel they can be improved in any way.

- Contracts can be improved by explaining the labs. better.

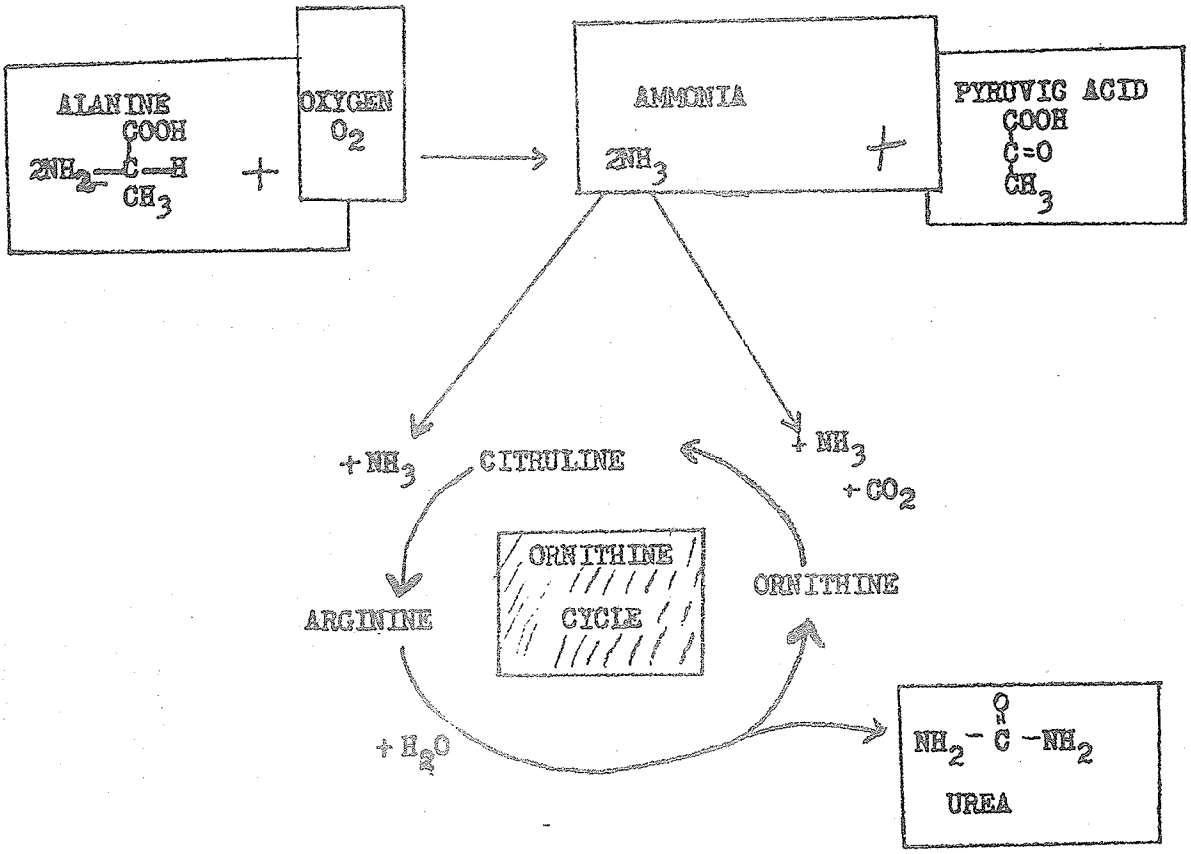
- Contracts may be improved under a completely different system. The contracts must be used where you can have the facilities more readily.

- I'd like to stick to our own textbook. I know I wouldn't work on the contracts.

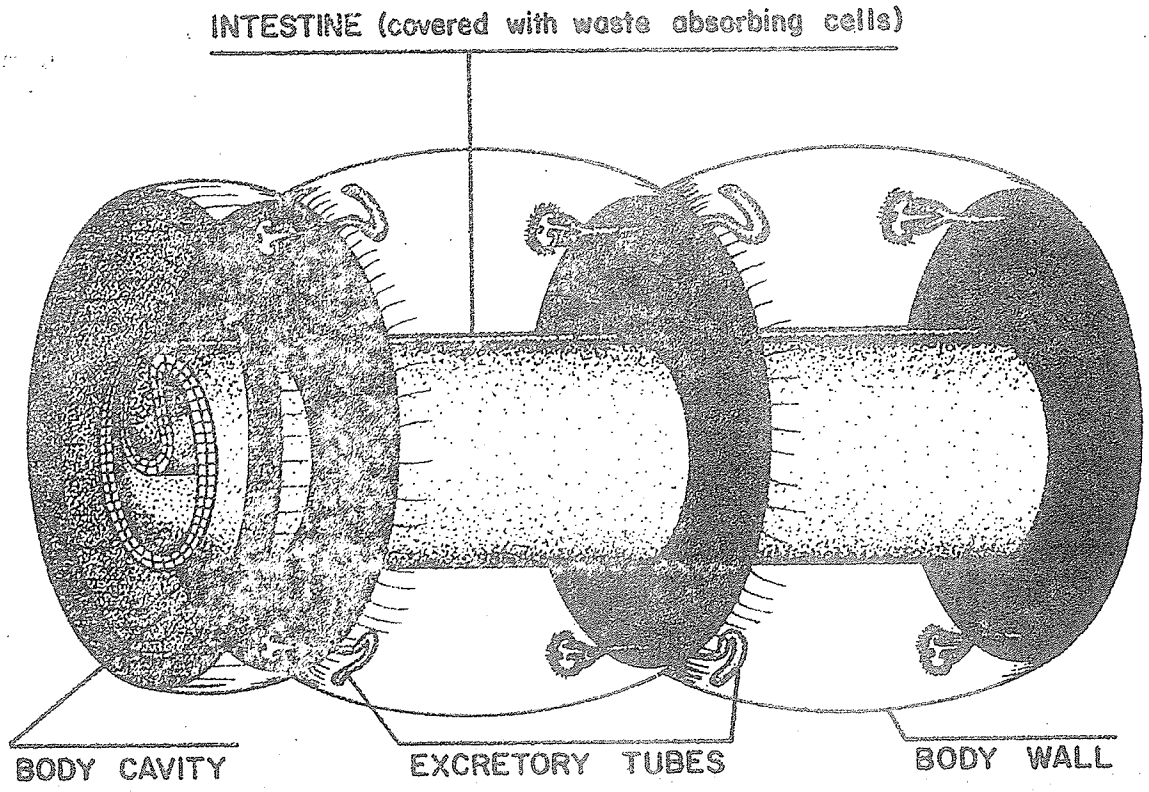
- There should be no reference reading as the best books are usually out when needed.
- They can be thrown out, discarded and dropped.
- The Multiple Choice tests didn't pertain enough to the material we covered.

APPENDIX F

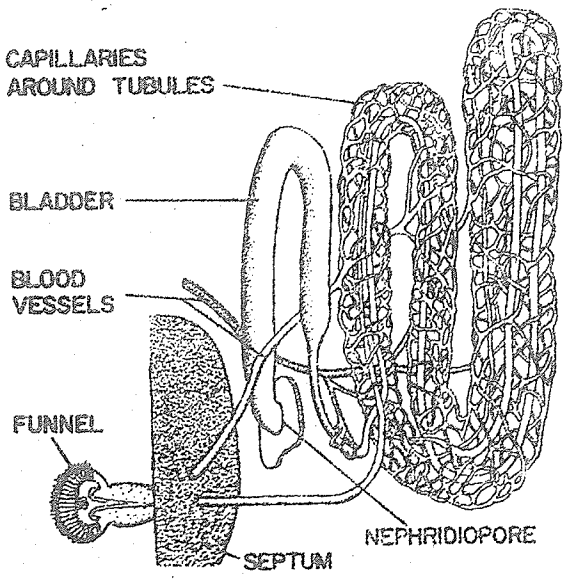
THE FORMATION OF UREA



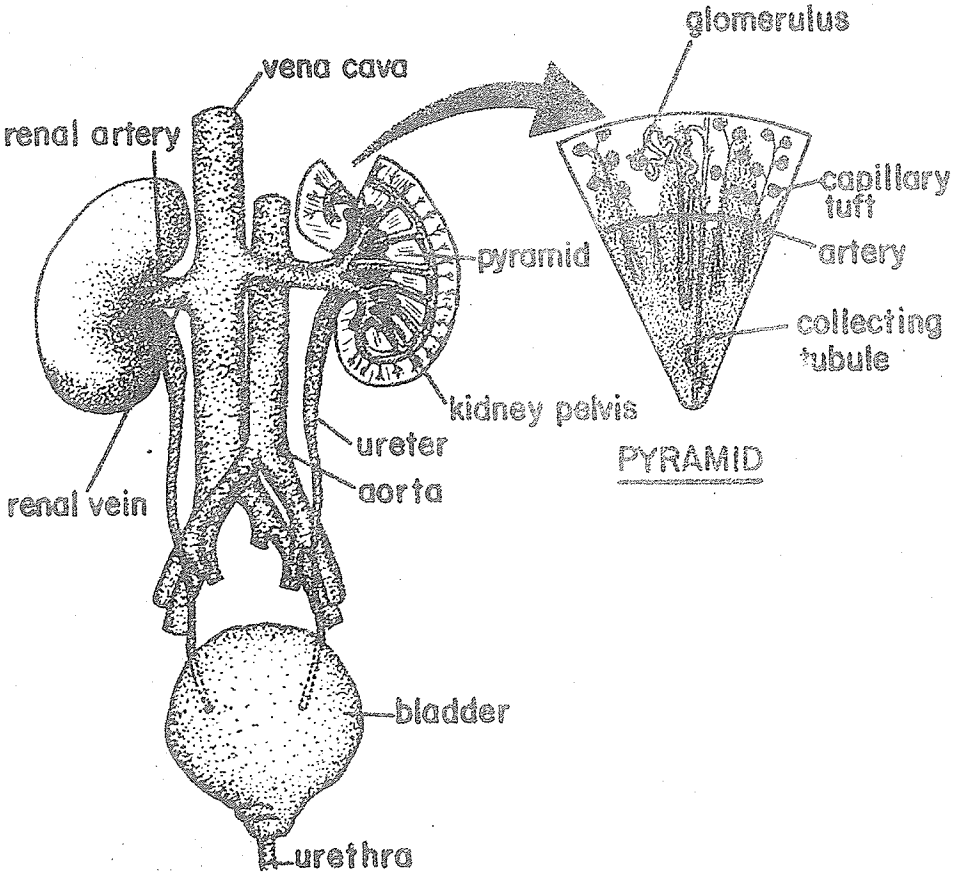
EARTHWORM EXCRETION



Excretory tubes in the earthworm.



Nephridia in the earthworm.



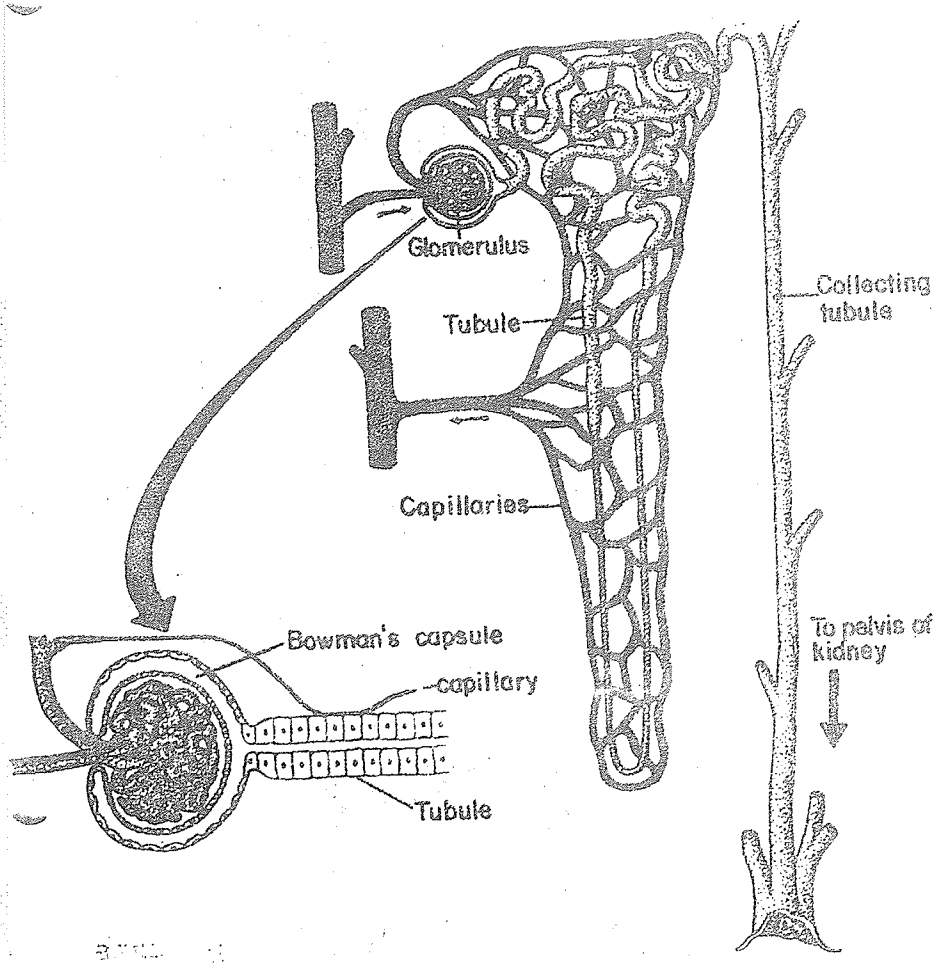


Diagram of nephron.

TAPE SCRIPT ON EXCRETION

You will need the 1963 BSCS Yellow Version reference book and three pages which I have prepared for you. One page deals with earthworm excretion, another page deals with the formation of urea and the third page deals with human excretion. We have previously discussed some of the waste products that are produced by cellular metabolism. One of these wastes is carbon dioxide. We dealt with the excretion of carbon dioxide in the chapter dealing with respiration. At that point the loss of water was also considered briefly as well as nitrogenous wastes such as ammonia, urea and uric acid. These all have to be removed and we refer to this process as Excretion. We dealt with excretion of carbon dioxide in the respiratory system so we can leave that and concentrate more on the excretion of water and of nitrogenous waste compounds. Again, we will discuss the six animals, beginning with the paramecium, then hydra, planaria, earthworm, grasshopper and finally man.

I would like you to note that the paramecium which was discussed in chapter nineteen has one big problem.

Since it lives in fresh water and the diffusion rate of water into the paramecium is faster than the diffusion rate of water going out of it, its problem is to pump out the excess water and it does so by means of special structures which are referred to as contractile vacuoles. It can get rid of the carbon dioxide and ammonia just by diffusion and, as we have discussed before, the paramecium will swim along to fresher waters from the waters that have greater concentration of carbon dioxide and ammonia.

The next animal is hydra. Hydra, being a fresh water animal has the same problem with water as the paramecium. It is a multi-cellular animal but it has only two layers of cells and all of these cells form the outside or the inside surface so the ammonia and the carbon dioxide will diffuse out of it. The mechanism by which the hydra excretes water is too complicated to be discussed here. Since it requires energy we refer to the getting rid of the excess water as that of "active transport", a term that you have been introduced to before.

In referring to the diagram on page 422 you can see that this is a very flat worm. The excretion of carbon

dioxide and ammonia is just simply a matter of diffusion due to the fact that all cells are close to the surface. However, you will notice a magnified area which contains a flame cell duct and an excretory pore. The cilia of the flame cell move the wastes out of the planaria as is illustrated on the diagram.

Now let us look at the earthworm. The earthworm as you know, has a closed circulatory system. It has many capillaries in its walls so that carbon dioxide and ammonia are taken in through the blood stream. It has many capillaries in the intestinal area and these can absorb some of the waste products. There are also waste absorbing cells which remove the waste products from the blood and later disintegrate leaving the waste as pigment under the surface of the skin. Water, mineral salts and nitrogenous wastes, are excreted by the pair of nephridia located in each body segment. The nitrogenous wastes are in the form of ammonia and urea. If you take a look in the text at the top of page 423 you will notice that there is an nephridium and an excretory tube that has at one end a diliated opening which we call a funnel. It also has an external opening of the excretory tube on the

far side of the tube of the body which is referred to as an excretory pore. If you will now look at the diagram that I have given you, you will see that at the top of the page in the top diagram I have the nephridial excretory tube showing. There are also funnels in each segment on the other side of the area that is shaded in black. That is where the nephridia of the earthworm are located. Another picture of this is found at the bottom of the same page.

Here is the way it works. (You will follow at the bottom of the same page.) The ciliated funnel conducts material into the nephridium through the septum which you can see at the top of the page. It conducts waste products as well as useful products, note that, as well as useful products. These then go through the tubules which are surrounded by many capillaries. A very important process takes place here. The capillaries which surround the tubules reabsorb the useful products into the blood stream, leaving the wastes inside the tubules. The material that is wasteful to the animal then goes through the tubules into the bladder and finally out through the excretory pore. This process is also common in man so I want you to pay attention to it now. The first part, the funnel, takes in useful material as well as waste material. Then

the capillaries that surround the tubules reabsorb the useful materials but not the wasteful materials. The waste materials go into the bladder, they are then conducted out of the body through the excretory pores.

Our next animal, the grasshopper, has a problem with water which is the opposite to that of the hydra, planaria or paramecium. Whereas these animals have to get rid of water, the grasshopper, being a land animal, does everything to conserve water. The hydra, planaria and earthworm could also excrete the ammonia by diffusion. The grasshopper excretes nitrogenous wastes in the form of uric acid which is non-toxic, (ammonia is toxic to cells). Man excretes urea but also quite a bit of water along with the urea so that the urea does not do any harm. The grasshopper has special structures which are referred to as malpighian tubules which empty from the cavity between the body organs. The nitrogenous wastes crystallize and since they need not be flushed out and are not toxic it is possible for the grasshopper to conserve water. The wastes are taken in by the Malpighian tubules, which are ciliated funnel-like structures that conduct the

wastes directly into the digestive tract. The grasshopper reabsorbs some of the material into the blood stream or into the body cavity as it passes through the intestine, whereas the rest of the uric acid will pass out through the rectum and anus along with the undigestible material. We have treated the carbon dioxide disposal in a previous chapter.

Before we discuss the removal of nitrogenous wastes in man we have to discuss the formation of urea. I would like you to take the second page that you were given, or, if you do not have that page, simply turn to page 425. As you know, amino acids can be used to produce energy. Amino acids are used as building blocks of proteins but if they are united with oxygen, as is shown in the diagram on page 425, they are referred to as being de-aminated. That means removing the amino group from amino acids such as alanine. From this point we have ammonia which as you know is highly toxic. Pyruric acid is produced which then can move into Kreb's cycle and produce quite a few ATP's. We are concerned with the fact that amino acids are a possible source of energy

and in this chapter we are concerned with what happens to the waste -- the amino group. The liver has the function of removing the amino groups from the amino acids thus trapping the toxic ammonia. This is done by means of a cycle referred to as the ornithine cycle. You start out with ornithine on the right hand side (following the diagram) and notice that it picks up one carbon dioxide which is floating around as a waste product. It can pick up one of the ammonias and form a new compound through several reactions which is called citrulline. The citrulline, again going through several reactions, can pick up another ammonia to form arginine. The arginine will then react with water to form urea. In other words, it can knock off what it picked up and become ornithine again as you can see from the diagram of reactions.

On pages 426 and 427 we have the kidney position and the kidney structure illustrated. Also, if you have the third page you may follow from it. The blood carries the urea from the liver, where most of the urea is formed, to the kidney. The urea is removed and goes into the bladder along with water and salts. This is what happens

in detail. The kidney has many small nephrones. These are the units that remove the waste products from our blood. The waste products that are removed from our body are urea, salts and water. Water is a waste product as well as a flushing agent. Notice the nephron at the bottom of the page. The blood comes in through the renal artery and goes into the glomerulus. The glomerulus is a capillary network inside the cup-shaped cavity called the Bowman's capsule. It is in this Bowman's capsule that the waste products as well as amino acids and sugar and other useful products are taken into the tubule out of the blood stream. All of these products, waste products as well as useful products, then go through the tubule and are separated out. The useful products, such as sugars and amino acids and others are reabsorbed by active transport into the capillaries, that is; into the blood stream. These then go into the renal vein and into the inferior vena cava. The remaining material which we now refer to as urine, keeps on going through the collecting tubules into the pelvis of the kidney. Then via the ureter into the bladder and out of the body through the urethra.

The kidney and the nephron have a very important part in homeostatic control. Anything that the blood has in it, except carbon dioxide, is maintained at a fairly constant level largely by nephrons. For example, if there is too much sugar in the blood the body does not know how to cope with it. This happens when we have diabetes. The level of sugar in the blood is so high the cells cannot use it. The nephrons remove the excess and we refer to it as diabetes which simply means that the nephrons are doing their job of releasing it from the blood. There is nothing wrong with the nephrons. They are attempting to keep the sugar at a safe level. Similarily, when you drink a lot of water or if you drink very little water the amount of urine that is produced will differ. This is simply because a fairly constant water level is maintained internally.

I would like you to refer to two sections now. On page 428 and page 430 the concluding remarks are extremely good. You should attempt to do questions number 5, and 6 at the end of this chapter.

APPENDIX G

TEST SCORES CONTROL GROUP

STUDENT	POST TEST 40 possible	PRE TEST 40 possible	NOV. BIOLOGY 100 possible
A	25	17	51
B	20	20	53
C	21	12	56
D	25	15	69
E	26	18	59
F	22	16	45
G	21	22	65
H	25	18	64
I	27	16	70
J	26	14	67
K	31	19	73
L	14	16	58
M	25	14	74
N	26	18	70
O	24	15	64
P	16	12	50

TEST SCORES — EXPERIMENTAL GROUP

STUDENT	Post Test 40 possible	Pre Test 40 possible	Nov. Biology 100 possible
AA	15	10	48
BB	22	17	69
CC	31	20	83
DD	28	21	77
EE	27	13	73
FF	27	17	71
GG	14	16	72
HH	25	16	54
II	25	11	61
JJ	26	19	70
KK	23	12	66
LL	17	17	37
MM	27	19	80
NN	25	16	44
OO	20	13	61
PP	21	14	75
QQ	30	20	77
RR	20	19	51
SS	23	13	47
TT	24	21	73
UU	19	14	80

TEST SCORES	EXPERIMENTAL GROUP		
STUDENT	Post Test 40 possible	Pre Test 40 possible	Nov. Biology 100 possible
VV	20	14	36
WW	16	7	48
XX	19	20	48
YY	16	15	85
ZZ	21	12	54

APPENDIX H

WRITING INSTRUCTIONAL OBJECTIVES

by Thorwald Esbensen

For many years, educators have talked about the importance of instructional objectives. The purpose of an instructional objective is to make clear to teachers, students, and other interested persons what it is that needs to be taught - or what it is that has been taught.

A well-written instructional objective should say three things: 1) what it is that a student who has mastered the objective will be able to do; 2) under what conditions he will be able to do it, and 3) to what extent he will be able to do it. To put the matter in a single sentence, a well-written instructional objective should specify under what conditions and to what extent a certain kind of student performance can be expected to take place.

Performance--conditions--extent. Let us consider first the word performance. Performing means doing. A student who performs something does something.

Here are two statements. Which one is expressed in terms of student performance?

A. The student will have a good understanding of the letters of the alphabet, A through Z.

B. The student will be able to pronounce the name of the letters of the alphabet, A through Z.

Statement B tells what it is that the student will be able to do. He will be able to pronounce the names of the letters of the alphabet, A through Z.

Statement A tells us that the student will have a good understanding of the letters of the alphabet. But this is not very clear. We cannot tell what it is that the student is supposed to be able to do as a result of this understanding.

Let's try another pair of statements. Which one is expressed in terms of student performance?

A. The student will have an adequate comprehension of the mechanics of punctuation.

B. Given a sentence containing an error in punctuation, the student will correct the mistake.

Statement B tells what it is that the student will do. Statement A, which says that the student will have an adequate comprehension of the mechanics of punctuation, is pretty vague. We cannot tell what it is that the student is supposed to be able to do as a result of his comprehension.

At this point, an objection may be raised. Isn't the person who is comprehending something doing something? Isn't intellectual performance an acceptable kind of student performance?

Certainly. The difficulty is that mental activity, as such, is not directly observable. We cannot literally open up a person's head and see the thinking that is going on inside. If it is to be of use to us, a statement of performance must specify some sort of behavior that can be observed.

This does not mean that we are not concerned about intellectual performance. It does mean that since mental activity, as such, is not directly observable, some sort of behavior that is observable will have to stand for or represent the intellectual performance we have in mind.

For example, suppose that we are interested in having students know something about the writing style of Ernest Hemingway. Whatever may be intellectually involved in the attainment of this goal, it should be apparent that the language of our aim as stated leaves much to be desired.

What is the student who knows able to do that the student who does not know is not able to do? This is the important question, because we cannot measure the accomplishment of our instructional purpose until we have worked out a clear answer to it. Although there is no single answer (our objective of "knowing something" is too vague for that), here is a possible statement of desired performance: Given ten pairs of short prose passages--each pair having one selection by Ernest Hemingway and one by a different author--the student is able, with at least 90 per cent accuracy, to choose the ten selections written by Hemingway.

Performance--conditions--extent. We have been talking about performance. Let us now consider conditions.

Here is one of our earlier statements concerning the alphabet: The student will be able to pronounce the names of the letters of the alphabet, A through Z. We have said that this statement is expressed in terms of student performance. Does this statement also set forth the conditions under which the performance is to take place?

It does not. For one thing, we cannot tell from our statement whether the student is to pronounce the names of the letters at sight or from memory. If the letters are to be shown, we do not know whether the student is to work with capital letters, small letters, or both. Nor do we know whether the student is to work with these letters in regular sequence or in random order. Obviously, each set of conditions is substantially different from the rest, and will make its own special demands upon the student who attempts to accomplish the objective.

Let's examine two more statements. Which one sets forth the conditions under which a certain kind of performance is to take place?

A. Given the Dolch list of the 95 most common nouns, the student will be able to pronounce correctly all the words on this list.

B. The student will be able to pronounce correctly at least 90 per cent of all words found in most beginning reading books.

Statement A, which tells us that the Dolch list will be used, sets the conditions for the demonstration of student mastery. We are told that these particular words, and no others, are the ones at issue for this objective.

Statement B, offering us only the dubious clue of "words found in most beginning reading books", does not tell us enough. Our conditions need to be defined more precisely than this.

We come now to the matter of the extent and level of performance. A well-written instructional objective will establish an acceptable minimum standard of achievement.

Look at this objective: Given twenty sentences containing both common and proper nouns, the student will be able to identify with very few mistakes both kinds of nouns. Does this objective establish a minimum standard of achievement?

It does not. It leaves open the question, how many mistakes are "a very few"?

Here is the Hemingway objective we looked at earlier: Given ten pairs of short prose passages--each pair having one selection by Ernest Hemingway and one by a different author--the student is able, with at least 90 per cent accuracy, to choose the ten selections written by Hemingway. Does this objective establish a minimum standard of achievement?

It does. The student is expected to be able to make at least nine correct choices out of the ten. This constitutes a minimum standard of achievement.

Let's try one more objective: The student should be able to pronounce from memory, and in sequence, the names of the letters of the alphabet, A through Z. Does this objective establish a minimum standard of achievement?

It does. The objective implies that we are looking for 100 per cent mastery. However, we could, if we wanted to be explicit, restate our objective in this way: The student should be able to pronounce from memory, in sequence, and with 100 per cent accuracy, the names of the letters of the alphabet, A through Z.

AN INSTRUCTIONAL objective should not ordinarily be limited to specific <u>means</u> (particular materials or methods), but should be stated in terms that permit the use of various procedures. Look at this statement of an objective: Given the California Test Bureau's E-F level programmed booklet on capitalization, the student is able to work through the exercises in this booklet with at least 90 per cent accuracy. Is this objective limited to the use of a particular instructional item or procedure?

It is. The objective is expressed exclusively in terms of performance with a specific booklet. Although the particular kind of skill development that is promoted by this booklet is presumably also fostered by other instructional materials and methods, no such options are available under the terms of our objective as it is now written.

Look at this statement of an objective: Given twenty sentences containing a variety of mistakes in capitalization, the student is able, with at least 90 per cent accuracy, to identify and rewrite correctly each word that has a mistake in capitalization. Is this objective limited to the use of a particular instructional item or procedure?

It is. The objective as expressly stated permits us to use a number of instructional items that show promise of being able to help students attain the desired performance. Among these items are not only the California Test Bureau's E-F level material but the somehwat simpler C-D level presentation, a programmed booklet by D. C. Heath, Unit 11 of English 2200, Unit 9 of English 2600, Lessons 87 and 88 of English 3200, several filmstrips on capital letters, and so on.

Finally, a well-written instructional objective will suggest how its accomplishment can be measured. This follows from our view that a well-written objective specifies under what conditions and to what extent a certain kind of student performance can be expected to take place.

Look at this objective: The student should know the alphabet. Does this objective suggest how its accomplishment can be measured?

It does not. The reason for this judgment is that knowing the alphabet can mean different things to different people. Therefore, depending upon what is meant, the measuring of this knowing will take different forms.

Suppose we elaborate upon our objective so that it reads: Shown the letters of the alphabet in random order (in both upper and lower case form), the student is able to say the name of each letter with 100 per cent accuracy. Does our objective now suggest how its accomplishment can be measured?

It does. The objective as stated makes plain how its accomplishment can be measured.

If teachers at all levels of schooling would be this explicit in writing instructional objectives, they might reasonably hope to eliminate almost immediately one major cause of learning failure among students: the traditional fuzziness of classroom assignments.

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