EVALUATION OF A SELF DESIGNED PROCEDURE FOR FORMULATING OBJECTIVES IN GRADE IX SCIENCE

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Master of Education

by

Garry W.C. Rogers

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ABSTRACT

The purpose of this study was to design and evaluate a format for writing objectives. The format must be followed easily by any science teacher who wants to create activities that will teach prescribed concepts. Variables found to influence learning of objectives were investigated and the concepts thought to be most relevant were organized, condensed and arranged on one sheet referred to as the "Activity Sheet Format" (A.S.F.).

Teachers who taught 90 students and 120 students each respectively were asked to teach the control groups and two teachers who taught 115 students and 130 students each respectively from a neighboring school in the same division were asked to teach the same chapter to the experimental groups using the A.S.F. to analyse each lesson. A pre-test/post-test design was used to investigate the differences in cognitive gains. Criterion-referenced tests were prepared by a certified teacher who had no knowledge of the methods to be used by the teachers of either group. The test period was identical for both groups.

Examination of statistical trends and mixed analysis of variance, a statistical procedure developed and written by Dr. Chebib for Stat-Pak, were employed to investigate the two independent variables for greater cognitive gains. The two independent variables were administration and preparation/administration of A.S.F. analysis.

Students taught by teachers using pre-analysed lesson plans according to the A.S.F. were found to achieve greater cognitive gains

than the students who were taught by teachers using published curriculum objectives. Students taught by a teacher who studied the philosophy and application and prepared his own lesson plans according to the A.S.F. achieved even greater cognitive gains than students taught by a teacher using lesson plans pre-analysed according to the A.S.F. A greater number of students in the combined experimental groups were found to have expressed appreciation for the science material in the content area.

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CHAPTER I

INTRODUCTION

The objectives of some texts are not stated explicitly. The implied objectives must be learned indirectly by reading information and following instructions written in such a text. In spite of the fact that the objectives are subtly injected in the context, teachers are able to construct tests and students are able to pass them. However, related activities are often omitted, the student is often required to memorize facts and the learning process is maintained at the level of simple recall. Many times physical activities prescribed by the text are observed to be taking place without the mental processes necessary to learn the implied concept. For example, one activity prescribed by the Exploring Science Nine text is: "Bend a piece of coat hanger in a hoop about a foot across. Toss the hoop anywhere on the lawn. Identify the weeds growing within the area covered by the hoop." [1] The student learns how to throw and bend a hoop. He also learns how to count weeds but, strangely enough, the review questions about random sampling go unanswered. Richard Feynman [2] cites a similar situation with respect to airplanes built by South Sea Islanders which are the same as the ones they see in the foreigners' airfields around them. Strangely enough, their wood planes do not fly. Perhaps teachers do not formulate comprehensive objectives because the tools required to do so are complex, numerous

1. Thurber, W.A. and Kilburn, Robert E., Exploring Science Nine, Allyn & Bacon, Inc., 1966. p. 9.
2. Feynman, Richard P., What is Science, The Physics Teacher., Sep. 1969.

and diffuse.

Teachers cannot be expected to research methods for formulating objectives every time the need arises. They must, however, make their own objectives if they are to meet the needs of their students. A text can list materials the students are required to learn, but the teacher must analyse the needs of his students and prescribe the appropriate representational system for them. The three representational systems listed by Bruner [3] are inactive, iconic and symbolic. Jerome Bruner states:

> The new models are formed in increasingly powerful representational systems. It is this that leads me to think that the heart of the educational process consists of providing aids and dialogues (models) for translating experience into more powerful systems of notation and ordering. [4]

When one representational system is presented by the text and the teacher knows from experience that his students will learn more efficiently by another system, then change is in order; eg., if the representational system recommended by the text is symbolic and the students are known to learn more efficiently with an inactive representation, the teacher can use that system only if the objectives of that particular section are realized. To get on with the task of formulating the representational systems, the "heart of the educational process", the teacher must know exactly what he wants to teach - his objectives.

In constructing objectives the teacher must consider not only the needs of his students but the needs of the school as well. Benjamin Bloom states that:

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3. Bruner, Jerome S., Toward a Theory of Instruction, Cambridge, Mass. Belknap Press of Harvard University, 1966. p. 10, 11.
4. Ibid., p. 21.

> It is important that the major objectives of the school must be identified if time and effort are not to be wasted on less important things and if the work of the school is to be guided by some plan. [5]

Because educational innovations are continually occurring, the role of the teacher must be dynamic. He must formulate his own objectives if he is to consider the major goals of the school and incorporate each valid innovation into his lesson plan.

Published objectives tend to be static. They reflect the goals of the author, provide one method of presentation and are sufficiently subtle to be inflexible. Without a means of analysing the context to separate them only these static objectives are likely to be taught.

THE IDENTIFICATION OF THE PROBLEM

The author believes that many teachers can be helped to construct their own instructional objectives if some tool is provided to reduce the complexity of the situation. In response to this belief he has developed and evaluated an "Activity Sheet Format". (Appendix "A"). The problem for this research thus becomes - Do Grade IX Science students taught by teachers who use the "Activity Sheet Format" achieve significantly differently from students who are taught by teachers who use the published curriculum objectives?

QUESTIONS TO BE CONSIDERED

This thesis will consider the following questions:

1. Is the achievement of students taught by teachers using

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5. Bloom, Benjamin S., Handbook 1: Cognitive Domain, David McKay Co. Inc., New York, N.Y., 1956. p. 26.

the "Activity Sheet Format" significantly increased when the teacher is given extensive training in the philosophy and application of the "Activity Sheet Format"?

2. Is the achievement of students significantly increased when the teacher is given a page by page analysis of the chapter according to the "Activity Sheet Format" as prepared by a teacher having extensive training in its philosophy and application?

HYPOTHESES

1. The null hypothesis asserts that no difference exists between the achievement of students taught by teachers using published curriculum objectives and students taught by teachers using the "Activity Sheet Format" when the teacher is given extensive training in the philosophy and application of the "Activity Sheet Format".

2. The null hypothesis asserts that no difference exists between the achievement of students taught by teachers using published curriculum objectives and students taught by teachers using the "Activity Sheet Format" when the teacher is given a page by page analysis of the chapter according to the "Activity Sheet Format" as prepared by a teacher having extensive training in its philosophy and application.

THE ACTIVITY SHEET FORMAT

DEFINITION

The "Activity Sheet Format" is a functional procedure to be used by science teachers for establishing instructional objectives which can be integrated with activities providing meaningful learning

experience for their students. According to Jerrold Kemp:

> Learning requires active effort by the learner. Thus, all objectives must be stated in terms of activities that will best permit student learning. [6]

The "Activity Sheet Format" is consistent with the aforementioned philosophy. The "Activity Sheet Format" will hereafter be referred to as the A.S.F.

APPLICATION

The "discovery approach" is an integral part of science instruction and its use is recommended strongly by the Department of Education in Manitoba. The student must participate in some activity if he is to discover. According to Bloom [7], a direct relationship between the activity and the objective of the lesson must exist or time and effort are wasted on less important things. Bloom also states:

> The final selection and ordering of the objectives become a matter of making use of the learning theory and philosophy of education which the faculty accepts. [8]

The "Activity Sheet Format" has been developed to supplement regular group instruction and incorporate major learning theories with the basic philosophies outlined in the Manitoba Science curriculum grades 7 - 9.

DESCRIPTION

The format of the A.S.F. (Appendix "A") is organized according

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6. Kemp, Jerrold E., Instructional Design, Fearon Publishers, Belmont, California. p. 19.
7. Bloom, op.cit., p. 26.
8. Ibid., p. 26.

to the following headings. A description and rationale for each of these headings is as follows:

A. Definition. A definition provides the vocabulary to be used or associated with the activity. This will lead to a prolonged retention and an intuitive notion of the word. It is desirable, according to George Mallinson, "to keep the essential vocabulary at the appropriate level." [9] Consideration of each new word to be used in the activity ensures that it will be used wisely rather than the unfortunate case where it becomes the basis of exercises in which science terms and their meanings are memorized. Mallinson goes on to summarize the need for definitions by saying,

> ... nearly everyone recognizes that the laboratory must be more than an environment for the expenditure of calories through the manipulation of hardware and preoccupation with isolated experiences. It must provide opportunity for developing meanings and perceptions of the experiences offered. [10]

B. Objectives. "If you are not interested in demonstrating achievement of your objectives you have just finished reading this book" [11], is the final sentence of the preface of Albert Mager's book, Preparing Instructional Objectives. It is important that each objective begins with - "After completing this activity the student should be able to ...." [12] In his final summary Mager explains that one must know exactly what the learner will be doing when demonstrating his achieve-

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9. Mallinson, George G., Science Learning and the Problem Reader. p. 2.
10. Ibid., p. 5.
11. Mager, Robert F., Preparing Instructional Objectives, Fearon Publishers, Educ. Div., Belmont, Calif. Preface.
12. Ibid., Preface.

ment; thus it is necessary to define criteria, givens and/or restrictions. A separate statement is written for each objective to ensure clarity. What should be included in objectives? R. M. Gagne infers that task analysed intellectual skills or capabilities specified in operational terms should be our objective. Objectives should be stated in behavioral terms since psychology has been successful in suggesting ways of teaching only when objectives have been operationally clear. Bruner believes objectives should be strategies which would produce superior problem-solving capabilities. Ausubel rejects strategies, processes and skills - advocates mastering well organized bodies of subject matter knowledge. E. R. Hilgard concurs that "each theory of learning accounts for some phenomena very well but it is less adequate in accounting for others." 13 The Activity Sheet Format is an attempt to include major theories of learning in an attempt to be adequate in accounting for phenomena. The page from the text or curriculum to be chosen as suggested under the subheading 'Content' on the A.S.F. ensures that well organized bodies of knowledge will be taught. Intellectual skills and problem-solving capabilities will be learned if the processes are injected appropriately into each lesson plan. The A.S.F. provides the opportunity for each teacher to analyse each situation and emphasize the theory he feels is most appropriate and at the same time incorporate any or all of the other theories in each lesson.

To facilitate the formulation of objectives within the framework of Bloom's taxonomy, a table of verbs has been included which is

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13. Hilgard, E. R. Theories of Learning, 2nd ed., New York, N.Y. Appleton-Century-Crofts, 1956.

arranged in a sequence from simple to complex. Each verb has been selected to be directly applicable to science.

The content in the introduction of most chapters is mainly definitions. If this content is used to teach simple processes and if simple verbs are used to word these objectives, then very precise basic objectives can be constructed. Towards the end of each chapter integrated processes and complex verbs can be included more frequently to ensure that higher mental processes will be utilized. Again, according to Bloom, "an overall plan must be followed if time and effort are not to be wasted on less important things." 14

C. Materials: Materials are listed separately so they can be organized ahead of time. This prevents interruption of thought processes as the student performs the activity and eliminates the necessity of of teacher wasting time deciding which tools are required each time the activity is assigned.

D. Activity: The activity section is a set of instructions to be given to the students. A reminder in the form of the statement "that the verbs and processes from the charts above can be used to word activity instructions" permits activities to be directly related to the objectives. It can be assigned verbally, reproduced on transparencies or chalkboard or duplicated on 'work sheets'. If the activity requires a lengthy description, it is typed on a separate page, referred to as a 'work sheet' to facilitate reproduction. If the reading level of the objective is such that the students would not be confused, then they could be given the whole 'activity sheet'.

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14. Bloom, op. cit. p. 26.

E. Discussion: The 'discussion' is a vital part of the discovery approach since all students will not learn all concepts just by 'doing the activity'.

F. Rationale: The rationale is included to promote a review of the completed analysis. It is hoped that, if an attempt is made to justify the inclusion of each objective, Kemp's conditions will be satisfied and activities will be stated in terms of objectives. Albert Canfield [15] says that rationale is needed for each activity. He says it can be an even more powerful tool if it includes a statement as to why the student is being asked to perform in this manner.

The analysis of a page of a text according to the A.S.F. is an activity for the teacher to perform so that he will know exactly what objectives are to be taught by a specific activity. An overall philosophy of this paper is that any explanation of an activity to be used as a learning experience should include each of the topics from Appendix "A". Those steps have been followed in preparing the A.S.F. as an activity for teachers to use for preparation of a lesson. Careful analysis of each aspect of this chapter will reveal that an attempt was made to include each A.S.F. topic.

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15. Canfield, Albert A., A Rationale for Performance Objectives, Audiovisual Instruction, Feb. 1968. p. 128.

CHAPTER II

REVIEW OF RELATED LITERATURE

INTRODUCTION

The prevalent attitude during the gathering of background information for this investigation was that a basic philosophy should be established that would provide a foundation for changing instruction. Once the importance of objectives was realized it became apparent that the complexity of writing comprehensive objectives might deter teachers from attempting to use them; hence a need for an organized concise procedure for constructing objectives was deemed necessary. A search for a logical sequence and topics ensued to determine some major concepts that might provide a basic outline and some clear, precise terminology.

It was decided that to be meaningful the information should be available for discussion and interpretation. It is for this reason that opposing as well as supporting articles are included and the author's opinion is interjected occasionally. The related literature has been organized under a series of topics. Each represents an area related to the investigation. The topics are:

1. The discovery approach
2. Topics for the A.S.F.
3. Establishing a need for the A.S.F.
4. Applications of the A.S.F.
5. Limitations of the A.S.F.

THE DISCOVERY APPROACH

DEFINITIONS

The A.S.F. was designed to supplement regular group instruction. The A.S.F. presupposes the use of the discovery approach if the recommendations of the Manitoba Department of Education are to be followed. This necessitated an inquiry into the definition of the 'discovery approach'. The discovery approach is based on "the student learning rather than on the teacher teaching." [1] The discovery approach provides guidance and inspiration to develop scientific thinking in students. [2]

To promote student learning the teacher must provide some inspiration and guidance. This can be achieved only if the teacher understands the objectives of his students' activities. The basic philosophy of this study was, therefore, established with the combination of these two definitions and the major goal of the discovery approach as stated by the Manitoba Department of Education. "A major goal of the discovery approach is the development of intellectual independence." [3]

RATIONALE

Since the final topic of the A.S.F. requests the teacher to provide a rationale for the inclusion of each objective, the author felt obliged to justify the use of the discovery approach even though

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1. Gagne, R. M. and Brown, L. T. "Some Factors in Programming of Conceptual Learning", Journal Experimental Psychology, 62, 1961, pp. 313-321.
2. Department of Education, op. cit. p. 3.
3. Ibid., p. 1.

it is the procedure recommended for regular group instruction. Gagne and Brown suggest that "what is learned is less important than how it is learned." [4] This is one outcome of a study to determine the effects of including the strategies of inquiry on problem-solving abilities. Gagne and Brown further suggest that "learning performance is higher when guided discovery is used." [5] Chester Raun and David Butts studied the cognitive and affective behavior change due to inquiry and involvement designed curriculum. They state that

> evidence seems to suggest that the opportunity to be an active participant in learning activities, rather than a passive recipient, to be involved in experience opportunities in which the teacher guides rather than tells, leads to increased student interest. [6]

In his article, "Learning for Mastery", Benjamin Bloom states that

> if school learning is regarded as frustrating and even impossible by a sizeable proportion of students, then little can be done at later levels to kindle a genuine interest in further learning. [7]

If active participation can increase student interest and therefore reduce the frustration of students, it must have some effect on future achievement.

Student learning through active participation requires thorough organization by the teacher to provide guided discovery. If the discovery is to be guided the teacher must know how to guide his

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4. Gagne and Brown, op. cit., p. 321.
5. Ibid., p. 317.
6. Raun, Chester E. and Butts, David P. "The Relationship Between the Strategies of Inquiry in Science and Student Cognitive & Affective Behavioral Change" Journal of Res. in Science Teaching, 5:207 (1967-68) p. 207.
7. Bloom, Benjamin S. "Learning for Mastery", U.C.L.A. Evaluation Comment, Vol.1, No.2, May, 1963., p. 2.

students through activities that will cause them to learn the material specified in the objectives. A systematic and complete guide is necessary if this is to be accomplished.

TOPICS FOR THE ACTIVITY SHEET FORMAT

The intent of this paper is not to debate the merits of all learning theories. The purpose is to summarize and organize some of them so as to construct a concise, handy but efficient sheet to be used in formulating objectives. There are many topics and sub-topics that may have been included. The following topics are considered to be most relevant for this study.

DEFINITIONS

Careful consideration must be given to each word that may be new to the student in each activity. George G. Mallinson's study was intended to investigate the relationship between the student's reading ability and his achievement in science. Mallinson lists a number of techniques that will increase student achievement in science through the proper use of scientific vocabulary. He suggested that:

> vocabulary load was not the sole criterion of the level of reading or learning difficulty of materials. An even more important criterion of difficulty seems to be the matrix of non-technical vocabulary and the writing style in which the scientific vocabulary appeared. [8]

He also states that "reading has been closely related to the attainment of the objectives of science teaching." [9]

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8. Mallinson, George G., Science Learning and the Problem Reader (See Appx. "F" for explanation of incomplete footnote)
9. Ibid., p. 7.

Mallinson suggests it is necessary to consider technical vocabulary as well since "the laboratory must provide opportunity for developing meanings and perceptions of the experiences offered." [10] This consideration of each new word is to ensure that it will be used wisely rather than the unfortunate case where it becomes the basis of exercises in which science terms and their meanings are memorized. [11]

OBJECTIVES

A need for objectives. It is necessary to establish a need for objectives since this study is based upon the supposition that there are basic concepts, processes and content each student must learn. Some authors who have studied educational objectives are Tyler, Bloom, Gagne, Glaser, Popham, Popham, and Baker and Synd and Picard. Bryant, who studied the relationship of instructing student teachers to use and construct performance objectives and their effectiveness in the classroom states that:

> the results of the study show that training teachers to use performance objectives had a significant effect on student cognitive achievement. [12]

If student cognitive achievement is increased through the use of objectives then there is a need for them.

Validity. The number of studies cited to determine a need for behavioral objectives have been researched by persons who may have overlooked some of the drawbacks in their determination to achieve

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10. Ibid., p. 2.
11. Ibid. p. 10.
12. Bryant, Napoleon Jr., and Anderson, Hans A., "Effects of Performance Objectives on Achievement", Journal of Res. in Science Teaching, Vol.9,No.4, p. 369.

their own objectives. These authors might have neglected to study the negative aspects of objectives. Some authors have opposed the writing of objectives stated in terms of measurable learner behaviors. Popham examines eleven reasons for opposing behavioral objectives. This work would be interesting reading for teachers who use behavioral objectives or teachers who oppose their use. Popham states:

> While these 11 reasons are not exhaustive, they represent most arguments used to resist the implementation of precision instructional objectives. The objections against behaviorally stated goals are not strong enough. To secure a dramatic increase in instructional effectiveness, we must abandon our customary practices of goal-stating and turn to a framework of precision. 13

For authors who have studied objectives to delve deeply into the rationale for each aspect of specific objectives would only confuse the reader's understanding of basic principles. Rather than discuss the pros and cons of each objection, James Popham explains how each objection is a misconception or wrong application of objectives. He explains that a framework of precision increases the effectiveness of a teacher because students and teacher realize more specifically where they are going. The idea that precision implies limitations is realized to be a misconception.

Wording of Objectives. By definition a behavioral objective requires that a student should be able to demonstrate the achievement of his objectives. Each objective should therefore begin with "After completing this activity, the student should be able to ...." 14 It is necessary to know exactly what the learner will be doing when

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13. Popham, James W., Probing the Validity of Arguments Against Behavioral Goals, Rand, McNally & Co. 1968.

14. Mager, op. cit., Preface, p. i.

demonstrating his achievement; thus it is necessary to "define criteria, givens and/or restrictions." [15] A major objection to full implementation of Mager's scheme is that it may stifle inquiry by preventing divergent questions. These statements from Mager's summary provide a framework of precision around which the teacher may formulate objectives. The teacher and student both know how well the student is to perform. The teacher knows what materials or information must be given the student and the student understands what he will receive. Both realize performance is to be demonstrated under certain conditions. This mutual understanding ensures that no confusion will exist for either party. Precise statements can provide a basis for divergent lessons since the end result will be firmly established in the mind of the teacher and the student.

Ordering of Objectives. The order in which material is presented is as important as the content itself. According to Bloom, "an overall plan must be followed if time and efforts are not to be wasted on less important things." [16] Bloom's taxonomy suggests a presentation of objectives from simple to complex. (See Verb Table in Appendix "A").

The Intellectual Development Stages of Piaget interpreted by Anderson and presented by Chittendon, give the reader an overall look at the relationship between general age range and the characteristics of that stage pertaining to problem solving activities. This article causes the reader to become aware that if teachers "teach them [the students] something too quickly, we keep them from reinvent-

15. Ibid., Final Summary.
16. Bloom, op. cit. p. 26.

ing it themselves." [17] Any attempt to consider these stages of development is beyond the scope of the "Activity Sheet Format" but a very good list of tasks that can be performed by 13-year olds is given in National Assessment of Educational Progress - Science Objectives. [18] Consideration should be given to the sequence of presentation and the A.S.F. has been constructed to ensure order through the chart of verbs arranged from simple to complex. Consideration of the Intellectual Development Stages could not be accomplished without a more complex lengthy format sheet.

Content of Objectives. The content of any lesson should not consist of a list of facts to be memorized. Harry Wong states:

> There are three levels of learning in the ITS program - concepts, processes and values. The three levels of learning do not take place in isolation. Attitudes, cognitive processes and concepts must be learned as a totality of human experience. 19

The A.S.F. is intended to serve as a reminder that there is more to be considered than the factual information in a text.

Five hundred American scientists and teachers contributed to the developmental process of "Science - A Process Approach", over a period of nine years. Each time a major change was made the revised edition was tested in a variety of schools across the U.S.A. The processes were to be taught within the framework of prescribed

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17. Chittenden, Edward A., "Piaget", Science and Children. Dec. 1970. p. 1,2.
18. Committee on Assessing the Progress of Education, National Assessment of Educational Progress - Science Objectives, 1969, National Assessment Office, 222 Fuller Rd., Ann Arbor, Michigan.
19. Wong, Harry K., and Solmotz, Melvin S., Ideas and Investigation in Science, Prentice-Hall Inc., Inglewood Cliffs, New Jersey, 1971., p. 15.

subject matters and novel thought was to be injected wherever possible.

> It rejects the "content approach" idea. It substitutes a notion of having children learn generalizable process skills, but which carry the promise of broad transferability across many subject matters. It rejects the notion of highly generalizable "creative ability" as a unitary trait. It adopts the idea that novel thought can be encouraged in relation to each of the processes of science. [20]

The A.S.F. provides the opportunity for each teacher to analyse each situation and emphasize the process he feels is most appropriate and at the same time encourages novel thought in each lesson.

OBJECTIVE ORIENTED ACTIVITIES

Activities performed by students may be good exercise. Some activities may even develop coordination, a healthy mind or a better appreciation for the student's abilities and surroundings. If specific science objectives are to be taught through activities, some scheme must be followed. A need for such a scheme is recognized by several authors. J. S. Bruner, in his book The Process of Education, suggests that performance by the student is necessary in order to know what he has understood. [21] Piaget agrees that learning is provoked by situations and must involve active assimilation. [22] Kemp goes one step further when he points out that "all objectives must be stated in terms of activities that will best permit student learning." [23] A method that might allow a teacher to describe acti-

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20. Science Process Approach, Xerox Corp. U.S.A., Appx. p. 293, 298, 299.
21. Bruner, J. S., The Process of Education, Random House, New York, 1960.
22. Piaget, J. "Development and Learning", Journal of Res. in Science Teaching 2. (1964) p. 176-187).
23. Kemp., op. cit., p. 19.

vities in terms of the objectives he expects his students to achieve is stated in the A.S.F. under the heading "Activity". The method is to try to use the same verbs, processes and content when writing out the description of the activity that were used in wording the "objectives."

JUSTIFICATION FOR THE SECTION HEADED "RATIONALE"

Canfield agrees with Mager's three elements of a behavioral objective (task, conditions and criteria) in an article entitled "A Rationale for Performance Objectives" but he says:

> One modification needed in statements of behavioral objectives is the inclusion of a statement of rationale or justification stating why the learner should achieve the objective.
>
> While a behavioral objective specifying tasks, conditions and criterion can provide an objective basis for instruction and its evaluation, it does not provide any inherent motivation for the learner. The conventional statement of objectives clarifies what the learner is being asked to do, but it can be an even more powerful tool if it includes a statement as to why he is being asked to perform in this manner. [24]

A NEED FOR THE "ACTIVITY SHEET FORMAT"

Many occasions arise where the teacher is required to formulate his own objectives and/or prepare activities. Kemp agrees that the only way to convince teachers to use behavioral objectives is for each teacher to try formulating his own objectives.

> It is not until the value of objectives to an instructional program become important that the teacher will be willing to put sincere effort

24. Canfield, op. cit., p. 128.

> into preparing them. Then the difficulties and frustrations are taken in stride and the individual gradually develops a habit and pattern for describing the desired outcome for student learning in specific unambiguous terms. [25]

Perhaps the "Activity Sheet Format" will provide a pattern that will reduce difficulties sufficiently to inspire teachers to put a sincere effort into preparing them.

John Koran, Earl Montague and Gene Hall agree that imparting knowledge to teachers of the theory and functional application of behavioral objectives will provide the teacher with additional information with which he can make more effective decisions. [26]

GENERAL APPLICATION

Murdock Macdonald says:

> In solving the problem which the student considers relevant for him, he learns to explore, to collect data from all sources, make choices, consider alternatives and reach his own conclusions. These processes then would seem more important than the content. [27]

If the teacher is to include these processes, he must have a scheme that will incorporate them into the general objectives he must teach.

EXTENSIONS

The duties of the teacher are becoming more demanding due to high speed information movement. The teacher must extend his objectives to include relevant topics.

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25. Kemp. op. cit., p. 19.
26. Koran, John J. Jr., Montague, Earl L., and Hall Gene E., "How to Use Behavioral Objectives in Science Instruction", National Science Teachers Association, 1969,p.2.
27. Macdonald, Murdock K., "Education and the Innovative Society", 46th Conv. of C.E.A., The Canadian Education Assoc. Toronto 5. Sep. 1969, p. 26.

Macdonald in The New School says:

> Our old information system is no longer adequate — and if education is viewed as the transmission of content from text books, it will not be accepted by young people who have always lived in a world of high-speed information movement. What we used to call facts do not always represent the truth to them and certainly many of these facts are hopelessly out of date before they are printed. [28]

> It would seem that principals and teachers have to set aims and objectives and then help plan the environments in which these can be carried out. [29]

The "Activity Sheet Format" is an attempt to provide a tool to facilitate the writing of these aims and objectives.

Existing innovations such as the issue-centered curriculum and the inquiry method must be incorporated into the teacher's lesson plan. Michael Andrew agrees that the processes should be included in lesson plans. His reason is that

> a skill such as inferring or predicting has a wide applicability in many disciplines and could serve as the major emphasis for cross-discipline curriculum planning. Inter-disciplinary, issue-centered curriculum offers an alternative. Socially relevant issues are presently treated in curriculum in partial, incomplete and often misleading or irrelevant form. [30]

The role of the teacher is dynamic since issues and the needs of his students are constantly changing. If a teacher is to incorporate issues in his lesson and at the same time meet the needs of his students at any point in time he must formulate his own objectives.

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28. Macdonald, op. cit., p. 26.
29. Ibid., p. 30.
30. Andrew, Michael D., Issue Centered Science, "An Integrated, Interdisciplinary Approach to Curriculum". March, 1969. p. 3.

The A.S.F. can be used to ensure that socially relevant issues are treated in an organized relevant form.

According to Andrew, "if the issues are of global and enduring nature and if they reflect prevalent social concern, then the issue centered curriculum will carry inherent justification as having educational value." [31] If issues are to be incorporated in lesson plans the only person who can relate issues to the needs of his students and formulate appropriate objectives is the classroom teacher. Andrew also states that "discovery learning is another educational ruse in which their discoveries are predetermined and prejudged. Issues may provide the authenticity which invited real involvement". [32]

John Renner and Donald Stafford in their article, "Inquiry, Children and Teachers" have found that

> Inquiry-educated teachers employ what they have learned about inquiry. They encourage pupils to become involved in experience and find their own answers to problems. Pupils learn how to do this systematically and scientifically if they are given the chance. Inquiry-educated teachers question more and tell less. [33]

An inquiry-oriented lesson will undoubtedly initiate divergent questions. The teacher must have each objective of his lesson precisely analysed if he is to achieve his goals, especially when divergent questions may cause him to meander. Precise analysis can be accomplished through the use of the A.S.F.

Assistance in accepting new ideas. In his article "Non-Graded-

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31. Ibid., p. 3.
32. Ibid., p. 3.
33. Renner, John W. and Stafford, Donald G., "Inquiry, Children and Teachers,". The Science Teacher, Apr. 1970. p. 56.

ness", Bob F. Steere [34] blames lack of acceptance and enthusiasm on failure to provide evidence of the advantages in incorporating non-gradedness. Perhaps many innovations are not accepted because of a lack of tools with which they can be implemented. To "individualize education" one must have very specific goals. To have very specific goals one must have a workable method to formulate objectives. The A.S.F. is an attempt to provide such a workable tool.

APPLICATION OF THE "ACTIVITY SHEET FORMAT"

GENERAL APPLICATION

Even material in texts should be analysed by teachers. Texts such as Exploring Science Nine provide students with information that will allow them to "understand the methods and philosophies of science so that they can carry out investigations with a minimum of direct guidance by teachers." [35] But R. M. Gagne suggests that "it seems reasonable to consider that strategies are mediating principles which do not appear in the performance of the task itself." [36] Teachers must understand the "mediating principles" if they are to be sure their students are utilizing the proper mental processes necessary to learn the concepts represented by the objectives. The teacher must formulate his own objectives so that he can provide some guidance for his students. One of the five variables for Mastery Learning Strategies is "the ability

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34. Steere, Bob F., "Non-Gradedness", Curriculum Bulletin, Manitoba Dept. of Education, Vol.7,#1,Nov. 1972,p.7.
35. Thurber & Kilburn, op. cit., Preface.
36. Gagne, R.M., The Analysis of Instructional Objectives for the Design of Instruction. Mimeograph American Inst. for Research p. 45-46.

to understand instruction." [37] Bloom defines the "ability to understand instruction as the ability of the learner to understand the nature of the task he is to learn and the procedures he is to follow in learning the task." [38] If the teacher has not analysed and understood the material in the text, it will be very difficult to transmit the nature of the task to the learner.

EXTENSION

The application of the A.S.F. can be extended to defining teacher roles in the administration of innovations.

Three statements are made by Roy Edelfelt in his article, "Differentiated Staffing - Where are We?"

(1) Involve teachers and plan in terms of educational purpose.
(2) Will teachers be able to participate effectively in planning?
(3) They would have to perform these new roles.[39]

Edenfelt says "roles couldn't be predicted and they couldn't be devised without considering the purposes and settings in which they were to be used." [40] Tools such as the "Activity Sheet Format" might be developed by teachers who assume an active role in educational planning. The A.S.F. can provide a stable format so that teachers will have a framework that will provide confidence through uniformity.

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37. Bloom, Hastings and Modaus, Formative and Summative Evaluation of Student Learning, McGraw-Hill Publishers Toronto. p. 18.
38. Ibid., p. 18.
39. Edelfelt, Roy A., "Differentiated Staffing - Where Are We?" The Manitoba Teacher, May, 1972, p. 6,7.
40. Ibid., p. 7.

LIMITATIONS OF THE A.S.F.

The "Activity Sheet Format" is by no means the final word in preparing objectives, but it may alleviate the "demanding mental effort required that causes many teachers to shy away from stating precise objectives" [41] until a 'habit or pattern' is developed. Further rationale, application and content of objectives can be pursued once some confidence has been achieved through the use of the A.S.F. The following is a suggested sequence and accompanying rationale to study if the reader wishes to improve his proficiency in formulating objectives.

The lessons in Science - A Process Approach [42] prove to be very useful in providing examples of the use of each process. Many implications of a process can be derived by reading the exercise associated with it. Behavioral objectives for each process are listed as an introduction to each exercise. Teachers can not only obtain an idea of verbs and direct objects that can be used, they can use many objectives verbatim.

The Summary Description of Grade Nine Science Objectives and Test Items [43] was helpful in providing ideas for this work since the groups in the study were grade nine students. Many authors have attempted to inject Bloom's taxonomy into science or general objectives. This article was found to be very helpful since "The purpose

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41. Kemp. op. cit., p. 19.
42. Science - A Process Approach, Xerox Corporation. U.S.A., Appx. p. 293,298,299.
43. The High School Entrance Examination Board, Department of Education, Edmonton, Alta. 1965. Summary Description of Grade Nine Science Objectives and Test Items.(Rev.Ed.)

of this paper is to simplify and adapt Bloom's taxonomy to Grade Nine Science and illustrate it with objectives and items from Grade Nine Science." [44]

FURTHER REFINEMENTS TO IMPROVE THE FORMULATION OF OBJECTIVES

A number of variations in wording and content are recommended by different authors. Some examples of the type of material that can be included to construct more effective objectives is found in Behavioral Objectives and Instruction. [45] In this book Robert Kibler, Larry Barker and David Miles "facilitate the formulation of statements of specific behavioral objectives within the framework of Bloom's taxonomy by means of a table which includes infinitives [similar to the "Activity Sheet Format" verbs] and direct objects." [46]

CONCLUSION

It has been realized from this investigation that a text can provide a useful guide for the teacher and some information for the student, but there are many aspects of education that cannot be found in a text. Many of the new theories that cannot be printed in a text will improve instruction if they are applied in an organized manner. This is not meant to imply that a teacher should jump on the bandwagon each time a new theory is developed but that he should consider the advantages of each innovation and decide if it suits his situation. To apply a new theory appropriately the teacher must in-

44. Ibid., p. 2.
45. Kibler, Robert J., Parker, Larry L. and Miles, David T., Behavioral Objectives and Instruction, Allyn and Bacon Inc. 1970.
46. Ibid., Appendix.

corporate it into his lesson plan. The number of items necessary to construct an efficient lesson plan which includes a new theory are so numerous that a teacher should not be expected to memorize all of them. Much of the information required to construct a comprehensive lesson plan has been organized and condensed from the review of literature. This information was valuable in the construction of the "Activity Sheet Format". (Appendix "A")

CHAPTER III

EXPERIMENTAL DESIGN

This study is concerned with the influence of the experimental factor, the "Activity Sheet Format", on the dependent variable, student achievement. After due deliberation, statistical manipulation was considered the most efficient method of studying the effects of two methods of teaching on pupil learning. It was then necessary to recruit teachers to teach according to each method and to select the student population. Criterion-referenced tests were administered to control and experimental groups before and after treatment. The difference between each pre-test and post-test was analysed to find out if a significant difference at the .05 level exists between the experimental and control groups. Any significant change in a positive direction was interpreted to indicate a more efficient method of instruction.

SELECTION OF SAMPLES

SELECTION OF TEACHERS

There are 18 Grade Nine science teachers in St.James-Assiniboia. The coordinator of the science section of the April St.James-Assiniboia in-service allotted the last half hour of the session to the recruitment of participants for the testing of the A.S.F. (see Appendix "C"). Two teachers who taught 90 and 120 students respectively, volunteered to participate as control group teachers. Two teachers from a Junior High School 6 blocks away who taught 115 and 130 students respectively volunteered to teach their students using the experimental method.

REPLICATION

To minimize any differences between two subjects, a multi-comparison of a large number of cases of the control and experimental group was made within the same experiment. This was accomplished because all participating teachers taught at least 90 students. Two control and two experimental groups were combined within the framework of the experiment in order to replicate the teacher variable which is not replicated when only two groups are compared.

CONTROL GROUPS

The control group was made up of 210 students from a Junior High School in St. James-Assiniboia. Each of two teachers used his own methods of instruction to teach his students using published curriculum objectives. Random determination of which teachers would teach the experimental and which teachers would teach the control group was not possible since the two control group teachers agreed to participate only if they could use their own methods. This is considered to be advantageous to the control groups because higher teacher motivation is retained by allowing them to use methods they want to use. (See Appendix "B")

EXPERIMENTAL GROUPS

One experimental group teacher who taught 115 students prepared his lesson plans according to the A.S.F. The activities resulting from these lesson plans were also administered by that teacher. This group of 115 students will hereafter be known as Experimental Group #1. In order to determine if the A.S.F. would be of any assist-

ance to a teacher who had no experience in teaching the chapter, another teacher was asked to participate in the experiment. She agreed on the condition that the chapter were analysed according to the A.S.F. (Appendix "B") and her responsibility would lie in the administration of the activities only. She was accepted in order to investigate the possibility of finding out if the A.S.F. was effective when activities were organized according to the A.S.F. by another teacher. This latter group of 130 students will be referred to as Experimental Group #2.

TESTING

TEST CHAPTER

Some chapters in the Exploring Science Series text receive no mention in the curriculum while others are 'optional'. "Life in the Past" was chosen to be the test chapter (see Appendix "B") because:

(1) It is designated by the Manitoba Department of Education as one of ten 'recommended' chapters, (Appendix "C" ii)

(2) The decision to conduct the tests was made in March of 1973 and "Life in the Past" was the chapter most teachers had postponed until the end of the year.

TEST PREPARATION

Since a prime objective of our schools is student achievement, this factor was used to determine the validity of the A.S.F. A pre-test/post-test design was chosen to determine if the experimental group would achieve at a significantly higher level than the control group. The pre-test was a prior knowledge test constructed by an experienced certified teacher who had no knowledge of the teaching methods to be used by the experimental or control groups. He was supplied with a copy of the curriculum (Appendix "D" ii), the prescribed text (Appendix "B"), the workbook published to be used in conjunction with the text (see Appendix "C" i), all test items applicable to the chapter from all standardized science tests available from the Manitoba Text Book Bureau (Appendix "C" iii) and all test items received from four teachers who submitted them in response to a request made at the previously mentioned in-service. He was requested to subtract from or add to the test items as he saw fit. He constructed the post-test from the same material. Two requests were made concerning test construction:

(1) that items considered more general and easier be at the beginning of the pre-test, and

(2) that, if similar items were used on both tests, they were to be assigned the same number.

To be as objective as possible he was asked to construct two tests of fifty multiple choice questions. Five choices were to be allotted to each question.

TEST ADMINISTRATION

The procedure outlined in the previous paragraph was followed

because the author participated in the study. A further precaution to prevent any 'teaching for the tests' was to have the tests prepared, duplicated, counted and stored three months before they were to be administered. The test was delivered to each teacher not more than one day prior to the date it was administered. To minimize the maturity factor, all participants were requested to complete the experiment between May 10 and June 23. This schedule was adhered to by all participants.

The pre-test was labelled General Science Test (Appendix "D"i). All general easy questions were written at the beginning and supervisors were instructed to tell their students that "this is a test to determine how much general knowledge you have of science." The purpose of this procedure was to prevent 'scaring off' students so the students would continue to answer all questions to the best of their ability. The post-test (Appendix "D" ii) was labelled and administered as a normal chapter test. This testing procedure was followed to reduce the possibility of the Hawthorn effect [1] influencing students to be more diligent or indifferent than normal.

TEST VALIDITY

To assure that each test will be as valid as possible, the following procedures were followed:

(a) All test items were chosen by a qualified science teacher.

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1. Krech, David; Crutchfield,Richard; Ballachay, Egerton L; Individual in Society, McGraw-Hill Book Co. Inc. 1962, p. 52.

(b) All test items were chosen from materials associated with the text recommended by the Manitoba Department of Education (see Appendix "B", "C"ii and "C"iii).

(c) A point biserial correlation was calculated for the control group and experimental groups to determine if each item is substantially correlated with the criterion.

DELIMITATIONS

This study is designed to determine if the "Activity Sheet Format" is an aid that is effective to increasing the achievement of students who are enrolled in Grade Nine science in St. James-Assiniboia for the chapter "Life in the Past".

LIMITATIONS

The scope of this study is limited because:

(a) Neither the pre nor post test was tested for reliability or validity.

(b) Some questions on the pre-test were slightly different in wording and content from questions in the post-test.

(c) Random sampling procedures were not used to select experimental and control groups.

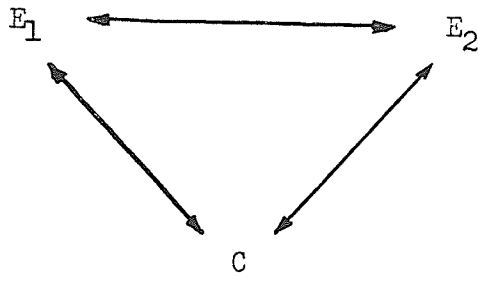
(d) The only chapter tested was "Life in the Past" from the "Exploring Science Nine" text.

(e) Two schools in the St. James-Assiniboia area constituted the sample for the study.

COLLECTION AND TREATMENT OF DATA

PRE-POST TEST COMPARISON

Pre-test and post-test scores were obtained for Experimental Group #1, Experimental Group #2 and for the Control Group. Mixed analysis of variance (Anvamix) was used to treat this data in accordance with the following design



Mixed analysis of variance allows the investigator to determine:

1. If there is a significant increase between pre and post test scores for all groups.
2. Whether or not the significant increase in pre/post-test results was significantly different between groups.

Each group was compared with every other group simultaneously and a significant F ratio was obtained only if all differences were significant.

ANALYSIS OF PRE/POST-TEST ITEMS

A point biserial correlation was administered separately for each group in each test to determine if each question was equally valid for each group.

STUDENT OPINIONS

In order to determine if there was a change in student attitude toward chapter content, items from the pre and post-test dealing with student attitude were compared. This data was represented as percentages of students who answered each question.

TEACHER COMMENTS

Comments were solicited from each participating teacher. These comments were treated as descriptive data.

CHAPTER IV

ANALYSIS OF THE DATA

A review of the basic design and procedures of this study is presented before proceeding with descriptive statistical trends.

The major purpose of this study was to develop a format sheet that would enable a teacher to write comprehensive objective-oriented activities and evaluate its effectiveness in terms of student achievement. Variables found to influence learning by other researchers were studied and the information condensed and arranged on a single sheet to promote teacher use through convenience, ease of comprehension and completeness.

The hypotheses to be statistically analyzed are

1. This null hypothesis asserts that no significant difference exists between the achievement of students taught by teachers using published curriculum objectives and those students taught by teachers using the "Activity Sheet Format" when the teacher is given extensive training in the philosophy and application of the "Activity Sheet Format".

2. This null hypothesis asserts that no significant difference exists between the achievement of students taught by teachers using published curriculum objectives and those students taught by teachers using the "Activity Sheet Format" when the teacher is given a page by page analysis of the chapter according to the "Activity Sheet Format" as prepared by a teacher having extensive training in its philosophy and application.

To test these hypotheses objectively, two fifty-question multi-

choice criterion referenced tests with five choices per question were constructed by a certified teacher who was not aware of teaching methods to be used by the control or experimental groups.

The criterion-referenced test scores of 210 students taught by two control group teachers were obtained from tests administered before and after they were taught concepts from published curriculum objectives. The same tests were administered to 245 experimental group students before and after they were taught by teachers using the A.S.F. Experimental Group #1 teacher analyzed and presented the concepts of the test chapter "Life in the Past", according to the A.S.F. Experimental Group #2 teacher presented only concepts which had been pre-analyzed in accordance with the A.S.F. The two control groups came from a Junior High School in St. James-Assiniboia, the experimental groups were from a Junior High School six blocks away in the same school division.

The data was accumulated from four sources:

1. Data was obtained from mixed analysis of variance of pre/post-test scores. This analysis yields an F ratio to determine if a significant difference in achievement exists between the control group, experimental group #1 and experimental group #2.

2. Item analysis of each test yields the validity of each item in the form of a point biserial correlation (r_{bis}) and percentage of students answering each choice. This analysis was considered necessary to determine if the tests are equally valid for the control and experimental groups.

3. Student opinions were determined indirectly by a comparison of the percentage of students answering questions about their sttitude

concerning interest in subject matter.

4. Descriptive comments about advantages and disadvantages of the A.S.F. as stated by teachers who have used it. These results are used as a formative evaluation to determine changes that might be made to promote more frequent and effective use of the sheet.

DETERMINATION OF DIFFERENCE IN ACHIEVEMENT

"Educational scientists know that studies of the effects of pedagogical methods and techniques [such as the A.S.F.] on educational outcomes [such as cognitive achievement] is in part a function of many variables." [1] Factorial analysis of variance was chosen in order to allow the investigator to study the simultaneous working of two independent variables so that a description of the differential effect can be found. Factorial analysis of variance, by definitions is "the statistical method that analyses the independent and interactive effects of two or more independent variables on a dependent variable."[2] This design was selected because the teacher of experimental group #1 was required to analyze and present lessons according to the A.S.F. whereas the teacher of experimental group #2 was required to present only sheets prepared by the experimental group #1 teacher. These variables obviously do not act independently. Rather, they act in concert.

Mixed analysis of variance, a special case of factorial analysis of variance, was required to analyse the data since the control

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1. Kerlinger, Fred N., Foundations of Behavioral Research, Holt, Rinehart & Winston Inc., Toronto 1964., p. 213.
2. Ibid., p. 213.

and experimental groups were not paired. This situation caused a different number of students to appear in each group. To deal with different numbers of subjects in each group, Dr. Clifford [3] developed a statistical procedure he called mixed analysis of variance which is a further refinement of the split-plot analysis. The number of students in the charts will differ from the original population because no further refinements could be found that could work with subjects if they did not write both pre and post-tests. Any student who did not write both tests had his scores rejected.

OBSERVATIONS BASED ON ANVANIX SUMMARY

Data from the Analysis of Variance, Table I indicate that

1. All three groups combined achieved significantly higher in the post-test than the three groups combined achieved on the pre-test.

2. Each group achieved significantly higher on the post-test than on the pre-test.

Data from the Means Table II indicate that

1. The pre/post-test difference in each group is significantly different from the pre/post-test difference in each other group.

2. The difference in the experimental group #2 pre-test/post-test mean is significantly greater than the control group difference.

3. The difference in the experimental group #1 pre-test/post-test mean is significantly greater than the experimental group #2 mean difference.

DETERMINATION OF TEST VALIDITY AND STUDENT OPINIONS OF A.S.F.

The tests were marked and item analysis was performed by the

3. Clifford, Dr., Psychology Journal, Vol. 69, 1968. p. 399.

TABLE I

VARIANCE OF MEANS BETWEEN GROUPS

Group	Pre-test/post-test Mean	N	Df	F
C	27.381	244		
E_1	29.351	168	2	11.166
E_2	26.167	180		
Combined	27.633	592	-	-

The obtained F ratio has been compared with the appropriate tabled entry at the .05 level and found to be significant. This indicates that every group must have achieved significantly greater cognitive gains on the post-test than they achieved on the pre-test. If the F ratio had been smaller than the tabled entry at the .05 level then at least one of the differences would not be significant.

TABLE II

VARIANCE IN MEAN DIFFERENCE BETWEEN GROUPS

Group	Pre-test Mean	Post-test Mean	Mean Difference	N	Df	F
C	25.549	29.213	3.66	122		
E_1	24.976	33.726	8.75	84	-2	11.166
E_2	22.344	29.989	7.65	90		
All three combined	24.290	30.976	6.67	296	1	277.737

The difference between pre and post-tests have been compared simultaneously and the resulting F ratio of 11.166 is significant at the .05 level. This confirms that each group is significantly different from every other group. Determination of which group is significantly greater is then accomplished by examination of the differences of the means. E_1 mean difference of 8.75, is significantly greater than E_2 mean difference of 7.65. E_2 mean difference of 7.65, is significantly greater than C, mean difference of 3.66.

computer. The print-out contained a point biserial correlation, percent responding correctly to each question and percent selecting each choice. A summary of items chosen for their direct relationship to student preference and interest relating to objectives of the A.S.F. was selected and entered in Table III. The r_{bis} print-outs are included in Appendix "E".

OBSERVATIONS BASED ON ITEM ANALYSIS

1. Observations based on summary of selected items, Table III:
   (a) In each of the questions related to student preference, interest and courses in which he will continue, the percentage of students in the experimental group responding positively increased; whereas the percentage of control group students remained the same or decreased.
   (b) In Question #42, more students in the experimental groups than in the control group preferred activities after they had taken the chapter.
   (c) In Question #39 more students in the experimental group than in the control group were able to select the correct process.

2. The point biserial correlation for each item is similar on the pre-test and post-test. For tables, see Computer Print-outs, Appendix "E".

DETERMINATION OF TEACHER ATTITUDE TOWARD THE A.S.F.

Since the A.S.F. has to be used by teachers if it is to be

TABLE III

RESPONSE SUMMARY OF SELECTED* TEST ITEMS

		Post Test % responding to each choice **		% of each group selecting correct choice ***			
		Control	Expt'l	Control		Expt'l	
				Pre	Post	Pre	Post
#34.	The science course I prefer is:						
	(a) Physics	18	15				
	(b) Geology	20	22	20	20	21	22
	(c) Chemistry	20	21				
	(d) Biology	50	40				
#37.	At university I plan to major in:						
	(a) English	24	25				
	(b) Science	25	34	29	25	30	34
	(c) Mathematics	20	24				
	(d) History	23	12				
#47	The part of the past in which I am most interested is:						
	(a) Yesterday	30	19				
	(b) Hundreds of years ago	20	20				
	(c) Thousands of years ago	10	10				
	(d) Millions of years ago	34	46	41	34	43	46
#39	The statement, "The fossil at the right is a clam" if made by an expert, would be:						
	(a) observation	25	36	35	25	34	36
	(b) inference	46	40				
	(c) hypothesis	19	10				
	(d) speculation	9	10				
#42.	The most interesting aspect of the chapter, "Life in the Past" was the:						
	(a) information	27	10				
	(b) fossils I examined	23	18				
	(c) activities	9	30	44	9	50	30
	(d) knowledge I gained about the past	41	39				

* #34, 37 and 47 are all of the questions related to student preference, interest and courses in which he will continue.

** All questions listed here are identical in content and wording on the pre and post tests.

*** Percent correct are written beside the answers that were considered to be correct by the teacher who prepared the test.

effective, the author felt obligated to request and analyse teacher's comments.

OBSERVATIONS BASED ON TEACHER COMMENTS

1. "The activity sheets prepared according to the A.S.F. are easy to use and help present the material in an organized way." Teacher of experimental group #2 comment, see Appendix "B".

2. "I used the A.S.F. to prepare my first six lessons and found it very efficient but I found it was too much work." Teacher of experimental group #2 comment, see Appendix "B".

3. "Some headings were applicable to my situation but others weren't", as stated in Appendix "B" by a teacher who used the A.S.F. to prepare a course.

4. "Relevant activities related to issues are difficult to recall or find." Teacher of experimental group #1 comment.

CHAPTER V

CONCLUSIONS

The statements in this chapter should be interpreted with consideration to the 'limitations' of the study.

RESULTS FROM ANALYSIS OF VARIANCE

Data from the variance in mean difference between group indicates that

1. All three groups combined achieved higher in the post-test than the three groups combined achieved in the pre-test.

2. The pre/post-test difference in each group is significantly different from the pre/post-test difference in each other group.

Data from the variance of means between groups indicate that

1. The difference in the experimental group #2 pre-test/post-test mean is greater than the control group difference.

2. The difference in the experimental group #1 pre-test/post-test mean is greater than the experimental group #2 mean difference.

CONCLUSIONS BASED ON THE ANALYSIS OF VARIANCE RESULTS

From the above stated observations the null hypotheses of no difference between the means is rejected at the .05 level of significance. Questions to be considered by this thesis are

1. Is the achievement of students taught by teachers using the "Activity Sheet Format" significantly increased when the teacher is given extensive training in the philosophy and application of the A.S.F.?

2. Is the achievement of students significantly increased when the teacher is given a page by page analysis of the chapter according to the "Activity Sheet Format" as prepared by a teacher having extensive training in its philosophy and application?

Since the null hypotheses has been rejected these questions can now be answered as follows:

Students within this study achieved greater cognitive gains when taught by -

1. Teachers using the A.S.F. than students taught by teachers using published curriculum objectives.

2. A teacher using the A.S.F. when the teacher had extensive training in the philosophy and application than students taught by a teacher given a page by page analysis of the chapter according to the A.S.F. as prepared by a teacher having extensive training in its philosophy and application.

CONCLUSIONS BASED ON INFORMATION OBTAINED FROM THE ITEM ANALYSIS

1. The point biserial correlation was performed on the pre-test and post-test for experimental and control groups separately. The tests, although slightly different in wording and content, are equally valid for control and experimental groups since each item is an accurate discriminator of the criteria to be evaluated. (Appendix "E")

2. Control and experimental groups received a similar point biserial correlation but a different percentage of students indicated 'correct' answers on a number of questions. Table II indicates that in the pre-test fewer experimental students chose the 'correct' answer but a larger percentage of experimental students chose the 'correct'

answer in the post-test for the following questions:

Question # 34. This indicates that more students have learned to appreciate geology after they have been taught by teachers using the A.S.F.;

Question # 37. Interest in Science has increased in a greater percentage of students taught by the A.S.F. method;

Question # 47. Paleontology is the aspect of geology that is preferred by more experimental than control group students after being taught by the A.S.F. method.

A major objective of the Grade IX Science course as stated by the Manitoba Department of Education is that the student should demonstrate a developing interest in science. The A.S.F. achieves this objective in a greater percentage of students. All questions referring to higher interest (#34, #37, #47) initiated more frequent positive responses from the experimental group.

Question # 39. To answer this question correctly the student must be taught the 'process' of observation. Perhaps the deliberate inclusion of processes in objectives has caused the experimental group to perform better on this question.

Question # 42. Activities were found to be most interesting by more students in the experimental group. Perhaps that is because the activities were more highly organized according to the A.S.F.

CONCLUSIONS THAT ARISE FROM TEACHER COMMENTS

1. The activity sheets prepared according to the A.S.F. are easy to use and help present the material in an organized way.

2. The activity sheets require too much time for one teacher to prepare for each lesson.

3. The work required to prepare activity sheets causes teachers to use only parts of the format or discontinue using it entirely.

4. Activities related to the stated objectives are difficult to recall or find when only one teacher is required to analyse a whole unit.

SUGGESTIONS TO ALLEVIATE PROBLEMS ENCOUNTERED IN PREPARING ACTIVITY SHEETS

1. Many teachers from one area might cooperate so that each might contribute a portion of the work and/or ideas for relevant activities.

2. In-service sessions might provide a common meeting place for a homogenous group. Along with providing a practical and useful exercise for the in-service session and a set of useful activity sheets, the A.S.F. might facilitate the definition of roles for teachers attending the in-service. Social pressures might promote an attempt by each teacher to write at least one activity sheet.

SUGGESTIONS FOR FURTHER RESEARCH

I CONVENTIONAL APPLICATION OF THE A.S.F.

Can significantly greater cognitive gains be achieved by students if the Activity Sheet Format is used

(a) in a study of broader scope utilizing a greater number of randomly selected teachers?

(b) in areas other than St. James-Assiniboia where different age, sex, I.Q., socioeconomic and other characteristics are prevalent?

(c) in science texts other than Exploring Science Nine that utilize the philosophy of the discovery approach?

(d) in any science texts independent of the philosophy?

(e) in subjects other than science?

II. EXTENDING THE APPLICATION OF THE A.S.F. TO ANOTHER MODE OF INSTRUCTION

Would the A.S.F. operate more efficiently in conjunction with a different mode of instruction? This study was based on a method designed to supplement regular group instruction. An attempt will be made to describe a text and teacher's guide which would include iconic, enactive and symbolic representation. The author feels that this could be accomplished through the use of (1) a content-oriented text that will present material symbolically to students who learn more efficiently with this representation and (2) an enactive teacher's guide that describes objective-oriented activities to be assigned to all students. This would allow symbolic-oriented students the opportunity to learn more efficiently by reading the text and students who prefer iconic or enactive representation a more efficient method of learning by observing and/or participating in suggested activities.

Some special features of the teacher's guide. The opportunity to inject some iconic and further enactive representations into lesson plans might be promoted if the "Activity Sheet Format" was used to write each lesson in the teacher's guide. This would hopefully give the teacher an expertise necessary to make up his own activities concerning issues. A few extra copies of the A.S.F. accompanying the teacher's guide, along with a preface explaining how the guide is organized and that the A.S.F. were used to write each lesson might promote its use

if only through availability.

Some objectives may be skimmed or rejected because the material is not known well enough to appreciate the value in teaching it. Some texts are so question-oriented that the answers cannot be found or examples given are so far removed that a lack of interest would make learning impossible. For these reasons it is necessary to include explicit methods, aids and instructions in the teacher's guide. Some examples are:

1. Films - Good films may not be used because the teacher may not know (a) the aid centre from which it is to be ordered; (b) its relevance or availability; or (c) the cost of the film. (Also, each time the film is shown much time is required to preview the film and prepare introduction, conclusions and tests). Some pages in the guide might be perforated, self-addressed postcards; other pages might contain an introduction, conclusion and tests to be used with the film. It is hoped that such pages might alleviate some of these problems and promote greater use of films. These pages would have to be restocked each year by the aid centre responsible.

2. Relevant Aids - Items such as cow's heart could and would be ordered and used if their sources were known and procedures of use made available. Instructions included should explain exactly where the best place to cut the heart is and what to watch for. Cards of the punch-out variety, addressed to the appropriate meat packing plant along with cost and pick-up

instructions could be once again included. The more available and easier to use these perishable items become the more often they are to be used.

3. Photographs - Chapters similar to "Man and His Environment" from Exploring Nine science text that include concepts such as changes in communities would become much more relevant if changes in the student's own surroundings could be viewed. Our changing environment would also be much easier to explain if familiar examples could be shown. Aerial photographs are taken of all parts of Canada at equal intervals. Photos of any section are available from the air photo lab in the government offices. If the cost of having them reproduced by a professional studio is too high or the quality of Xerox copies is not adequate, then the nearest technical school may be willing to print copies. The advantage of having pictures copied at a technical school is that they will print, punch holes and cut the pictures to 8" x 10" or even 8½" x 11" to fit a 3-ring binder at a nominal cost. The teacher's guide would become a portable resource centre or "mail-an-aid".

The teacher's guide consisting of 8½" x 11" three-hole sheets and a binder similar to a parts catalogue would allow removal and addition of objectives. The teacher would be given the objective, an idea of how it could be presented and aids that could be used. Each teacher would choose to use the given presentation and aids or make up his own. All objectives, aids and tests would be based on some text so

that each student could have a copy.

The order in which objectives are to be presented is one thing that can be left totally to the discretion of the teacher. Flexibility in this respect is retained through the use of removable sheets. Further flexibility might be achieved by leaving large blanks between headings of guide activities. These blanks would accommodate extra notes the teacher might like to add.

There are many reasons for encouraging the classroom teacher to write his own lesson plans. One reason is that experts often reject material because it seems redundant and over-simplified, not realizing these facts are necessary to present the information to someone who is less familiar with the material. There is even some merit in having the classroom teacher rewrite an activity already written up in the guide. Experiments such as cutting up a cow's heart (see Relevant Aids) might be improved by a classroom teacher who has tried the professional procedure, especially if he has perused answers to questions he found that were not answered sufficiently well for a layman to understand. The material could be checked for English and scientific accuracy by experts in the field on request. Units or even pages could be traded, bought or sold according to the needs of each teacher, board, branch or country.

III A COMBINED APPLICATION OF THE A.S.F.

Could each of the applications mentioned above be modified so that the new mode of instruction could be integrated into a program being presently used?

The author has always felt that radical changes where it is

necessary to throw out the old to adopt the new can be disastrous. If a system is working, it is better to work within that framework at least until improvements or new methods have been developed to take over. It seems that the Department of Education in Manitoba made a mistake when they threw out the old science course before it could be replaced by an adequate general science text.

The only general science text available at the time was the Exploring Science Nine series which was so question-oriented that the teachers even found it hard to follow. Information/activity oriented texts were introduced to supplement the Exploring Nine series. According to Bill Soprovich, "Since no single suitable general science text was available, five different texts were brought in and referred to as the 'multitext approach' ". [1]

Theoretically, a teacher can find out what he is to teach by checking 'recommended chapters' under the heading 'Course Content' in a booklet printed by the Department of Education. The next step would be to examine the appropriate Exploring Series science text and associated teacher's manual and workbook. If the material found in those 'write-ups' is not suitable or if the teacher wishes to elaborate on that topic he can refer to the 'Scheme for cross-referencing' section of another booklet printed by the Department of Education named "Selected Approaches to Planning and Teaching". The author feels that this is a confusing and disorganized approach that could be improved by using the A.S.F.

It is suggested that the Department of Education print one "Teacher's Guide" as described in Question II above. General objectives

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1. Soprovich, Bill, Curriculum Consultant, Manitoba Department of Education, as stated in telephone conversation, January 15, 1974.

would be stated and sub-divided according to the A.S.F. into suggested specific objectives and activities. One of the 'materials' listed could be one or more of five books now in use or a 'Reference' heading would be added to the A.S.F. to accommodate this new scheme. Teachers all over Manitoba could contribute to this guide, by mail, if necessary.

By requesting that each teacher wishing to add an activity, follow the A.S.F. every teacher who uses that Activity Sheet should be able to apply it easily. The author would like to make one additional recommendation at this point. If many good activity sheets that will teach a set of concepts related to a particular objective are received, they should all be included in the Teacher's Guide. Each teacher can accept or discard sheets at his own discretion. To follow this scheme the Department of Education would have to act as the central agency for distributing and receiving the A.S.F. and a description of its use, Activity Sheets, perforated 'aids' postcards and general information.

IV. CAN THE A.S.F. ITSELF BE CHANGED?

As stated in previous chapters, the A.S.F. is not the final word in writing objectives. Since the A.S.F. was developed to promote flexibility in lesson plans by providing a format for the classroom teacher to follow in writing his own lesson plans in terms of organized activities then by definition the A.S.F. itself must be flexible. In fact, the A.S.F. might be thought of as a sample format a teacher might examine to construct his own A.S.F. The A.S.F. would not be an efficient method of instruction for some teachers without reordering, deletions or additions of headings. For example, social studies would require a different 'processes chart' and the teacher might prefer to label this

chart 'skills'. Mathematics teachers might want to include definitions as a sub-heading of 'Activities' and English teachers might not require the 'Materials' heading at all.

BIBLIOGRAPHY

Andrew, Michael D., Issue Centered Science: An Integrated, Interdisciplinary Approach to Curriculum, March, 1969.

Bloom, Benjamin S., Handbook I, Cognitive Domain, David McKay Co. Inc., New York, N.Y.

Bloom, Benjamin S., "Learning for Mastery", U.C.L.A. Evaluation Comment, Vol. 1, No. 2, May, 1968.

Bloom, Hastings and Modaus, Formative and Summative Evaluation of Student Learning. McGraw-Hill Publishers, Toronto.

Bruner, J. S., The Process of Education, Random House, New York, 1960.

Bruner, Jerome S., Toward a Theory of Instruction. Cambridge, Mass. Belknap Press of Harvzrd University, 1966.

Bryant, Napoleon Jr. and Anderson, Hans A., "Effects of Performance Objectives on Achievement", Journal of Research in Science Teaching., Vol. 9, No. 4.

Canfield, Albert A., "A Rationale for Performance Objectives," Audiovisual Instruction, Feb. 1968.

Chittenden, Edward A., "Piaget", Science and Children, Dec. 1970.

Committee on Assessing the Progress of Education, National Assessment of Education Programs - Science Objectives, 1969. National Assessment Office, Rm. 201A Huron Towers, 2222 Fuller Road, Ann Arbor, Michigan.

Department of Education, High School Entrance Examination Board, Summary Description of Grade Nine Science Objectives and Test Items. (Rev. Ed.) Edmonton, Alta. 1965.

Department of Youth and Education, Selected Approaches to Planning and Teaching Science 7-9, 1971.

Edelfelt, Roy A., "Differentiated Staffing - Where Are We?" The Manitoba Teacher, May, 1972.

Ferguson, George A., Statistical Analysis in Psychology and Education, 2nd Ed., McGraw-Hill Book Co., New York, N.Y. 1966.

Feynman, Richard P., "What is Science", The Physics Teacher, Sep. 1969 .

Gagne, R.M., "The Analysis of Instructional Objectives for the Design of Instruction", Mimeograph American Institute for Research.

Gagne, R. M. and Brown, L. T., "Some Factors in Programming of Conceptual Learning." Journal Experimental Psychology. 1962.

Hilgard, E. R., Theories of Learning, 2nd Ed. Appleton-Century Crofts, New York, N.Y., 1956.

Kemp, Jerrold E., Instruction Design, Fearon Publishers, Belmont, California.

Kerlinger, Fred N., Foundations of Behavioral Research, Holt-Rinehart & Winston, Inc., New York, N.Y. 1964.

Kibler, Robert J., Parker, Larry L. and Miles, David T., Behavioral Objectives and Instruction, Allyn and Bacon Inc., 1970.

Koran, John J., Jr. Montague, Earl J., and Hall, Gene E., "How to Use Behavioral Objectives in Science Instruction", National Science Teachers Association, 1969.

Kretch, David; Crutchfield, Richard S.; Ballachay, Egerton L, Individual in Society, McGraw-Hill Book Co. Inc., 1962, p. 52.

MacDonald, Murdock K., "Education and the Innovative Society", 46th Convention of C.E.A., The Canadian Education Association, Toronto 5, Ontario. Sep. 1969.

Mager, Robert F., Preparing Instructional Objectives, Clarke Irwin, 1962.

Mager, Robert F., Preparing Instructional Objectives, Fearon Publishers, Lear Siegler Inc., Education Div. Belmont, Calif.

Mallinson, George G., Science Learning and the Problem Reader. See Appendix "E".

Piaget, Lean, "Development and Learning". Journal Research Science Teaching, 1964.

Popham, James W., Probing the Validity of Arguments Against Behavioral Goals, Rand, McNally and Co. 1968.

Raun, Chester E. and Betts, David P., "The Relationship Between the Strategies of Inquiry in Science and Student Cognitive and Affective Behavioral Change". Journal of Research in Science Teaching. 5:207 (1967-68).

Renner, John W. and Stafford, Donald G., "Inquiry, Children and Teachers", The Science Teacher, April 1970.

Steere, Bob F., "Non-Gradedness", Curriculum Bulletin, Manitoba Department of Education, Vol. 7 #1, Nov. 1972.

Taylor, Peter A., and Taylor, Lil, Writing the Objective Classroom Test. The Manitoba Educational Research Council, Bulletin No. 1, Oct. 1970.

Thurber, W. A. and Kilburn, Robert E., Exploring Science Nine, Allyn and Bacon, Inc. 1966.

Wong, Harry K. and Solmotz, Melvin S., Ideas and Investigations in Science, Prentice Hall Inc., Inglewood Cliffs, New Jersey, 1971.

_____ Xerox Corporation, U.S.A., Science - Process Approach.

APPENDIX

APPENDIX "A"

Activity Sheet Format

ACTIVITY SHEET FORMAT

PLEASE WRITE OUT ACTIVITY SHEETS ACCORDING TO THE FOLLOWING FORMAT.

A-Definitions-Give a foundation on which a student can base his discoveries.

B-Objectives-Define criteria, givens or restrictions and word the objectives thus: After completing this activity the student should be able to:

1...)
2...) To complete this sentence use a different statement for each objective.
3...)

For each statement choose CONTENT, PROCESSES and VERBS from the following:

CONTENT-Choose a page from the text or the curriculum.

PROCESSES-Choose one or more from the following chart.

Simple Processes	Integrated Processes
1.Observing	9.Formulating hypothesis
2.Classifying	10.Defining operationally
3.Using numbers	11.Controlling variables
4.Space-time relationships	12.Data interpretation
5.Communicating	13.Use of models
6.Measuring	14.Experimenting
7.Inferring	
8.Predicting	

VERBS-Choose one from the following table for each statement.

Verbs from these columns construct objectives useful as introductions.		Right-hand columns construct objectives which require higher mental processes.	
Recall	Find, Make, Use	Plot a graph	Formulate hypotheses
Define	Describe, Do	State a problem	Discuss critically
Copy, Memorize	Gather data	Identify variables	Discover, Reorganize
Explain, Tell	Investigate	Organize data	Propose reasons and
List reasons	Compute	Estimate, Analyze	defend them, Infer
State	Measure	Apply, Inter ret	Generalize from data
Repeat, Imitate	Prepare	Devise a method	Predict, Integrate
Duplicate	Manipulate apparatus	Contrast, Compare	Deduce, Synthesize
		Suggest, Relate	Manipulate ideas
(CAUTION:	Recognize	Specify limitations	
If you find you	Examine	and assumptions	(NOTE:This is the
are using MANY	Identify	Differentiate	more sophisticated
objectives of	Recognize & cite	Discriminate	type of behaviour.
this type, you	evidence for	Reformulate, Prove	Create opportunities
should re-examine	Classify	Justify, Contrast	for this in your
your intentions.)	Illustrate	Distinguish between	lesson planning.)
Simple ——————————————————————→ Complex			
Recall → Comprehension → Application → Analysis → Synthesis → Evaluation			

Wherever possible the following should be included in your objectives: student participation, scientific method, expression of divergent points of view and concepts.

C-Materials-Include sources and addresses.

D-Activity-Allow the student to discover. NOTE that the verbs above can be used to word the instructions to be given to the students.

E-Discussion-Assure ALL students are aware of ALL possibilities.

F-Rationale-Give reasons for including the above.(e.g.The discussion can be cut off and the remainder can be duplicated as a handout or transparency.

NOTE THAT THE VERBS ABOVE CAN ALSO BE USED TO WORD TESTS

APPENDIX "B"

1. Sample chapter, "Life in the Past"

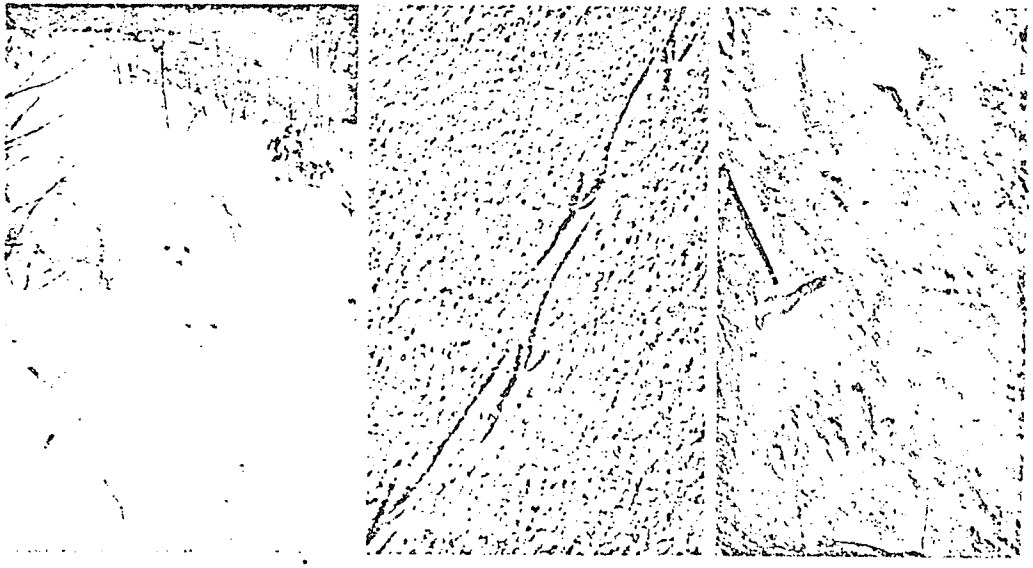
   (a) Sample chapter from "Exploring Science IX" text.

   (b) E_1 analysis according to the "Activity Sheet Format.

2. E_2 letter of confirmation, explanation and application.

3. Control group letters of procedure and confirmation.

4. Letter of permission to reprint the chapter "Life in the Past".



CLUES TO THE PAST

Complete remains of long dead plants and animals are very scarce. Usually, only bones, shells, wood, or other hard parts are preserved. Such fossils provide incomplete and uncertain clues as to the nature of ancient life.

Geologists compare fossils with living organisms in order to make guesses, or *inferences*, about the nature and habits of extinct plants and animals. What type of training should a geologist have for making trustworthy inferences?

Tracks as Clues. The picture above shows that an animal crossed a snow-covered field. People who have studied common animals can tell what animal made the tracks and which way it was going. They can also make trustworthy inferences about speed and size of the animal.

Examine the photograph. Which prints were made by the hind feet and which were made by the front feet? Which way was the animal going? What gait was it using? Check your inferences with those given later in this chapter.

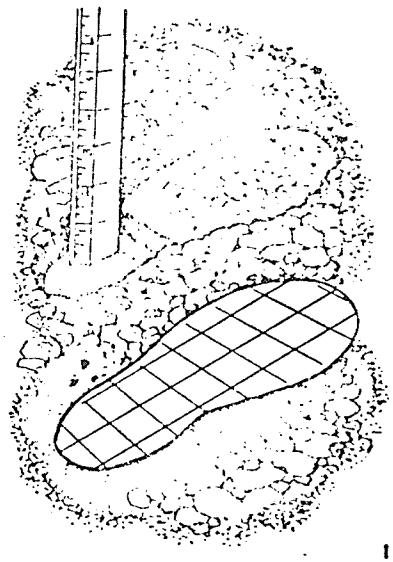
Two other sets of tracks are shown above. The middle set is recent; the other was found in a slab of ancient sandstone. What inferences can you make about these tracks? Which inferences are probably more trustworthy? Why? Check your inferences with those given later in this chapter.

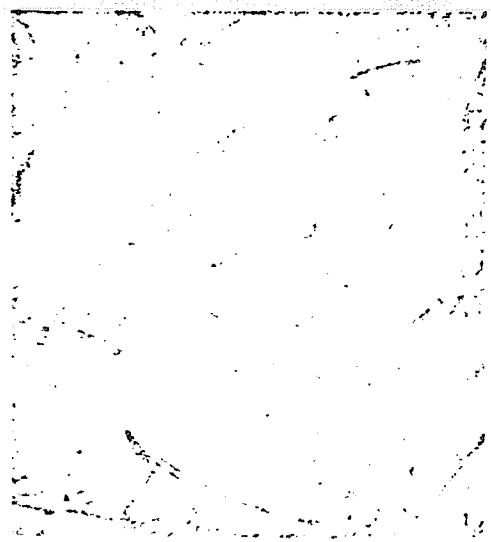
Using Experimental Evidence. Dampen clay soil until it shows a clear print when you step on it. Measure the depth of the print. Mark off a sheet of paper with one-inch squares, cut it to the size of the print, and determine the area.

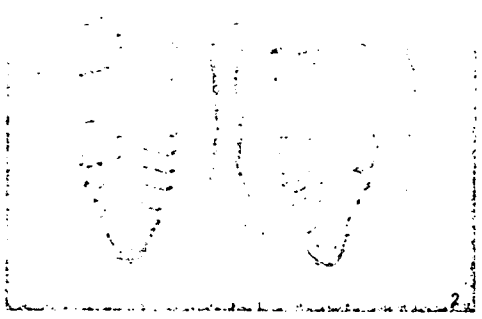
With what force did you step on the soil? What was the pressure on each square inch of soil?

Ask a child and an adult to make prints in the same soil. Use measurements of depth and area to estimate the weight of each person. How close are your estimates? How might you improve them?

Estimate the area and depth of the dinosaur track in the photograph. Assume that the animal stepped in soil like that used in your experiment. Infer the weight of the dinosaur. What would be the difference if the animal walked on two legs or four legs? What assumptions might make your calculation too large? What assumptions might make it too small?

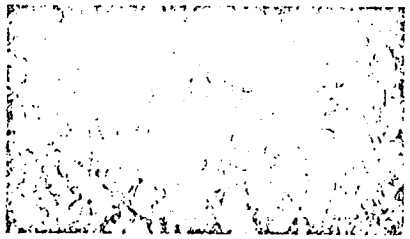


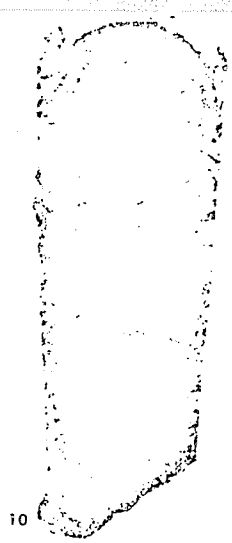


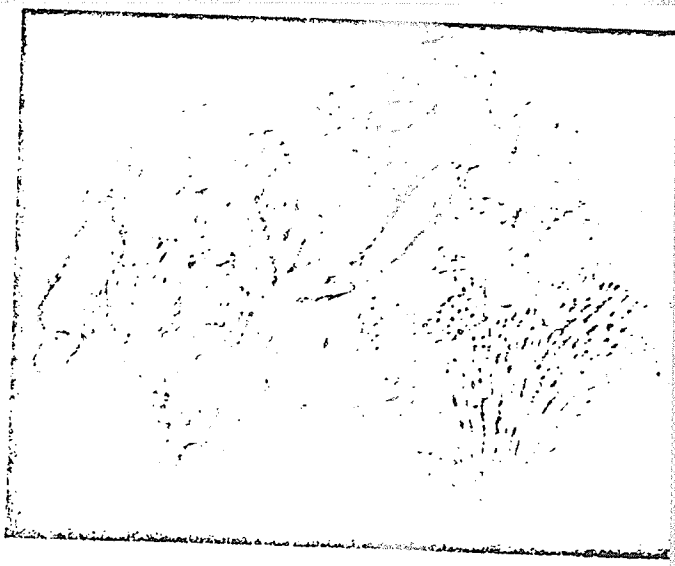


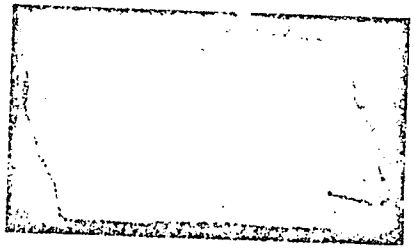
Inferences from Incomplete Remains. A number of fossils are shown on these two pages. None of those shown are complete remains of the original organisms. Study the pictures and look for clues that can help you make inferences about these plants and animals that have been dead for many years. Compare your inferences with those made later in this chapter.

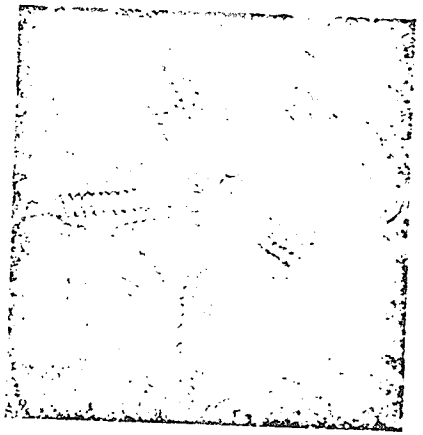
Study fossils in the school collection and fossils that you collect for yourself. Write down your inferences about them. At the end of this chapter, review your inferences. Make changes in agreement with your added knowledge of fossils.

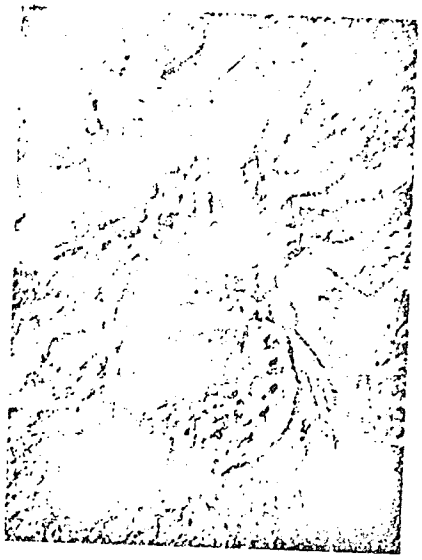


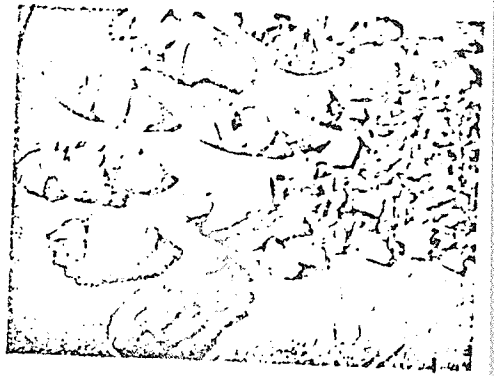












HOW FOSSILS ARE FORMED

A fossil is any trace that a plant or animal has lived somewhere in the distant past. A piece of wood, a shell, or a bone is a fossil. So too, is an animal track or the burrow of a long-dead worm.

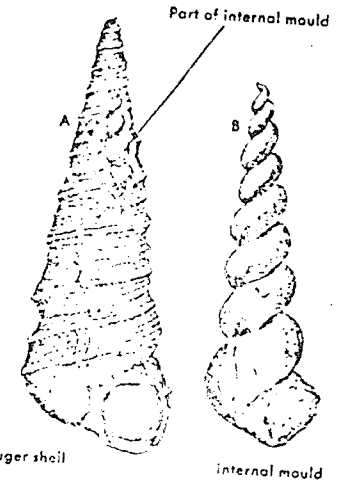
Very few actual remains of plants and animals are preserved as fossils. Chemical changes usually take place and the original material is replaced with new substances. Sometimes the original material dissolves away completely, leaving only prints in the sediments that surrounded the remains.

Moulds of Shells. Prints of shells and bones are called *moulds*. A mould of a shell has the shape of the shell in reverse; that is, a mould shows a groove where a shell has a ridge, and a ridge where a shell has a groove.

Make a clam shell mould in plaster of Paris. Prepare a thick mixture of the plaster and water. Press the clam shell into the mixture until it is level with the surface. Let the plaster harden. Then coat the plaster with Vaseline and pour another layer of plaster on top. On the following day, separate the layers and remove the shell. Compare the markings on the mould with those on the shell.

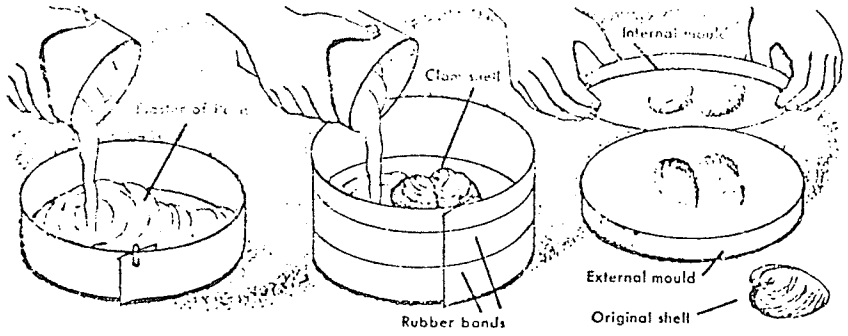
The mould of the outside of a shell is called an *external mould*. The mould of the inside of a shell is called an *internal mould*. The photograph on the opposite page shows both internal and external moulds. *A* and *B* are both moulds of the same shell. Which is an external mould and which is an internal mould? What is *C*? *D* and *E* are also moulds of the same shell. Which is internal and which is external?

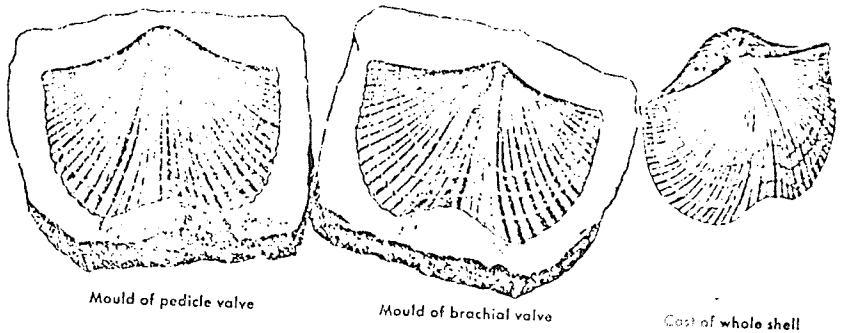
Casts of Shells. Ground water seeping through a rock may dissolve away shells within the rock. Empty spaces are left between the moulds. Fit together the plaster moulds you have made. Describe the space remaining between the moulds. What would you see if you made a break across the moulds? Explain the space between *F* and *G* in the photograph on the opposite page.

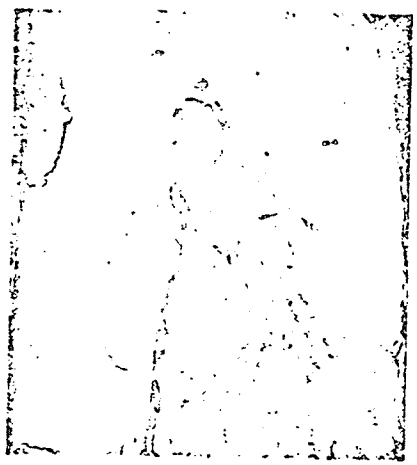


After ground water has dissolved away a shell, it may deposit other minerals in the space. The new minerals form a cast. In what ways is a cast like the original shell? In what ways is it different?

The fossil at *A* is a cast. Explain how it might have been formed. What is *B*? How might it have been formed?







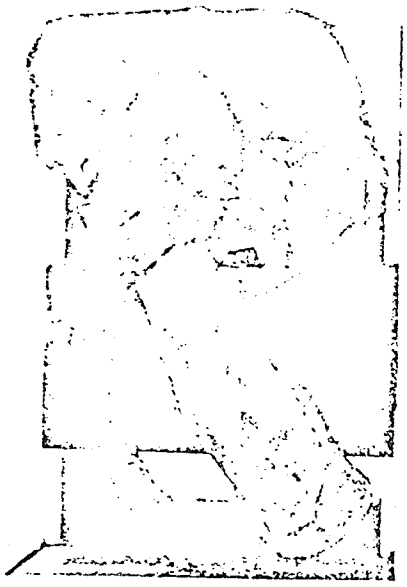
Original Remains. The photograph below shows the remains of a relative of elephants found in frozen arctic soil. Note that skin, hair, and flesh remain on parts of the body. Why did they not decay? How might the animal have become buried before decaying or being eaten?

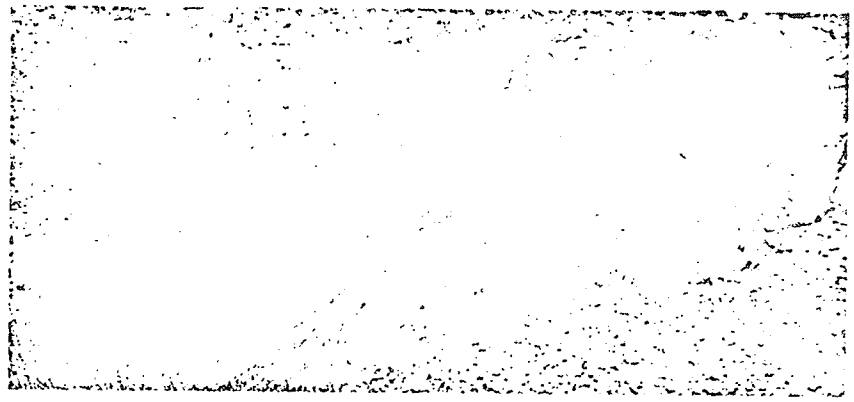
The bodies of insects are found in many pieces of the mineral called amber. Geologists believe that amber was once a gum given off by wounds in the bark of cone-bearing trees. Explain how insects might become buried in this gum. How can the gum prevent decay?

Why are original remains like these especially useful to geologists?

Carbonization. Plants and animals buried quickly in clay or sand may not decay if oxygen and bacteria are absent. However, other types of chemical changes usually take place, producing natural gas and oil, but leaving part of the carbon. Coal is formed in this manner.

The carbon that remains in the rocks sometimes shows clearly the nature of the buried plants and animals. Sometimes even internal organs can be seen. What do the carbonized remains in the photographs below show you?

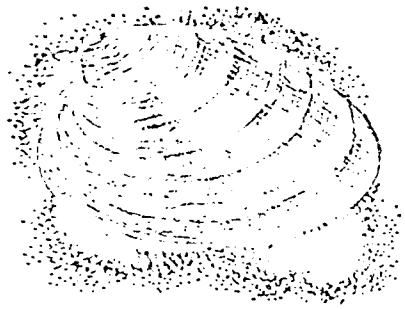


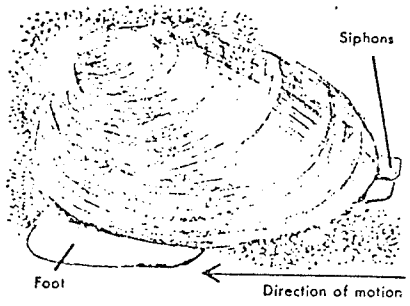


Petrification. Petrify means turn to stone. The process of petrification is not well understood.

To the best of our knowledge, ground water sometimes dissolves materials of which an organism is made, replacing molecules with equal amounts of some mineral. Thus the fossil is almost exactly like the original organism, even when viewed through a microscope.

Shells, bones, teeth, and wood are the parts most often petrified. The pictures on this page show petrified tree trunks. The wood has been replaced by silica. Notice how well the appearance of the trunks has been preserved. Even the growth rings can be seen. The cells that made up the wood can also be seen clearly with the aid of a microscope.





INTERPRETING FOSSILS

Many animals of the past have left only their hard, outer coverings as fossils. No one knows exactly what these animals were like. Satisfactory inferences about fossils are possible only if there are living relatives. The closer the relationship, the more likely that trustworthy inferences can be made.

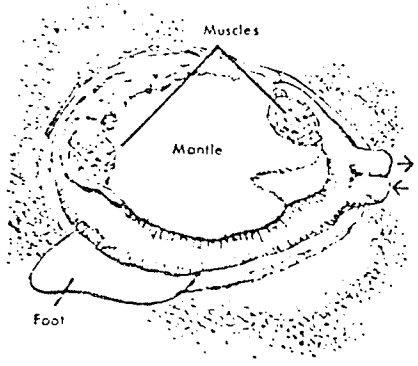
Fossils show that relatives of clams have been numerous for millions of years. Therefore, a knowledge of living clams is very helpful in understanding some of the most common fossils.

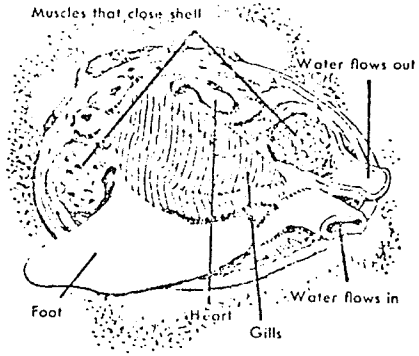
A Clam's Exterior. Drop a clam into warm water until its shells open. Push a chip of rock between the shells to keep them open.

Look for the tough ligament that serves as a hinge for the shells. This ligament also acts as a spring which opens the shells.

Look between the shells for a thin membrane that comes to the edge of each shell. This membrane is called the *mantle*.

The oldest part of a shell is the point near the hinge. The shell grows, as glands along the edges of the mantle give off calcium carbonate and other chemicals. Note that a shell does not grow equally in all directions. In which direction is growth most rapid?





Structure of a clam

Ridges on a shell also show that growth is not regular. Each ridge was formed during a period of slow growth. Large ridges probably represent long periods of little growth, such as during winters. The age of a shell can be estimated from these large ridges.

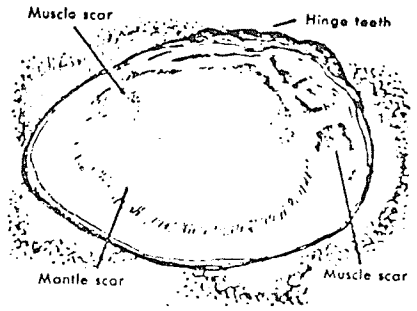
Interior of a Clam. Slip a thin knife blade between the shells, keeping it close to one shell. Cut the muscles that hold the shells together.

Fold back the mantle from the body of the clam. Find the muscular foot which is thrust out between the shells when the clam crawls.

Notice that the mantle is joined at the rear of the clam to form two tubes called *siphons*. Water is drawn in through the lower siphon, bringing in oxygen and tiny particles of food. Water is forced out through the upper siphon, carrying away wastes.

Remove the body of the clam from the shell. Notice how the muscles which close the shells were attached. Notice also where the mantle was attached to the shell.

Boil the two shells for a few minutes and remove all the tissues.

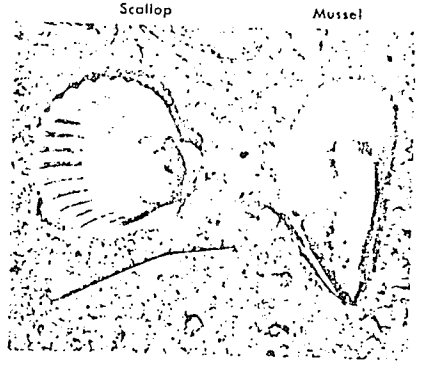


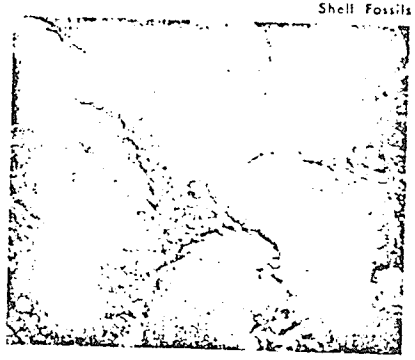
Study the markings on the interior of the shells. Which scars show where muscles were attached? Which show where the mantle was attached? Describe the scar where the siphons were located.

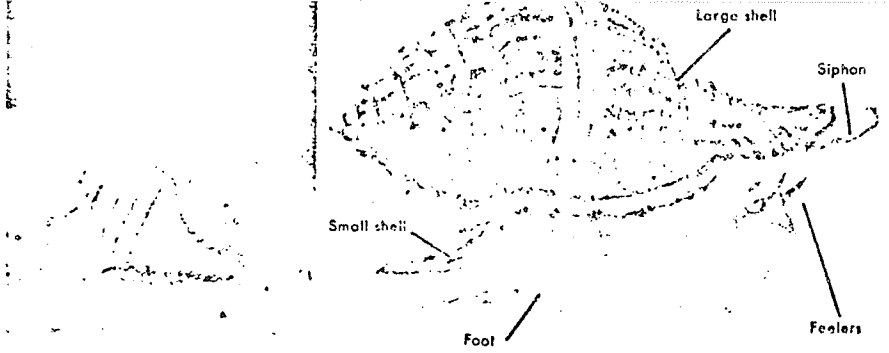
Fit the two shells together. What keeps the shells from being twisted out of line with each other?

Shells of Related Animals. Study shells of animals related to clams; including oysters, scallops, mussels, and fossils like those below. Compare each with your clam shells.

Try to imagine the animals in their shells. What was the natural position of the animals? How did they move about, open and close their shells, and obtain food? Explain as many of the markings on the shells as you can.







Mollusks. Clams belong to a group of animals called *mollusks*. Most mollusks have shells.

One division of the mollusks includes clams, oysters, mussels, and scallops. These animals are called *pelecypods* (*pelecy*—hatchet, and *pod*—foot) because the foot of some species reminds biologists of ancient battle axes.

Gastropods. Another division of mollusks includes snails. These animals crawl on a broad foot as shown above. They are called *gastropods* (*gastro*—stomach, and *pod*—foot). Why do you think this name was given to these animals?

Generally, gastropods have one large, coiled shell. The shell is made up chiefly of calcium carbonate given off by glands in the mantle. One side of the mantle grows much faster than the other. How does this affect the shape of the shell?

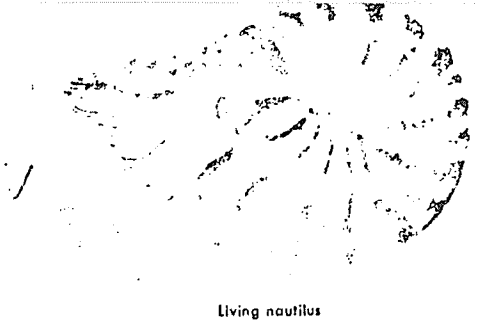
The gastropod in the diagram has a second shell. Where is this second shell when the animal is crawling? Where is it when the animal is inside its shell?

Watch a snail crawl up the glass side of an aquarium. Note the movement of the foot. Find the mouth, feelers, and eyes. Does your specimen have a second shell? Does it have a siphon? What happens if you disturb the animal?

Drop a snail into boiling water to kill it. Saw open the shell with a fine blade. Does the snail's body go to the end of the shell? Find the muscles that pull the body inside.

Cephalopods. A third group of mollusks includes octopuses and squids. These animals are called cephalopods (*cephalo*—head, and *pod*—foot) because they move about by means of tentacles attached to their heads.

Living cephalopods have well developed eyes and tentacles. How does an octopus use its tentacles? Judging from the name, how many tentacles does it have?



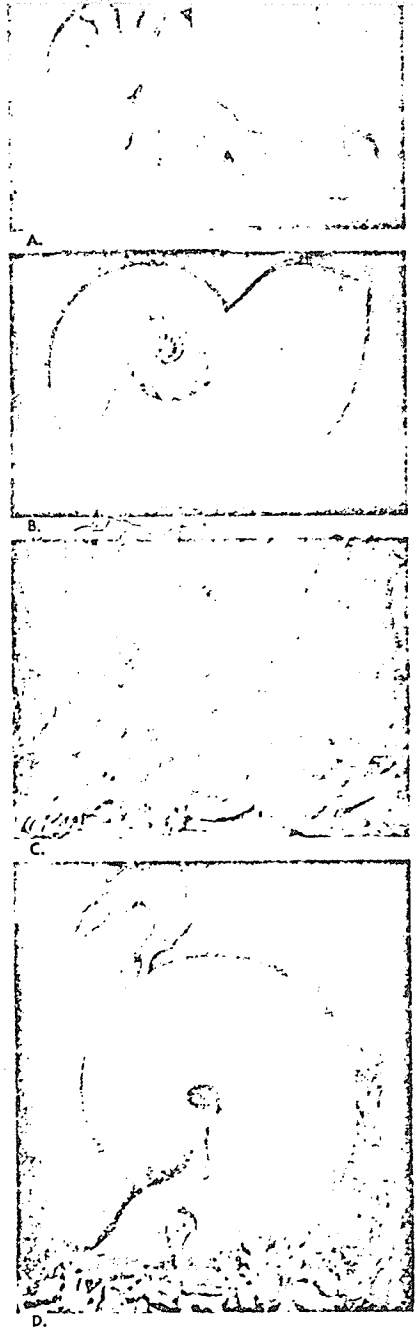
Living nautilus

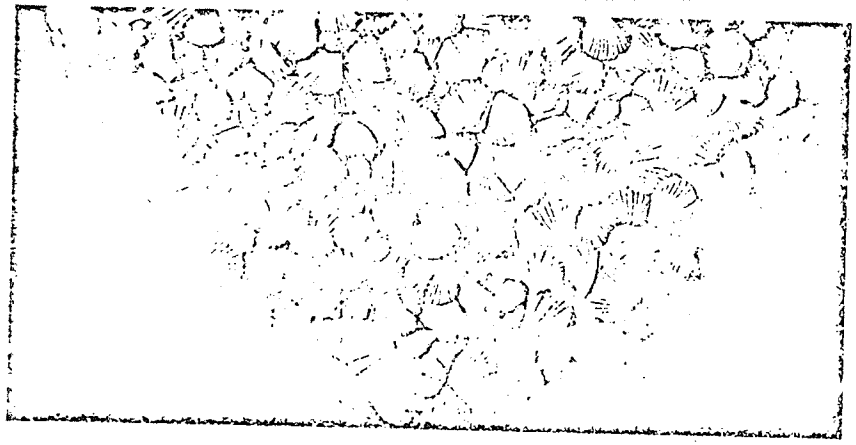
Only one living species of cephalopod has a shell. This is the nautilus shown above.

A nautilus shell is divided into many chambers but the animal's body occupies only the outer chamber. Each of the other chambers represents a location of the animal's body when the nautilus was smaller. The nautilus produces a new partition each time it moves its body farther toward the end of the shell. How many times did the nautilus move in making the shell as in *B*?

Fossil cephalopods can be identified by the partitions and chambers of their shells as in *A*. How else are the shells different from those of other mollusks?

The restorations at *C* and *D* show some cephalopods that lived several million years ago. Note that one type has a straight shell and one has a coiled shell. Which parts of these models are probably correct? Which parts are based upon inferences? How might the models have appeared if they were based upon different inferences?



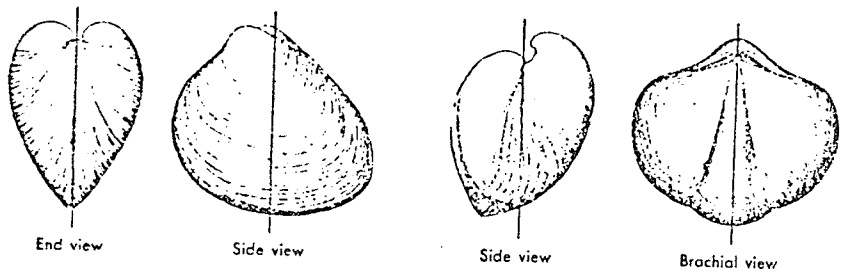


Brachiopods. Brachiopods (pronounced *brack-i-o-pods*) were among the most common animals in many ancient seas. Some rocks are made up almost completely of brachiopod shells. Brachiopods are not nearly as numerous today as they were in the past.

Brachiopods are not closely related to clams even though both types of animals have two shells. The diagrams below show two important differences between the shells: (1) the two shells of a pelecypod are much alike but those of a brachiopod are unlike; (2) a brachiopod shell grows equally on both sides of a centre line but a pelecypod shell does not. Try to identify brachiopod and pelecypod shells in a collection of fossils.

The photograph on the next page shows the natural position of a living brachiopod. This brachiopod is attached to a rock by a fleshy stalk which passes through a hole near the hinge line of the shells. Compare the position of this brachiopod with the natural position of a clam.

A brachiopod has two arm-like organs within the shells as shown in the diagram on the next page. Biologists once thought that these organs served for moving about and so they gave the animals their name (*brachio*—arm, and *pod*—foot).



However, brachiopods remain fixed in one place most of their lives.

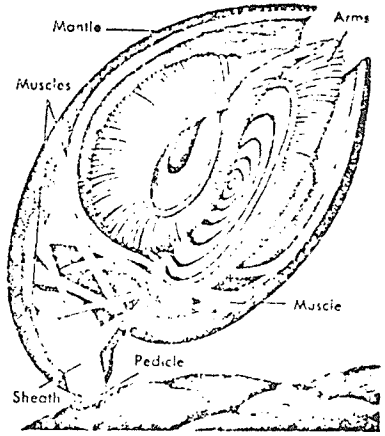
The arm-like organs of a brachiopod serve for obtaining food and oxygen. They are covered with microscopic fingers called *cilia*, which wave a current of water into the shells. Oxygen and food particles are carried in with the water.

A brachiopod opens and closes its shells by means of muscles. One set of muscles opens the shells; another set closes them. Scars on empty shells show where muscles were attached.

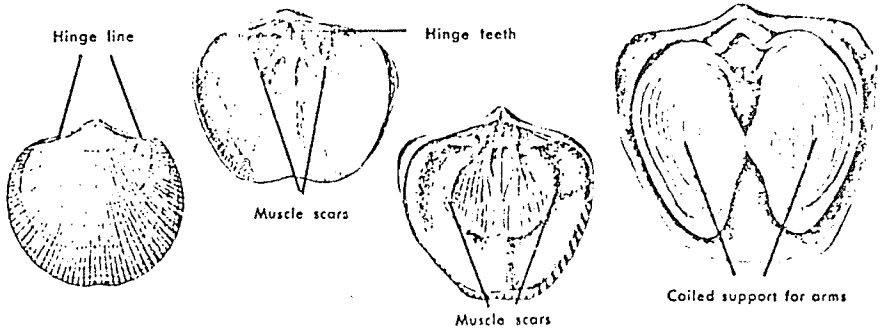
Fossil brachiopods are found in many shapes and sizes. Examine as many kinds as you can. Hold a specimen in its natural position. Find the hinge line. Look for the hole through which the stalk passed. If there is no hole, this species may have cemented itself fast to a rock.

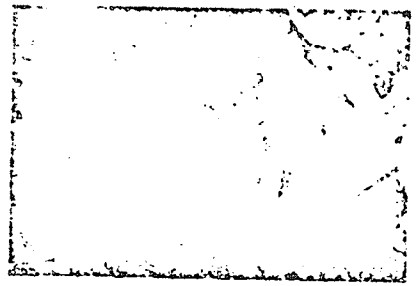
Notice the ridges on the outside of the shells. These ridges show changes in speed of growth. Where is the oldest part of the shell?

Notice also the large ridges and grooves on some specimens. These shells are stronger than smooth shells and it is believed that the animals could live in rough water along wave-swept coasts.



Look for muscle scars on the interiors of brachiopod shells or their internal moulds. Well-preserved specimens may also show supports for the arms.





Sea Anemone ▲ ▼ Solitary Coral Fossil

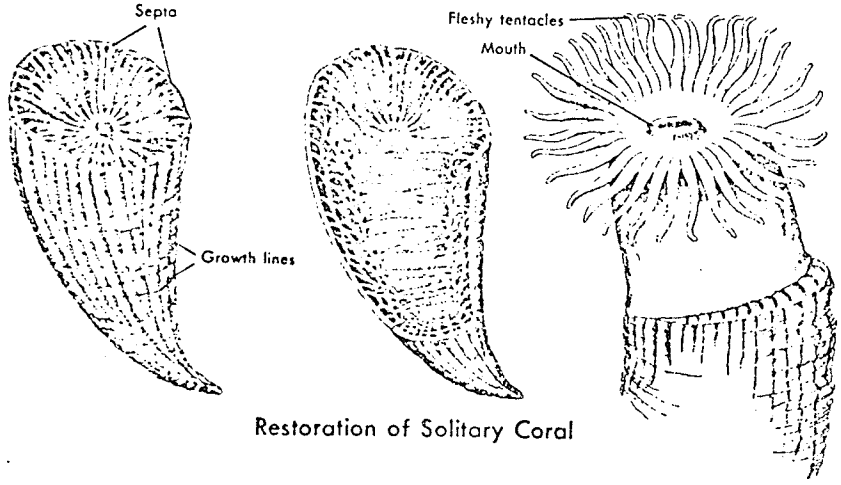
Corals. Corals were as important in many ancient seas as they are today. They often formed huge reefs which may have become islands, like certain Pacific islands today.

Modern corals are found in colonies made up of a great many tiny animals. In the past, there were both colonial corals and solitary corals.

It is believed that the solitary corals of the past were somewhat like the sea anemone shown at the top left. A sea anemone is a sac-like animal, open at the top. Around this opening, which serves as a mouth, are many small tentacles. These tentacles can grasp small animals, sting them, and place them in the mouth. But unlike corals, sea anemones have no hard parts.

Fossils show that a solitary coral built a cone of calcium carbonate around its body. The cone was strengthened inside with plates running up and down. As the animal grew, it added to the cone at the top. Explain the shape of the coral shown at the left.

As the cone grew taller, the animal had to pull itself upward occasionally. Each time it did so, it produced a supporting floor under its body. The diagram at the bottom of the opposite page shows the location of some of these floors. If possible, break open some solitary corals and find the parts described.



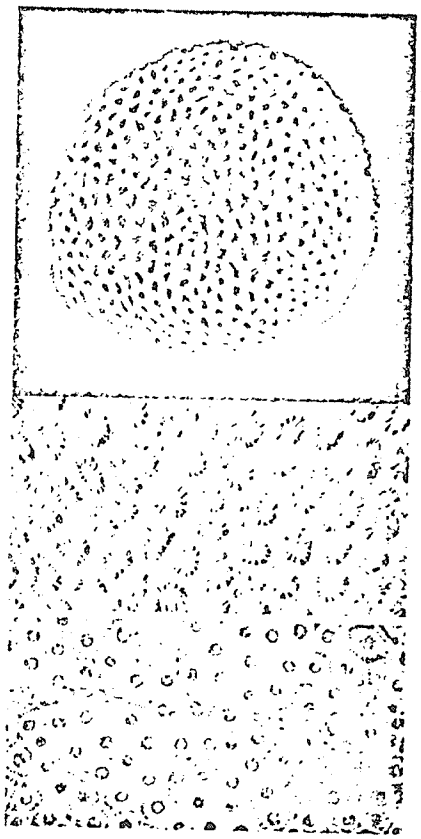
Restoration of Solitary Coral

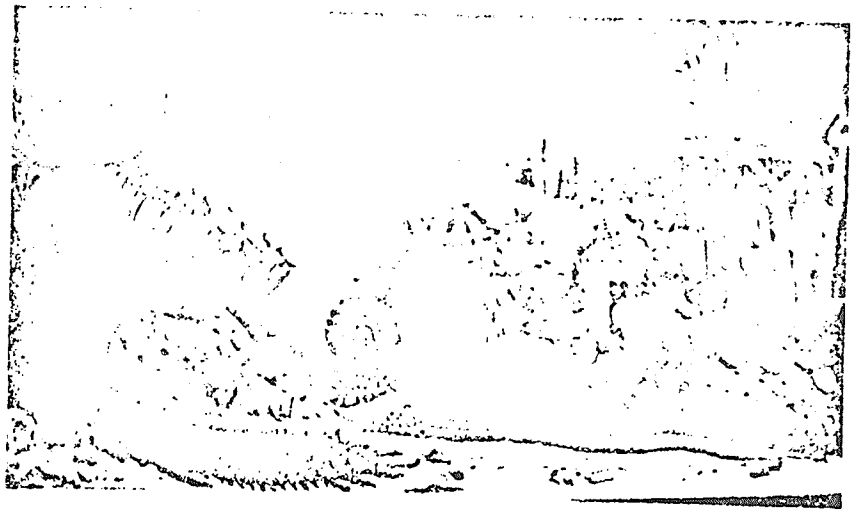
Three specimens of colonial corals are shown here. The type that is shown in the first photograph lives today; the types shown in the second and third photographs are extinct. Both species have made large reefs.

The parts shown here are made up of calcium carbonate. The holes on the surface are the cones within which the many tiny coral animals once lived. The growth of the cones can be traced when a specimen is broken open.

The restoration shows a number of extinct animals that might have lived together in an ancient sea. Upon what evidence would such an inference be based?

Which models are of solitary corals? Which are of colonial corals? What other animals can you identify? Which parts are probably accurate? Which doubtful?





Crinoids. These animals look so much like plants that they have been named *crinoids* (*crino*—lily, and *oid* —like). They were once much more numerous than today.

A crinoid's body is at the top of a stalk. Its mouth is surrounded by several arms bearing cilia. The cilia wave a current of water along grooves in the arms toward the mouth. Particles of food are swept along with the water.

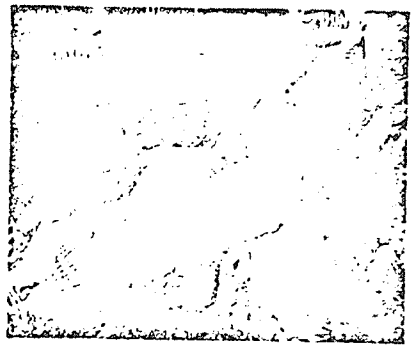
The body of a crinoid is surrounded with plates of calcium carbonate. The stalk is made up of discs of the same material. These discs and plates usually fall apart when the soft parts decay. Therefore, complete fossil crinoids are rarely found.

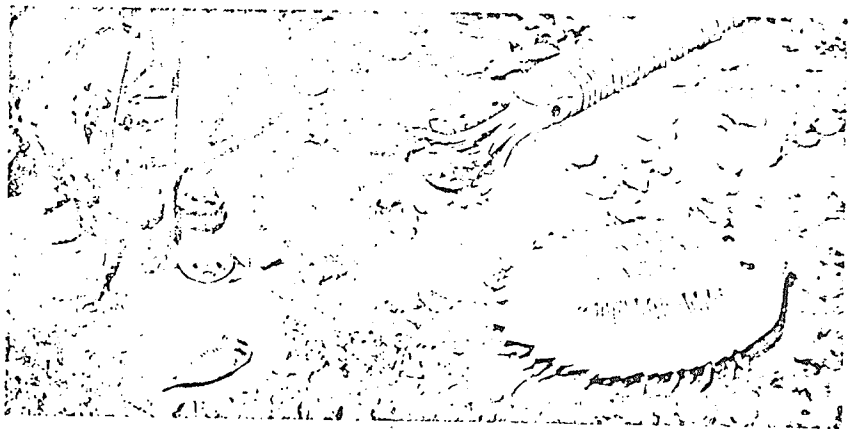
Trilobites. These animals were given their names because their bodies have three lengthwise divisions called lobes (*tri*—three, and *lobos*—lobe). Trilobites were once common but are now extinct.

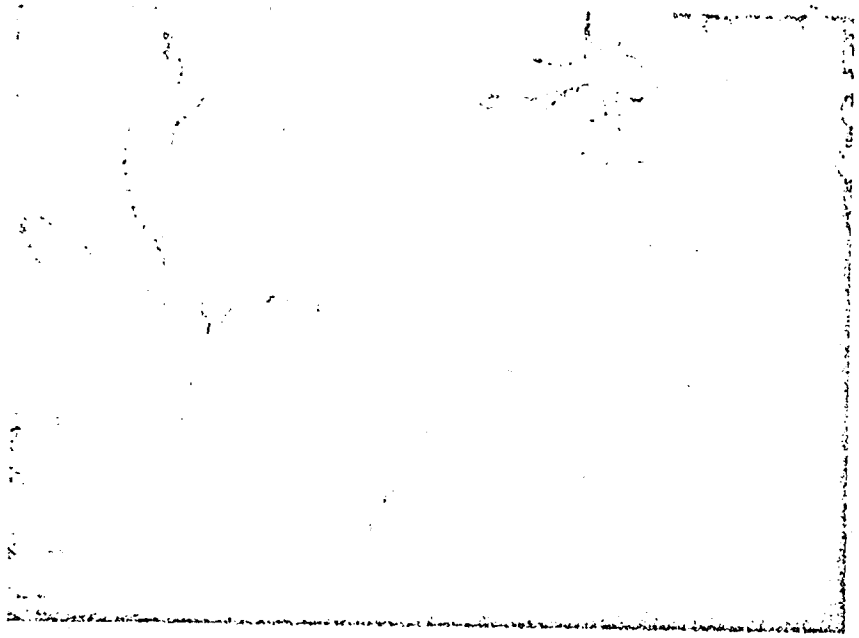
A trilobite had an external skeleton divided into many segments like those of crayfish, centipedes, and insects. It is believed that trilobites shed their skeletons several times while growing, just as insects do. These skeletons usually fell apart and are not often found complete.

A few fossil trilobites show limbs which could have been used for walking. A few show limbs that could have been used for swimming. Most trilobites had eyes; the eyes of some species were compound like the eyes of certain insects. Many trilobites had feelers on the head and a few had feelers on the rear as well.

The restoration shows two kinds of trilobites. What animal is capturing a trilobite? What other animals can you identify?







RECONSTRUCTING ANCIENT ANIMALS

Bones of mammoths have been found in many parts of the Northern hemisphere. Many people claimed that they were the skeletons of giants. Some people thought them to be bones of huge moles because they were always found buried in soil. Early attempts to assemble skeletons produced some amazing creatures, especially when the bones of two animals were mixed.

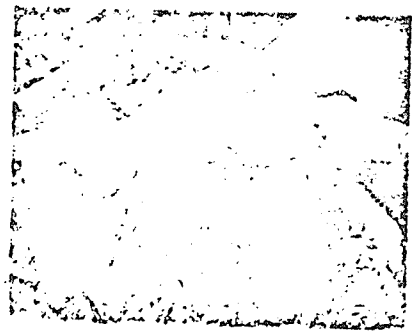
Finally, a few complete skeletons were discovered and recognized as belonging to a race of elephants. Specimens found frozen in arctic soil gave information about the hair and skin. The reconstruction shown here is probably accurate, but as late as 1900 the tusks were shown pointing outward. New discoveries may make other changes necessary.

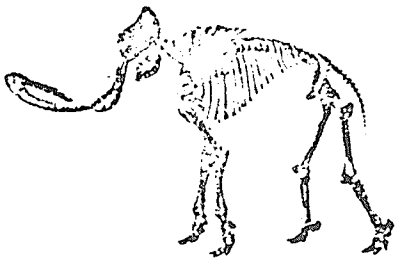
The Skeleton. The reconstruction of an animal often begins with a pile of bones. A geologist must first sort out these bones, keeping only those of the animal in which he is interested. If some bones seem to be missing, he studies skeletons of related animals, and makes inferences about the sizes and shapes of the missing bones.

The geologist then mounts each bone in what he believes to be its natural position. Why is a knowledge of living relatives of the animal a great help at this time? Why does a geologist make records of the arrangement of the bones before removing them from the rocks?

The Fleshy Parts. A geologist must make many inferences while reconstructing the muscles and other soft parts. If he can decide from the skeleton whether the animal flew, swam, hopped, ran, or waddled, he can decide which muscles had to be large. Scars on the bones show where the muscles were attached. Knowledge of living animals is of great help at this time.

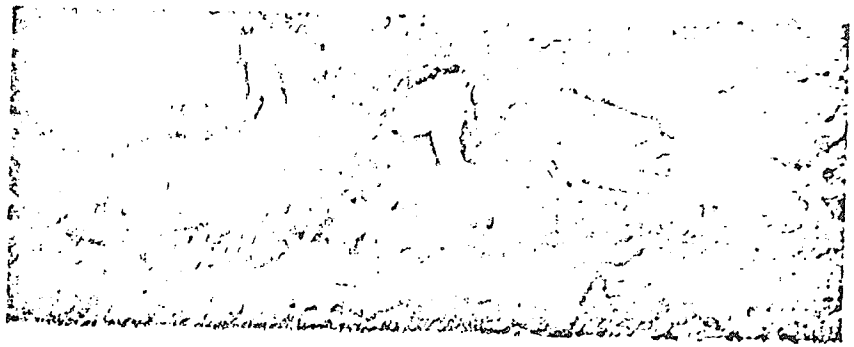
A reconstruction is not made on the original skeleton. Instead, a framework of rods and wire is used to support clay or other modelling materials which can be carved to the desired shape.

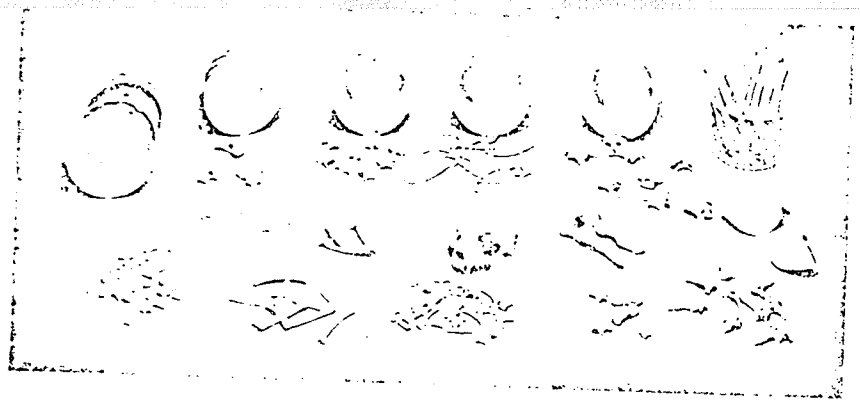




Scales, Hair, and Feathers. A geologist can only guess at the covering to put on many reconstructions. A few prints of feathers and scaly skin have been discovered. A little hair has been found in caves and frozen soil. Generally, a geologist must depend upon his knowledge of living animals when deciding whether to give his model a bare skin or whether to cover it with hair, scales, or feathers. He chooses whatever colours seem reasonable.

The restorations seen in museums are based partly on facts and partly on inferences. When looking at these restorations, we should keep in mind which portions are probably accurate and which portions may not be accurate.



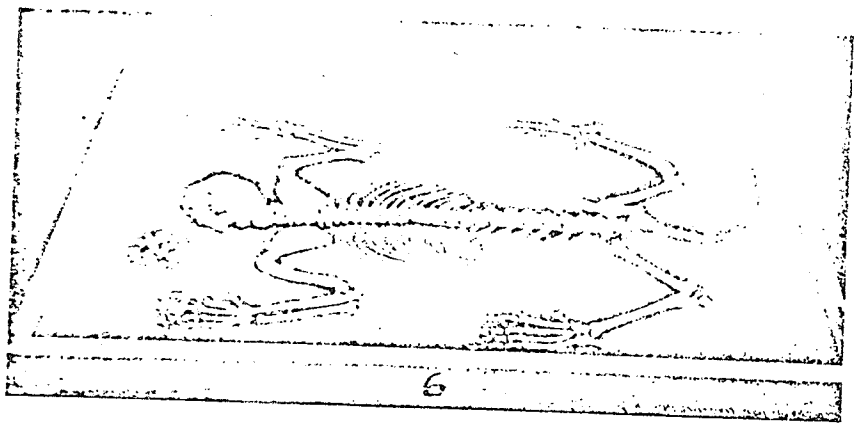


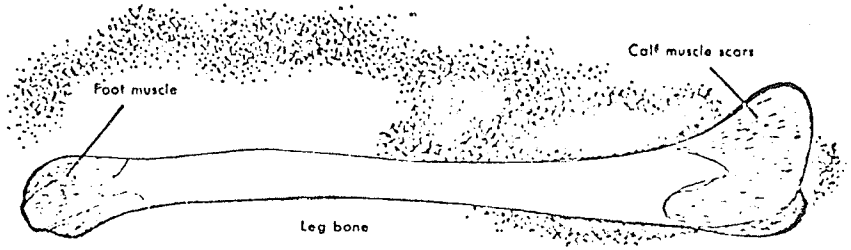
Obtaining Skeletons. Skin a small animal, such as a cat, and remove the internal organs. Cook the animal until the meat is soft (a pressure cooker speeds the process) and separate the bones from the meat. Dig the brain from the skull with a stiff wire. Boil the bones once more, this time in strong soap, to remove the grease.

If possible, obtain skeletons from several kinds of animals. It is well to mark the bones of each animal with coloured paint to help in sorting them if they become mixed accidentally.

Assembling a Skeleton. It is helpful to assemble a skeleton yourself to better understand how a geologist works. First sort out the loose bones, putting similar bones together. Then place the bones in what seems to be their proper positions in the skeleton, fitting them as closely together as possible. However, do not try to mount the skeleton; lay the bones flat as shown below. If you cannot find places for some bones, place them at one side.

After you have assembled a skeleton, notice how many loose bones you can identify.





Inferences from Bones. Scars on bones show where muscles were attached. Generally, the larger the muscle, the larger the scar. Note the scars on the leg bone above. This animal had large calf muscles. What type of animal needs large calf muscles? What type does not need large calf muscles?

Study the picture of the breast bone and compare this with your own breast bone. Large chest muscles were attached to both sides of the centre keel. What type of animal needs large chest muscles?

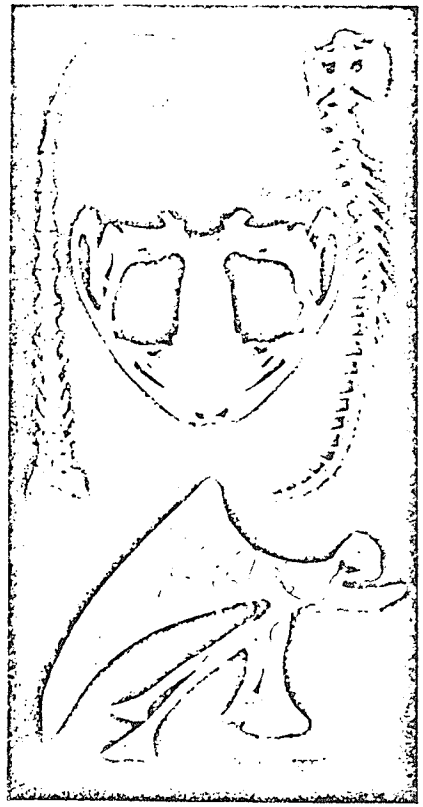
The larger bones of many animals are hollow. What is the advantage of a hollow bone? What types of animals might need hollow bones?

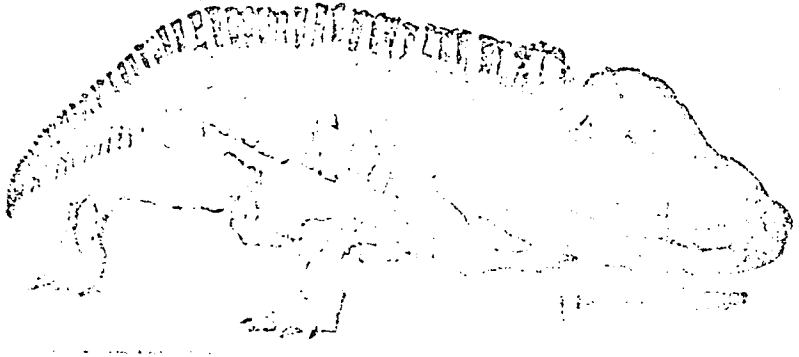
Most of the bones of the neck, back, and tail have spines and other projections. Muscles are attached to these projections. Two sets of tail bones are shown. Which belonged to a strong, muscular tail? Which were part of a weak tail? How might an animal use a strong tail? What animals have need for such tails?

Where are the eye sockets in the skull shown here? In what position would you expect this animal to hold its body most of the time? What are some animals commonly seen in this position?

Compare your inferences with those given later in this chapter.

Make a study of bones of different animals. Note the size and arrangement of foot and leg bones, then make inferences about the habits of these animals.



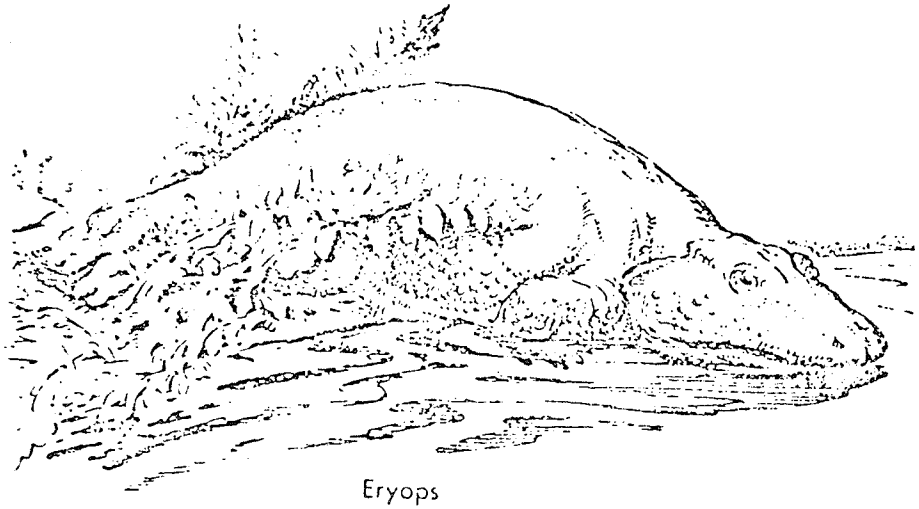


Early Amphibians. This skeleton belonged to an amphibian which has been extinct for many millions of years. Note the shape of the skull and the types of legs. What inferences can you make from these bones?

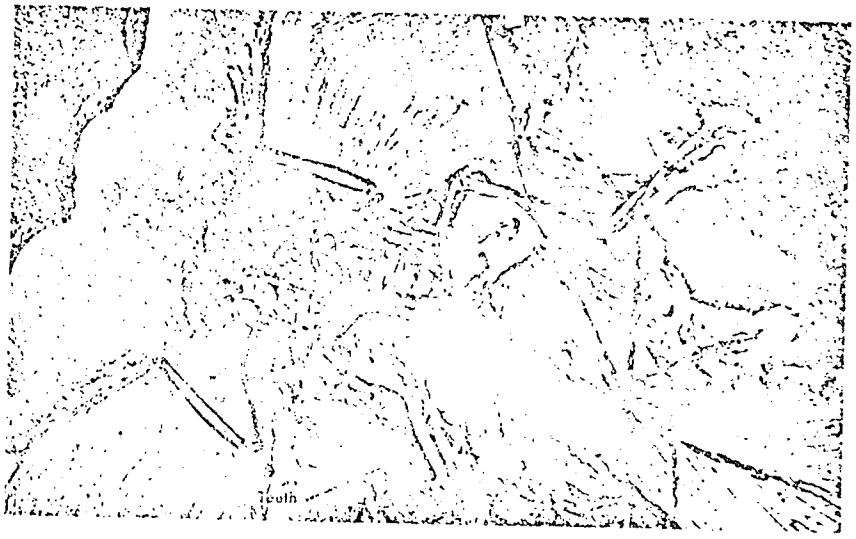
Compare the ribs, backbone, and tail bones with those of a cat. What inferences can you make about the amphibian from bones?

The photograph below shows a restoration based on one geologist's inferences. What parts of the animal are probably correct? What parts may be inaccurate?

What inferences can you make about the habits of this ancient amphibian? Base your thinking on both the skeleton and on your knowledge of the habits of living amphibians.



Eryops



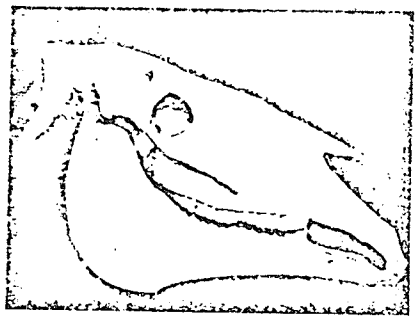
The Earliest Known Bird. This fossil of a bird is the earliest one that is known to geologists. How do they know that this prehistoric animal was a bird?

In what ways are the front legs of this fossil like the front legs (wings) of a living bird? In what ways are they different? Compare the tail of the fossil with that of a living bird. What inferences can you make about the flying ability of this ancient bird?

Note the teeth in the skull of this fossil. What living birds have teeth?

The restoration shows an animal that looks more like a reptile with feathers than like a living bird. Geologists believe that this ancient bird was closely related to certain reptiles.

Inferences from Teeth. Our own jaws contain four types of teeth: (1) cutting teeth (incisors), (2) tearing teeth (canines), (3) crushing teeth (bicuspids), and (4) grinding teeth (molars). These types are about equally developed. We could probably eat a mixed vegetable and meat diet if we were wild animals.

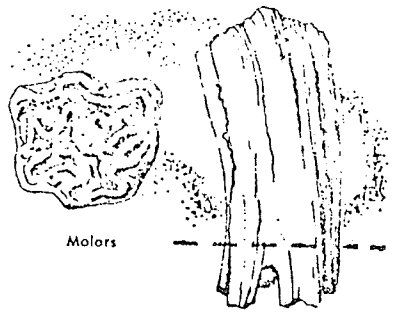


Which type of teeth in the skull at *A* are most highly developed? Which teeth are so small as to be almost useless? Describe the molars. For what purpose might the molars be used? What inferences can you make about the food of this animal?

The skull at *B* lacks one type of tooth. Which is lacking? Which type is very highly developed? How might this type of tooth be used? Describe the molars. What is the advantage of this type of molar? What food does this animal probably eat?

Study the skull below and the diagram of one of its molars. How might this animal use its front teeth? For what type of food are its molars well fitted? What inferences can you make about the food of this animal?

Inferences about food habits are not always dependable when based on teeth alone. Name some animals that have teeth fitted for eating meat but which eat as much plant material as meat. Can you name some animals with teeth fitted for eating plant material but which eat meat?



What type of food is probably eaten by the fish whose skull is shown here? How may the fish use these teeth?

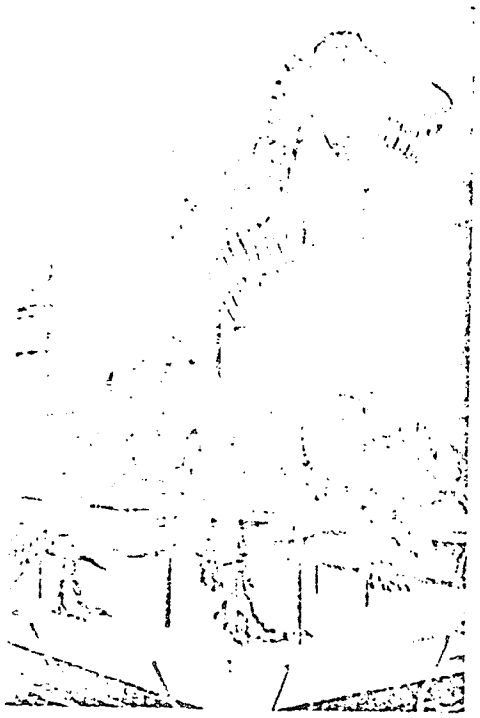
Compare the bills of the bird skulls shown here. What are some possible differences in the food of these birds?

CHECKING INFERENCES

Tracks as Clues: (1) The larger prints at the left of each group were made by the hind feet. The animal was travelling to the left. It was hopping. (2) The tracks in the snow were made by a walking bird. The fossil tracks were made by a reptile that walked on two legs.

Inferences from Incomplete Remains: (1) A giant animal lived in the region where these bones were found. (2) This fossil shows that ferns lived at some time in the past. (3) Empty snail and clam shells were probably washed into a place where they were later covered by sediments. (4 and 4a) The segmented bodies suggest that these animals were relatives of insects and crayfish. (5) These are fossil reptile eggs. Bones of unhatched dinosaurs have been found in some of them. (6) These look like worm burrows made in mud that became rock long ago. If they were made by worms, no trace of their soft bodies has been found. (7) Count the legs. It probably was a spider. (8) This certainly looks like honeycomb but geologists believe that it was a bit of coral. (9) Yes, it is a starfish. Starfish have been numerous for millions of years. (10) This specimen was once labelled as the skull of a man drowned in the Great Flood. Today, it is believed to have been the skull of a giant salamander.

Inferences from Bones: (1) Animals that walk and run need much larger calf muscles than do animals that swim, fly, or crawl. This is the leg bone of a dog. (2) Animals that fly need strong chest muscles but this is the breastbone of a chicken which does not fly well. Inferences can be wrong. (3) The right set of tail bones belonged to an alligator which used its tail for swimming. The set of bones at left belonged to a cat. (4) The eyes of this animal were at the top of its head. Probably it kept its head low and its body in a crouching or crawling position. It is the skull of a frog.

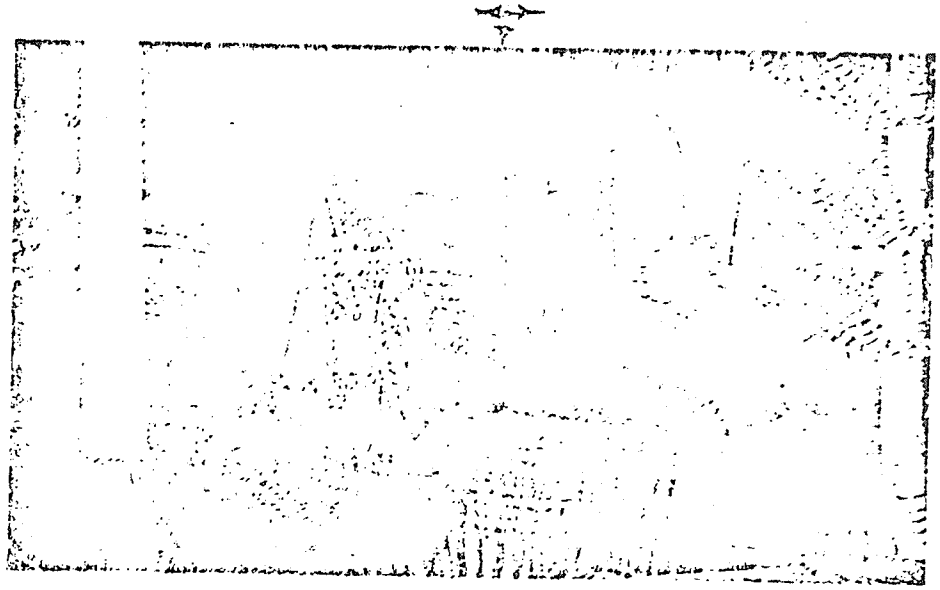


Habits of Dinosaurs. This restoration suggests that different dinosaurs had different feeding habits. The skulls shown here provide the evidence for this inference.

Study the skulls. What type of food do you think each animal ate? Why do you think so? Explain why your inference might be wrong.

Note the position of the dinosaurs in the restoration. Why is it unlikely that the skeletons were in this position when found? What type of evidence may have suggested that the animals stood differently?

The large dinosaur in the foreground, called Tyrannosaurus rex, is shaped somewhat like a kangaroo. Why do you suppose it is shown running rather than hopping? Note the way this dinosaur holds its tail. Explain this position in terms of a dinosaur's centre of weight and its balance.

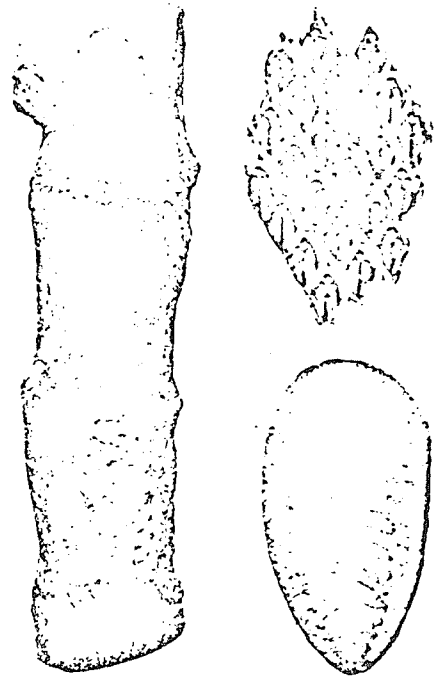


Restorations of Plants. This restoration shows the type of forest that produced the great beds of coal in Pennsylvania. Fossils like those seen here show that the forest was made up of giant ferns together with certain of their relatives, such as club mosses and horsetails.

At a later time, the giant ferns seem to have been crowded out by cone-bearing trees and by trees looking like present-day palm trees. Much later, flowering trees became plentiful, such as maples, elms, and oaks.

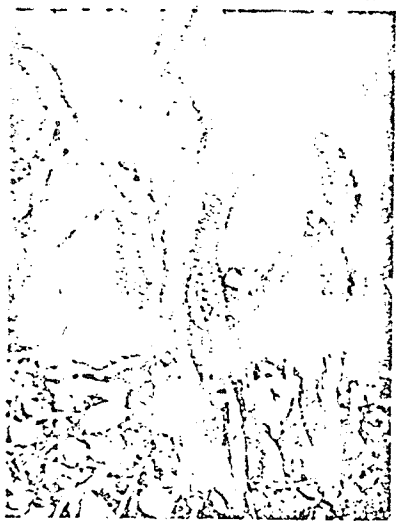
Study the restorations throughout this chapter. Which shows plants like those above? Which shows more modern looking trees? Which scene represents an older period in the earth's history?

What inferences can be made from the restoration shown on the opposite page?

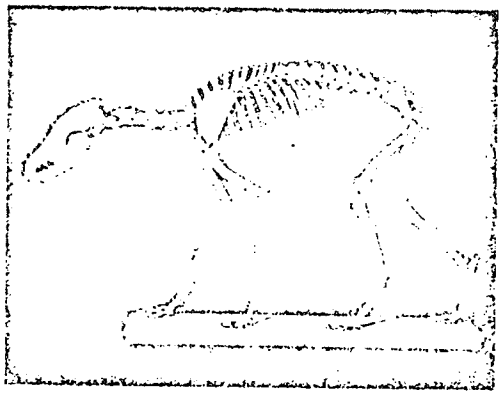


Fern

Club moss



Horsetail

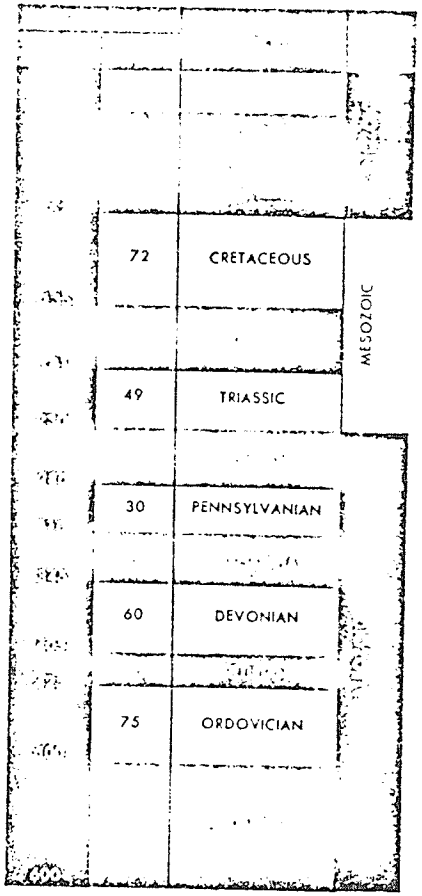


Experimental Research

1. Reconstruct the skeleton of some animal, such as a rabbit. Thread the backbone on a heavy wire and bend it to the proper curves. Drill tiny holes at the joints and fasten the bones together with fine wire. Drill the toes lengthwise and thread them on stiff wire. Attach the ribs with quick-setting cement.
2. Make a collection of fossils. Prepare a label for each, giving the name of the group to which it belongs, where it was found, and any inferences you can make from the specimen or rock in which it was found.
3. Collect reconstruction pictures of ancient life and use them for a bulletin board exhibit.
4. Dissect the leg of a chicken or rabbit and locate the muscles, tendons, and ligaments. Find the scars showing where these were attached to the bones.
5. Collect ferns, club mosses, and horsetails like those shown here. Use them to construct a miniature coal-age forest scene. Do not add models of animals unless you are sure that they lived in this type of forest.
6. Read about the fossil evidence upon which restorations of early man are based. Describe this evidence to your class and explain the inferences that have been made from it.
7. Prepare an exhibit showing different ways plants and animals have been fossilized.

Other Investigations and Projects

1. Prepare a diorama showing a reconstruction of ancient life in miniature. Use a cardboard box open at the front for the case. Paint a background on a strip of cardboard which curves across the back. Make vegetation from sticks, wire, and coloured crepe paper. Construct model animals from clay. In one diorama, show only species that lived at the same time.
2. Make a restoration of one of the fossils you have collected, using clay, paper, and other materials as needed.
3. Read about the different kinds of fossil horses that have been found and write a report on them, illustrating the report with pictures, diagrams, and maps.
4. Read about the famous Rancho La Brea tar pits in Los Angeles. Report to your class on the many types of animals that were trapped in the tar.
5. Take a trip to a museum to see fossils and reconstructions of ancient life exhibited there. Report on your visit.
6. Study the fossils and rocks of your region and make inferences about conditions that existed during the periods of time represented.
7. Prepare a chart listing the major periods of geological history. Paste on this chart pictures of the common types of organisms which lived during each of the periods.



ORIGINAL REMAINS ACTIVITY SHEET

DEFINITIONS: Operational definition of original remains is discovered. Food& decay.
OBJECTIVES: The student should be able to:
1: Identify and name the observable properties that can be used to classify original remains
2: Recognize and repeat the five types of original remains
3: Construct an operational definition of original remains

Materials: To be found by students

Activity: Most food is not used immediately after preparation so it must be stored. Various methods are used to prevent the food from "spoiling".

List 20 foods. Each must be found in a different container or storage place. Make a 5 column chart and divide these items into 5 groups according to the reason it is preserved.

What was the most important single idea that enabled you to group these items? What 5 facts must be known about that idea to subdivide the items into 5 groups?

Name 5 different situations that could cause food to be preserved naturally. Any dead plant or animal is food. If the remains of a plant or animal are preserved in such a way as to tell us anything about the original organism we call it a fossil. What fraction of the prehistoric animals have been preserved?

What fossil evidence of our generation will be found a million years from now?

What is the most important single idea that animals have in common? What is the most simple animal you know? What is the most complicated animal you know? What factor has simplified classification of plants and animals?

DISCUSSION: The idea that food is spoiled by a living thing (bacteria) and all living things require: (1) the initial living bacteria to begin the population as well as (2) warmth (3) air (4) food (5) moisture (6) space and (7) conditions under which bacteria can live should be explained for the sake of the students who did not "discover" these ideas.

This would be an awful lumpy world if all the dead cowboys, Indians and buffalo were still lying around.

RATIONALE: Even at the Grade 9 level students do not realize where dead organisms go.

This activity reviews the idea that bacteria actually "eat" remains and removes doubt about existence of fossils created by the dogma that all corpses "disappear".

This activity can be used to introduce the chapter, or later on as suggested by the author of the text.

ORIGINAL REMAINS WORK CHART

Make a 5-column chart and write each of 20 food items in a column according to the method used to prevent spoiling. Write the method of preservation at the top of each column.

METHOD	1.	2.	3.	4.	5.
FOODS					

What is the most important single idea that enabled you to subdivide these items into the 5 groups above?

If you think of the reason foods spoil you will have the answer. (You only need to remove one of the five life-supporting essentials to prevent spoiling. *)

Name five different situations that would cause food to be preserved by nature. (N.B. Any dead plant or animal is food)

What fraction of dead plants or animals do you think would be preserved by nature?

What happens to the rest?

If the remains of a plant or animal is preserved in such a way as to tell us anything about the original organism we call a fossil, what will be the condition of fossils we find? Why? Have fossils of all ancient forms of life been uncovered? (See p. 177)

What dead plants or animals of our generation will be preserved for people to study millions of years from now?

Imprint Assignment Activity Sheet.

Definition: Fossil - any imprint or actual organism naturally preserved that enables us to learn more about prehistoric life.

Objectives: When you have completed this exercise you should be able to:

1. List materials in which imprints can be made.
2. Make an imprint
3. List characteristics of molding material that affect the detail of the mold.
4. List materials found in nature suitable for imprints.

Materials: To be found by students.

Activity:
1. Make a footprint of any animal in any material.
2. On a piece of looseleaf write out 3 advantages of using the material you chose.
3. Below, list 3 disadvantages.
4. List and underline 4 materials found in nature that could be imprinted and would retain the shape for years. Beside each material write one advantage or disadvantage in using that material.

In one sentence tell what you think happens to most imprints.

After the assignment has been explained the students can spend the rest of the period making notes from pages 182 & 183. The information on these pages helps them understand the assignment a little better.
The assignment can be done in one evening for homework and handed in the next day for correction. While the molds & casts are being corrected the students can be assigned notes P. 181 & 180 to prepare them for making inferences on pages 178 & 179.

Discussion: Shrinking, cracking, filling in, coarse texture, even rising if made of dough, make for interesting discussion along with materials that won't harden such as plasticine.

Names are checked off as molds are handed in and observations marked later. The results can be used to determine how much more discussion is required.

Rationale: "Simple objectives listing simple processes and content provides basic knowledge required to allow the student to discover." Discussion is required to combine findings of all students and stimulate discussion.

ENCOURAGE student PARTICIPATION and EXPRESSION of DIVERGENT points of view. Learning is most effective when relationships are discovered.

IMPRINT ASSIGNMENT WORK SHEET

Activity:

1. Make a footprint of any animal in any material.
2. On a piece of looseleaf write out three advantages of using the material you chose.
3. Below, list three disadvantages.
4. List and underline four materials found in nature that could be imprinted and would retain the shape for years. Beside each material write one advantage or disadvantage in using that material.

In one sentence tell what you think happens to most imprints.

Make a mold of some object. Remove the object and fill the mold you have made with a substance that will harden. Write the word "mold" on the mold and the word "cast" on the cast.

Place the footprint, mold and cast in one container with your name and room number on it and hand in.

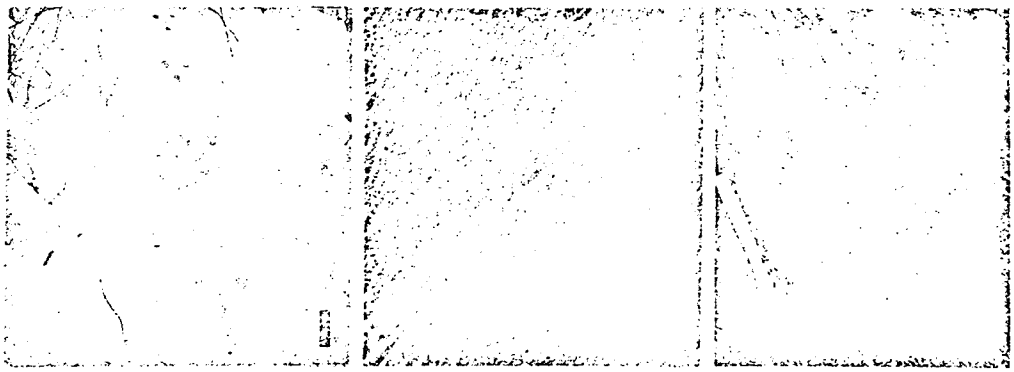
INFERENCE ACTIVITY SHEET.

Definitions: 1. An inference is an explanation of an observation.
2. An observation is an experience that is obtained through one of the senses.

Objectives: The student should be able to:
1. Identify observations that support an inference.
2. Construct inferences from a set of observations.
3. Identify reptile footprints.

Materials: Text open to P.178

Activity: 1. Make a list of observations about the footprints in each picture across the top of P.178.
2. Make an inferences about the direction, kind, speed and size of each animal.
3. List the observations that substantiate. each inference.



Discussion: The student's own observations and inferences are more important than the "correct" answer from P.203. Inferences listed on P.203 under the heading, "Tracks as Clues" are: 1) The larger prints at the left of each group were made by the hind feet. It was hopping. 2) Tracks in the snow were made by a walking bird. 3) A reptile walking on two legs made the fossil tracks. Identifying characteristics around the edge and on the bottom of the print are used to verify tracks of some animals. Police use this technique.

Rationale: Knowing the difference between an observation and an inference helps a student distinguish speculation from fact.

At times marks are required to provide incentive and to allow both teacher and student to realize how much was actually understood. This activity is supervised so no incentive is required and the discussion allows immediate evaluation.

OBSERVATIONS AND INFERENCES WORKSHEET

Each item below really requires two observations for each inference, ONE from the picture and ONE from a similar animal you observed, studied or learned about before.

	Inference	Observations
Direction		
Kind		
Speed		
Size		
Safety Points		

Make three charts similar to the above and fill in one for each picture across the top of Page 178.

NB. An inference is only as good as the number and kinds of observations on which it is based. Which picture did you find easiest? From which picture did you make the worst inferences? WHY?

List the two most important things we should do if we expect to write better inferences. That is: (1) What can we <u>do</u> to prepare ourselves to make better inferences? AND (2) What can we <u>get</u> to prepare ourselves to make better inferences?

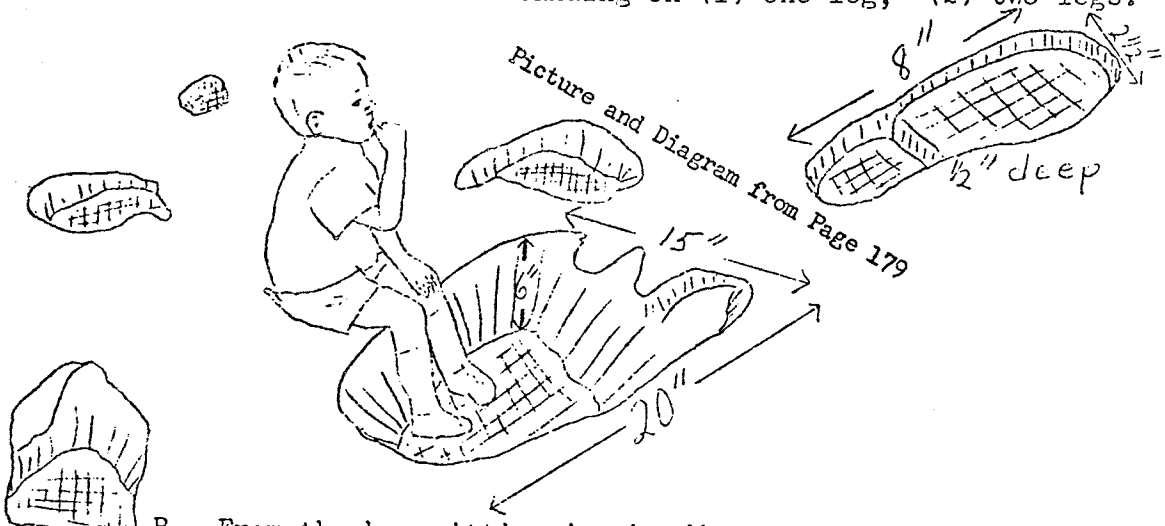
USING NUMBERS ACTIVITY SHEET.

Definition: Pounds per square inch = $\frac{\text{weight}}{\text{area}}$

Objectives: The student should be able to:

1. Compute the weight of an animal from the area and depth of the foot print.
2. Recall the approximate weight of a dinosaur.
3. Recognize weaknesses and necessity of assumptions used.

Activity. A. From the ruler which shows the average depth of the foot print to be about half an inch, and the plaster cast beside it, divided into square inches, calculate the weight of the man if he was standing on (1) one leg, (2) two legs.



Picture and Diagram from Page 179

B. From the boy sitting in the dinosaur track, which shows the average depth to be about 6", decide on the width and length and calculate the dinosaur's weight.

Discussion: A. 20lbs/sq. in. is required to make a track 1in. deep, therefore, the man's foot must have applied 120lbs/sq. in. The area of the track is 20 sq.in. (or 21 sq.in)
10 $\frac{\text{lbs}}{\text{sq.in.}}$ x 20 sq.in. = 200lbs if the man is standing on one leg. 10 $\frac{\text{lbs}}{\text{sq.in}}$ x 40 sq.in. = 400 lbs. if he is standing on two legs.

B. From the shale in which the dinosaur print is found it has been inferred that the mud in which it stepped was soft enough to sink 1 inch for each 20lbs/sq.in. pressure (same as above). Since the track is 6 inches deep then 120lbs/sq.in must have been applied. The area of the track is 20in. x 15 in. = 300 sq.ins. 120lbs/sq.in. x 300 sq.ins. = 36,000 lbs. if all his weight was on one foot. 120lbs/sq.in x 600 sq.ins. = 72,000 lbs if bipedal. 144000 lbs. or 72 tons if quadripedal. Students must understand necessity and weaknesses of the assumptions about type and condition of soils and the gait of the animal. RATIONALE: Some students require review of calculation and meaning of area and pressure.

NEW COMPOSITION ACTIVITY SHEET.

Definition: Osmosis - The mixing of two liquids or gases of different thickness when separated by a porous membrane.

Objective: After completing this activity the student should be able to: (1) Distinguish between original remains, an organism that has been chemically changed, and a fossil that has had its decayable parts replaced. (2) Describe the processes that change an organism to a non-decayable state.

Materials: Bunsen burner, piece of wood, test tube, stopper, short glass tube, egg, vinegar and a beaker.

Activity: Place a piece of wood in the test tube and plug it with a one-hole stopper that has a short piece of glass tubing inserted in it (or do the experiment p.318). Heat the wood on a bunsen burner. What escapes through the tubing? Why can O2 not enter the test tube? Will the escaping gas burn? What is the new color of the wood? Why? Will the solids left in the test tube burn? Do you think it might decay? Why? How is this process similar to carbonization (see p.184).

Soak an egg in vinegar overnight and change the vinegar in the morning. Repeat this procedure until the shell is removed. Leave the egg in any thin liquid. Why does the egg increase in size? Place the egg in sugar or salt. Why does it become smaller? What might happen to the cells of a tree that has fallen into a mineral solution? What organisms are most often petrified (see p.185)? Why? What happens to most organisms before they can be petrified?

Discussion: Partial distillation takes place when wood is heated in a test tube if O2 cannot get in to support combustion. Methane is boiled off leaving H2 and C (charcoal) that cannot decay. If sufficient wood is in the container and heat is added long enough to drive out the air the methane (natural gas) can be ignited. This same process took place when a forest was buried years ago. The earth, silt, etc. prevented O2 from reaching it and spontaneous combustion provided the heat. This impervious layer had a pocket in which the liquids and gases were trapped. 20-30 ft of dead tree became 1ft of coal. Most of this took place during one time when dense forests of ferns, etc. covered the earth (p.205). Because of this carbonization it is referred to as the carboniferous period.

A discussion of the minute amounts of sand, iron, etc. that can be dissolved by water might give the students a better understanding of the time required to replace the cytoplasm in each cell with minerals. The porosity of the wood allows the preserving chemicals to penetrate it while petrification takes place.

Rationale: Fossil fuels are in the news and are a perfect example of a non-renewable resource since it takes millions of years to make more (p.318-321).

The most common rock in the agate pits around Souris, Manitoba is petrified wood. Pails full can be picked up in minutes.

CRITICAL EVALUATION ACTIVITY SHEET

Definitions: 1. Speculation - unsupported statements
2. Probable - supported by strong evidence
3. Fact - that which is known for certain

Objectives: A student should be able to: (1) recognize and cite evidence that probable speculative or factual information is included in all written work (2) distinguish between fact, speculative and probable statements (3) deduce that further study of basic facts and definitions enables one to evaluate information more accurately.

Materials: Sheets provided (or some more recent article from a magazine or paper)

Activity: The student is directed to make a(n):
(f) if he thinks it's fact
(p) if he thinks it's probable
(s) if he thinks it's speculation
to the left of each paragraph as he reads

Discussion: Questions asked by students should be "how can we tell how accurate each article is?" One answer is that we must rely on the source. If the integrity and research of the author is reliable then the material is well founded. Bias and incomplete data can be discussed in terms of the scientific method.

The advantages of some basic knowledge of the subject can be pointed out and the chapter "Life in the Past" introduced by stating that the next chapter will give us some ideas of the kind and amount of research that is required to put an article like this together

Rationale: Recent, interesting and well done articles are used to develop an interest in geology. The curriculum states one outcome is to "Demonstrate a developing interest in science".

If more related, interesting or contemporary articles are used the activity can be improved considerably.

Note: The third objective is introduced in the discussion but a separate activity sheet could be produced to teach it.

Test Items:

According to Mager "If you give a learner a copy of your objectives you may not have to do much else".

The teacher should decide what portion of this sheet the student will receive.

CRITICAL EVALUATION WORK SHEET

Universe Origin Tested

CHURCHILL, Man. (CP) — A team of scientists has been working around the clock in the bunkers and laboratories of the National Research Council rocket range in northern Manitoba attempting to measure cosmic background radiation.

Using an intricate scientific "thermometer" imbedded in the nose cone of a Black Brant rocket, the scientists have collected data that will take several months to analyze but the results, when complete, could go a long way to either proving or disproving one theory about how the universe began.

Dr. Herbert Gush, head of the scientific team, said the theory of scientific genesis up for analysis is the "big-bang" theory.

Dr. Gush, a professor of physics at the University of British Columbia, and co-workers from the University of Saskatchewan's space engineering division, have been experimenting directly with one offshoot of this scientific theory.

In a telephone interview Monday from the northern Manitoba rocket range on the shores of Hudson Bay, Dr. Gush said the theory that the universe was created eons ago by a primeval fireball was largely unsubstantiated until recently.

According to the theory, when this ball of energy exploded, it also condensed rapidly into matter and formed the stars and the planets. In later years the theory was further advanced by a scientist at Princeton University who suggested that if the theory was correct, deep space should be a sea of radiation all within a certain spectrum or intensity.

Dr. Gush explained that when the first communications satellites went up they received strange signals from deep space and that this appeared to support the sea-of-radiation theory.

Dr. Gush and his team harnessed a delicate apparatus to the nose cone of a Black Brant rocket and shot it 85 miles skyward.

"We know now that the apparatus works and we received some data," said Dr. Gush.

He said the data gathered now must be analyzed, a process that could take several months. Then, he said, if all goes well, the scientific team will repeat the experiment.

Asked whether his equipment was anything like a complicated geiger counter, Dr. Gush explained the radiation is not nuclear radiation. It would be fair to compare his equipment to a thermometer.

He said the correct title is cosmic background radiation. Using generalities, the scientist likened his experiment to placing a hand in front of a hot stove.

"You feel something. . . . The stove is radiating toward the hand. It has a higher temperature than the hand."

In Dr. Gush's experiment, the rocket was the "hand" and the measuring equipment in the nose cone was kept at one degree above absolute zero by a liquid helium bath.

The radiation being measured is characterized by a temperature of three degrees above absolute zero. Dr. Gush said scientists have known for some time that the radiation is there but its intensity and spectrum are mostly unknown.

He said the rocket is necessary because the earth's atmosphere is opaque and the radiation does not get through. The intensity of the radiation now has apparently been measured but Dr. Gush said it may take some months to find out whether the experiment actually worked.

Depending on the results of this and future experiments, Dr. Gush said the "big-bang" theory of the universe could either be substantially strengthened or weakened.

WINNIPEG FREE PRESS.

Earth Formed From Moons?

SAN DIEGO (Special-TPNS) — The solar system once contained a great many bodies the size of the moon that were swept together to form the earth and other planets, according to Harold Urey, University of California at San Diego chemist.

He said the earth itself may have formed from the accretion of 80 or more of such moon-sized bodies.

Dr. Urey, a Nobel laureate in chemistry, said there is evidence the solar system once consisted of lots of these big moons. There are seven of them left — Jupiter has four, and Neptune, Saturn and earth one apiece. Other moons, such as Mars' two, are too little to be included by Dr. Urey in this class. They are just broken pieces of moons.

He said it is possible that Pluto, the outermost planet of the sun, is actually a moon that "escaped" from Neptune.

In Dr. Urey's reconstruction of the evolution the solar system these steps occurred:

- The system began as a huge mass of gas. As this mass began to contract the sun started to form at the centre.
- When the sun had contracted to the size now encompassed by the orbit of Neptune, it began to throw off great gobbets of gas and solids from its equatorial region where the centrifugal force was greatest. This continued until the sun had just about reached its present size.
- While the sun was contracting the solids and gas thrown off accumulated in a flat disk-like band or nebula, around it.
- The process of planetary evolution began as smaller lumps of solids bumped into each other and joined to form a countless number of larger bodies about the size of the earth's moon.
- These continued to collide to form the present planets. A few of them did not collide with others and remain today as satellites of the planets.

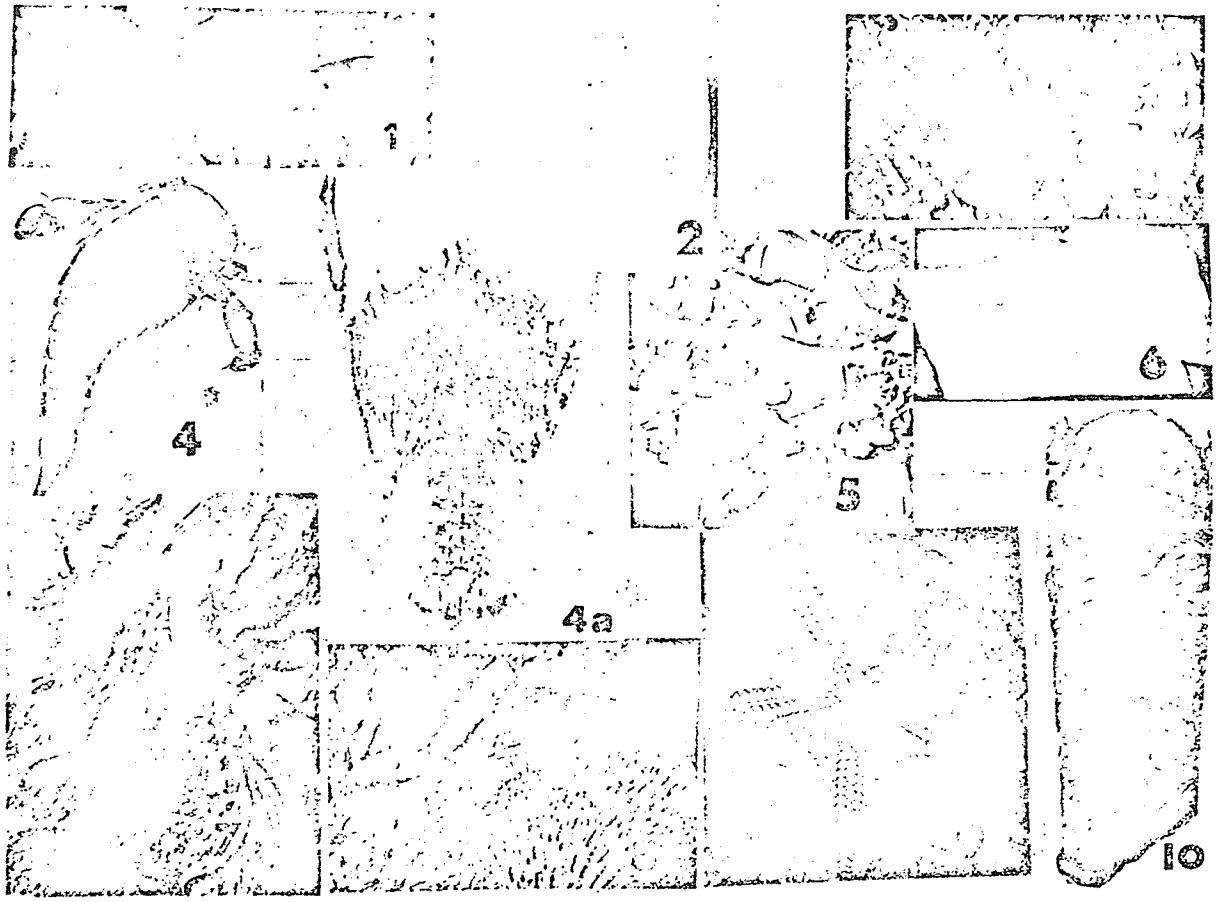
87

INFERENCE ACTIVITY SHEET

Definition-Inference-A conclusion based on incomplete evidence.Inferences are often revised as additional evidence becomes available.

Objectives-After completing this activity the student should be able to:(1)distinguish between shapes of animal remains (2)compare and contrast shapes of animal remains with familiar animals of the present (3)recognize that additional evidence increases the accuracy of an inference. (4)find the glossary and use it to define words.

Activity-Copy the definition of "inference" from page 563 (the glossary).Make notes and follow the instructions given on page 180 in your text.

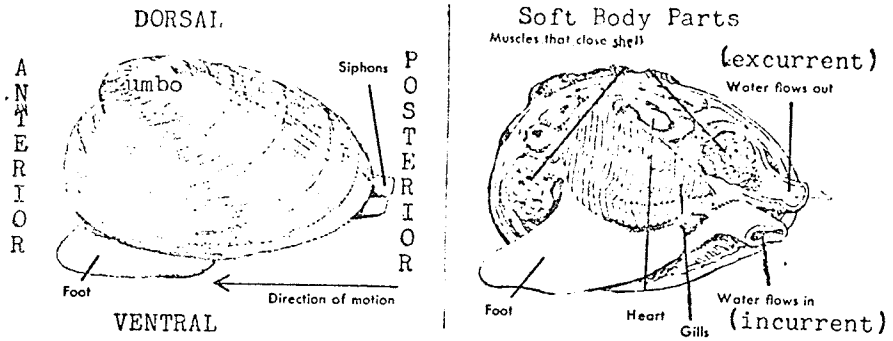


Discussion-Inferences made by the students are more important than the "correct" answers below especially if they can recognize that they're speculative because they are made from pictures.The possibility of improving inferences by obtaining further information and learning more about similar animals alive today is even more important.(1)A large vertebrate lived in the region at the time the layer of sediment was deposited.The flesh was decayed and the bones were forced apart as the soil settled.(2)A fern frond carbonized suggesting it was buried before it could decay.(3)Shells washed together by wave action.(4)An eurypterid related to king crabs.It's related to insects,crayfish & other arthopods.(5)Dinosaur eggs (6)Worm burrows(7)Spider(Note the 8 legs)(8)Coral(favosites or honeycomb coral) (9)A starfish(10)An amphibian.

Rationale-"Shell prints" and "fossils" are synonomous terms to most students until this exercise is completed.

CLAM CHARACTERISTICS.

Materials: clam, dissecting needle and tray; scalpel; scissors; screwdriver; hand lens.



Activity: Examine your specimen and note that the shell consists of two parts, called valves. The shells are fastened together along the dorsal surface by an elastic ligament (hinge). Locate the elevated bump, the umbo, that is near the anterior end of the ligament. This is the oldest part of the shell. As the clam grows, it secretes additional layers, each one extending beyond the last one laid down. This produces a series of concentric annual growth rings which you can locate on the shell. (See third paragraph P. 186 of text).

The outer portion of the shell is a thin, dark, and horny layer. It is often lacking on the umbo of older specimens. The middle layer, or prismatic layer is formed of crystals. Examine the inner layer, or pearly layer. Using a probe, locate the two openings on the posterior end. The ventral one is an incurrent opening for the entrance of water currents, and the dorsal one is the excurrent opening, through which currents of water leave the clam. The shells open on the ventral surface.

Use your screw driver or another flat instrument to open the shells. Cut the two large muscles that hold the shell closed. These are the anterior and posterior adductor muscles. Open the shell and lay it back on the dissecting tray. Note the scars that are left by the removal of the muscles. Examine the dorsal edge of the shell and note the toothlike projections that fit into the grooves in the opposite shell. (a) What purpose does this arrangement serve? _____. Examine the interior of the shell, noting the smooth, glistening appearance. This is the third layer, or pearly layer, of the clam shell. (b) Why is the interior of the clam shell smooth? _____

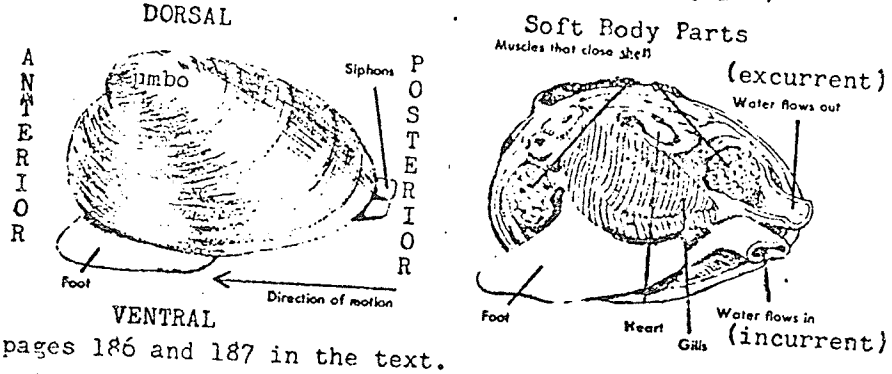
Locate the soft body parts that lie in the dorsal region between the two large muscles that close the shells. Examine the mantle covering the soft body parts and note that it extends along the ventral edges forming two mantle lobes, (sheets) one just inside each shell. The space between the two lobes is the mantle cavity. Remove a mantle lobe and expose the mantle cavity and its organs. The muscular foot extends into the mantle cavity and out between the shells. Locate the pair of sheet-like gills that hang into the mantle cavity on either side of the foot. Use the hand lens to find the cilia on the gills. The beating of these cilia draws water into the incurrent opening. Locate the mouth and the pair of folds, the palps, on either side of the mouth. Insert the probe into the mouth and direct it into the esophagus and into a saclike stomach.

Use a scalpel to cut away the muscle of the foot and expose the intestine, digestive gland surrounding the stomach, and the pericardial cavity

I. MOLLUSKS.

Definitions: Mollusk - has a fleshy mantle, a dorsal visceral hump and a muscular foot.

4 Pelecypods (see paragraphs 1 and 2 P. 188)



See pages 186 and 187 in the text.

Objectives: The student should be able to:

1. List the characteristics common to all mollusks.
2. Recognize body parts of an actual clam or a diagram.
3. Describe the nature of the foot, mantle, gills, radula and shell symmetry (see P. 190 b) common to all clams. (Identify and name observable properties of clams that can be used to classify them).
4. Construct an operational definition of a clam based on the classification scheme in #3.

Materials: 4"-5" clams (#57756-2 in the Cenco catalogue P.308. They can be ordered by phoning 783-9765 or by mail @ $3.00 per dozen. Delivery 10-14 days from date order is received); dissecting needle and tray; scissors; scalpel; screwdriver; hand lens. Two or three students per set of materials listed above is ideal.

Activity: See "Clam Characteristics" over. Instruct students to locate and name each body part from the above diagrams.

Discussion: How are evolution and classification related? How can classification be used in dating strata? What characteristics do oysters, scallops and mussels have in common with clams? (see P. 187 b).

Rationale: Mollusks are separated into classes on the basis of their symmetry, the nature of the foot, the mantle, gills and radula.

This activity points out that similarities put mollusks in a phylum of the animal kingdon and that differences divide them into classes.

Interrelationship of Biology and Paleontology.

Through the course of evolution the original body plan has become modified into several different forms as the animals spread to different environments. Similarities originate from the basic body plan of the original group causing them to be classified in the same phylum. Differences caused by different environments, etc. caused them to be placed in different classes.

Concept-A living thing is a product of its heredity and environment.

A Golden Nature Guide book called "Seashells of the World", is a $1.50 pocket book containing excellent charts and illustrations and can be purchased for about $1.10 at the U of M book store.

ORDOVICIAN ORGANISMS DEFINITION SHEET

Mollusks (*See functional definition below)

Pelecypods (bivalues)			Gastropods	Cephalopod		
clams	oysters	scallops		squid	octo-pus	nau-ti-lus

Canines				
dogs			wolves	coyotes
collies	poodles	terriers		

* Similarities place all mollusks in the same phylum e.g. 1. all have a mantle
2. all have 2 shells, gills, siphons etc.

Differences place apelecypod in a class by itself because 1. The mantle of each shell grows at the same rate.

2. Each mantle grows lop-sided producing a lop-sided shell (NOTE that because each mantle grows at the same rate both shells will be identical (symmetrical).

Differences place gastropods in a class by itself because 1. Single coiled shell
2. Mantle grows rapidly in one direction
3. Distinct head with tentacles and a rasping tongue (rodula)

ORDOVICIAN ORGANISMS ACTIVITY SHEET.

Definitions: Radula - Hard tongue-like structure found in the mouth and used to scrape off material, e.g. algae - from rocks or squarium walls.

Objectives: The student should be able to:

1. Compare and contrast calcium carbonate exoskeletoned animals listed in the text.
2. Make inferences about fossils with characteristics similar to these animals.
3. Specify limitations and assumptions included in inferences when comparing and contrasting today's animals with fossils.

Materials: Exploring Science text.

Activity:

I MOLLUSKS.

A. Pelecypods - (Make notes P. 186 and 187).

* Describe the nature of the: foot, mantle, gills, radula and shell symmetry (P. 190b)

Define a clam.

In what ways are scallops and mussels different from clams and in what ways are they different from each other (see diagram P.187b).

The other classes of mollusks (gastropods, chitons, cephalopods and tusk shells) can be examined by following the procedure above * or experiments. In the text you will find some steps to follow in examining live gastropods.

B. Gastropods - (Make notes P. 188 also diagram P. 188 trh)

C. Cepholopods (Make notes P. 188 and 189)

II BRACHIOPODS

Make notes P. 190 and 191 and diagram P. 191m)

III CORALS

A. Solitary Coral (notes P.192 and also diagram P. 192b)

B. Colonial Coral (make notes P.193)

IV CRINOIDS.

Make notes and diagram P. 194m. "Lucky rings" found on Winnipeg and Victoria beaches are really the calcium carbonate coverings of ancient crinoid stems.

V TRILOBITES.

Make notes and diagram P. 195. Name the group of animals to which each of the lettered models in the restoration (P. 208t) belongs.

(Letters after page numbers mean: t-top, b-bottom, m-middle, r-right, l-left, h-hand).

Discussion: Which parts of each restoration is: fact, which is probable and which is speculation? State the significance of location, size and distance from pivot point of muscle scars. What factors make restorations of soft body parts more accurate? What weight is placed on the assumption that the soft body parts in the fossil shells were the same then as they are today? Justify this assumption.

The significance of muscle scars on other animals can be pointed out as an introduction to "Reconstructing Ancient Animals," P. 196.

Rationale: These animals are strange to Manitoba students. Fresh water mollusks are not of any commercial value so many students have never even seen the freshwater varieties.

INFERENCES FROM BONES ACTIVITY SHEET.

A Definition: Meat - muscles of an animal.
Scar - a mark left after a wound
Articulate - fit joints together.

B Objectives: After completing this activity the student should be able to: (1) recognize muscle scars; (2) estimate the size of a muscle and the animal from which it came from a scar on a bone; (3) Specify limitations and assumptions used in formulating the inference made in number two.

C Materials: Bones can be obtained from a butcher shop or at home. Carcasses of whole animals are available from your local taxidermist free of charge - see the yellow pages. The animals are skinned and wrapped in plastic bags.

D Activity: Pull the meat from a bone and describe the location on the bone that gave the most resistance. The drumstick of a chicken with the skin removed is ideal. Make an inference that would explain the difficulty in removing the muscle (meat) from one location and not another. Contrast the texture of the area that resisted separation with the texture of the rest of the bone. Name the area that resisted separation (see p.199t).

Perform the activity described on p.198. The meat is easily removed when boiled in soapy water, but the skinned animal from a taxidermist can be cleaned easier by placing it on an ant hill. A cage around the carcass will prevent it from being eaten or carried away by larger animals.

Compare the size of the front and back muscles on the upper part of your arm. Which muscle is used more often? Why? If we found similar muscle scars on the bones of an animal fossil what inferences could we make concerning its habits? Make a drawing of your arm that will show where the front muscles are attached. Compare the front and back muscles on the lower portion of your leg. Which is used most often? How do your leg muscles compare with the muscles on a drumstick?

E Discussion: The meat on the drumstick is still attached to the bone at the foot end but it is loose the rest of the way up. The muscle scars are obvious and large indicating that the chicken uses its leg muscles frequently. Large breast bones and scars on the chicken indicate large flying muscles. This is the reason the breast of the chicken provides much meat. Red muscle cells (dark meat) correlate positively with sustained flight. The area of the muscle is proportional to the size of the muscle.

To illustrate the relationship between muscle size and habit ask the student to slide your desk ahead with his foot. He should use his toe less frequently. Ask him to choose between chinning himself and doing a handstand from an inverted position standing on his head. The correlation between the more frequent use and the larger size of the biceps shows some connection between habits and muscle scars.

F Rationale: The students should have learned many of the recall and comprehension type objectives so these were constructed from application and analysis verb columns.

BIRD RESTORATION ACTIVITY SHEET

Definitions: Restoration, archaeoptryx and pterosaur.

Objectives - After completing this activity the student should be able to:

1. Distinguish between inferences and observations.
2. Gather data useful for constructing inferences.
3. Recognize and cite evidence for revising inferences
4. Justify inferences about fossil archaeoptryx.

Activity — Read the articles and underline all observations and double underline inferences, then on a sheet of looseleaf answer the questions (printed sideways on the work sheet). Question "C" can be answered easier if you examine the head and feet of a bird. Make notes on bird skulls, p. 203.

Materials — Any issue concerning recent discoveries or observations that have lead to formulation of new inferences. The science or environment page of Time magazine is a good source of such an article. The head and feet of a chicken or other bird and Exploring Scienve Nine text.

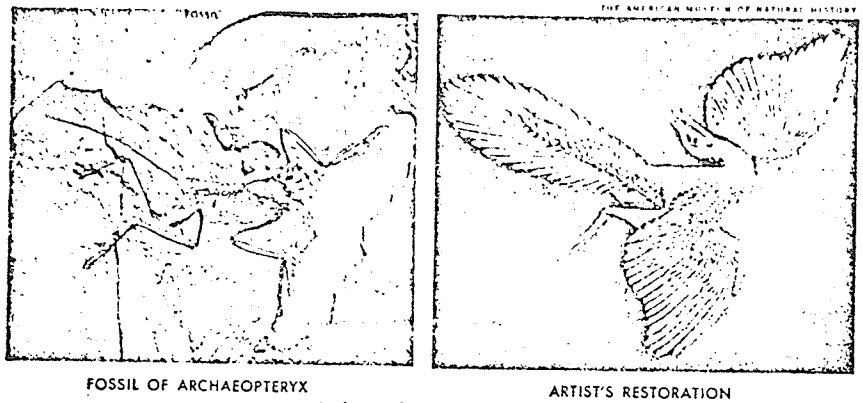
Discussion — Critical reading can be discussed here. The validity of an article is based on the number and kind of observations on which an inference is based and * the revision of inferences as new evidence (observation) are discovered would allow a student to realize that science is dynamic. * The ethics of the authority stating the inferences also influences the validity of statements made in an article.

Present day events and organisms are studied and then compared with data and fossils that were preserved during prehistoric times. NOTE: that it is necessary at times to realize that conditions were not the same millions of years ago as they are today. We must try to compensate for the differences, eg. the temperature of the earth may have been much higher so we would not necessarily infer that a bear had a thick fur coat if we were to make a model of a fossil of a bear.

Rationale — The student may be asked to find articles of his own as well. Recent discoveries add relevance. Even if the article negates the information of the text the student will learn an important lesson if he realized that information is only correct to some degree.

BIRD RESTORATION WORK SHEET

SCIENCE



FOSSIL OF ARCHAEOPTERYX — ARTIST'S RESTORATION

A distinctly unreptilian impression.

How Birds Began to Fly

Poking through the fossil collection of The Netherlands' Teyler Museum in September, Yale Paleontologist John H. Ostrom spotted one musty specimen that looked odd to his trained eye. It was labeled pterosaur, a flying reptile that inhabited the earth from 65 to 200 million years ago. But when Ostrom held the fossil to the light, he saw the distinctly unreptilian impression of a feather. "My heartbeat began going up fast," recalls Ostrom, who quickly recognized that the specimen was not a pterosaur at all. It was, in fact, a far rarer prehistoric aviator: an Archaeopteryx (literally "ancient wing"), the earliest known bird.

What makes the "newest" Archaeopteryx fossil especially significant is that it may help resolve an old scientific argument about the evolution of birds. According to the more popular theory, birds are descended from small tree-dwelling reptiles that developed crude "wings," like those of the modern flying squirrel. They used those wings for gliding round their arboreal habitats and dodging foes. The other theory says that birds evolved from ground-dwelling reptiles that grew similar membranes, helping them to take increasingly longer leaps after insects and other fast-moving prey.

When he examined the specimen under a microscope, Ostrom noticed a feature on "Archy" that had not been preserved on the three other known Archaeopteryx fossils. It was the faint imprint of a horny sheath—or fingernail-like covering—on the three claws protruding from each of the wings of these ancient birds. Resembling the talons of a contemporary eagle, these razor-sharp, miniature scythes were obviously better suited for catching and slicing up prey than for scampering up the trunks of trees. Thus, Ostrom suggests, Archaeopteryx's lizard-like forebears probably launched themselves into the air from the ground—not from the limbs of ancient trees.

TIME, DECEMBER 7, 1970

A Write 2 sentences to answer each of the following questions. Each sentence must explain how one of the articles answered the question. (1) How are fossils obtained? (2) What observations were stated when the fossils were first examined? (3) What inferences were made from those first observations? (4) What further information or observations were discovered that disproved the original inferences? (5) What new inferences were made that were based on the further observations discovered in number four?

B From "How birds Began to Fly" and the picture P.201 b find an archaeoptryx and a pterosaur. Explain how the information from "How Birds Began to Fly" agrees with the way the animals are placed in the restoration on page 201 b (in your text)

C Explain how examination of a present-day bird would assist you in answering each question on page 201 in your text.

D How would knowledge of skulls & teeth assist in analysis of fossils? Make notes P.202

Magnetic Havoc

At least 171 times in the past 76 million years, the earth's magnetic field has mysteriously faded in strength and then returned to normal with the North and South poles reversed. Scientists have long suspected that these reversals may somehow be linked with such old biological puzzles as the sudden disappearance of the dinosaurs some 65 million years ago. Now investigators from Columbia University's Lamont-Doherty Geological Observatory have added new evidence to the old speculations. They report that six species of Radiolaria—tiny marine animals—suddenly became extinct during or shortly after switches in the earth's magnetic poles.

The evidence comes from 28 samples of the sea bottom drilled in the Pacific and Antarctic oceans. After microscopic examinations of half a million individual fossils taken from the deep-sea cores, Paleontologist James D. Hays and Geophysicist Neil Opdyke concluded that two species of Radiolaria became extinct 2.4 million years ago, another about two million years ago, two about 1.8 million and one about a million years ago. The dates, Hays told a meeting of the Geological Society of America, are significantly close to known reversals in the earth's field.

Vanishing Field. Exactly how the reversals could have wreaked such biological havoc is a matter of dispute. Some investigators have theorized that the deterioration in the earth's protective magnetic shield during reversals of the magnetic poles allowed an increased amount of damaging solar radiation to reach the earth. More recently, a number of geophysicists have calculated that even if the magnetic field completely vanished during reversal, the additional radiation would not be intense enough to destroy entire species. As a result, some investigators are beginning to think that the changed magnetism itself may somehow have been responsible.

If dinosaurs were affected by magnetic reversals, could they also harm higher animals like man? No one knows the answer, but the question may not be entirely academic. In the past 10 million years, the earth's magnetic poles have reversed themselves, on the average, every 220,000 years. But the last event occurred 700,000 years ago —which means that another switch is now long overdue.

RADIOLARIA FOSSILS MAGNIFIED 100 TIMES

Another switch long overdue.

FIELD TRIP ACTIVITY SHEET.

Definitions: Printed on student worksheets.

Objectives: After completing this activity the student should be able to:

1. Measure strata and use the numbers to compute the relationship between the depth of rock and the passage of time.
2. Recognize observable characteristics of rocks and fossils and make inferences from them.
3. Identify and classify familiar fossils of Manitoba.
4. Discover that a living thing is the product of its heredity and environment.

Materials: Letter sheet, consent form and work sheets are all that are required to introduce, perform and sum up 3 different field trips labelled A, B, and C. (Note: Permission sheets should be given to the students as soon as a date is set.Students lose forms if they are kept too long so it is advisable to ask that the sheets be returned the next day).

Activity: 60 students supervised by 2 teachers can be accommodated at A, B or C.

A An afternoon is ideal to visit (1) Steele or (2) Standard Quarries. It takes half to three-quarters hours to drive to either from the city. Half hour at one of these quarries is sufficient to allow the students to view and measure the high walls. (The strata slope could be checked as well if one of the students takes a level). Some fossils may be found at Standard or Steele Quarries but many more can be found in the quarry (a 15-20 min. drive) behind (3) the Stony Mountain Penitentiary. Any time left can be well spent investigating glacial till at (4) a gravel pit. Drive 2 miles west then half mile south of the penitentiary.

B Gillis Quarries at Garson, Man. has high walls and large fossils. The fossils are almost impossible to obtain since they must be chiselled out of the rock, but many fossils at various levels can be observed.

Sorted material, from the large stones at the floodway bridge to the silt in Birds Hill Provincial Park is, evidence of a river that flowed off the glaciers into Lake Agassiz, that can be pointed out on the way to Garson.

C The Silver Plains Mine staff would appreciate it if tours could be organized between 10 and 11 A.M. The mine is located on the east side of Highway 75, 30 miles south of Winnipeg. The gypsum, a Jurassic rock, is covered by 105 ft. of glacial lake clay and till, so the student can see the labour and machinery required to study rock that is not naturally exposed. The shaft slopes to a depth of 120 ft. below the Red River.

Discussion: Student participation and expression of divergent points of view can be encouraged by allowing students to voice observations and inferences.

Rationale: Fossils can be found in any crushed limestone on driveways or places along the track where the railroad has dumped limestone. To identify the age, kind of rock or fossil names it is necessary to phone the Railroad Co. to find the source.

Extra field trips can be developed from "A Field Guide to Devonian Outcrops" available from the Mines Branch (946-7444) for $1.00. The book is one big Field Trip Activity Sheet.

Variety is the spice of life - Projects, notes and experiments are excellent activities for some chapters but this chapter readily lends itself to a field trip.

ORDOVICIAN OUTCROP WORK SHEET

The following exercises must be done in the order listed below. DO NOT do #4 & 5 until you have completed steps 1,2 & 3

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1. When you arrive at the bottom of the quarry note the different substances along the top of the wall. Describe each of the three layers covering the limestone. List them in the order in which they have to be removed to quarry the rock. These layers can be observed along the top of the quarry wall. Are there any large rocks in any of those three layers that are different from that of the quarry wall? These are called erratics.

2. Choose any wall of the quarry and select one strata (layer) of rock then walk across to the opposite wall and find the same strata. Make five observations to substantiate that it is the same strata.

3. Measure the total depth of the rock quarry.

4. Collect and identify at least one fossil.

5. Bring plasticine, plaster of Paris or polyfiller to make a mould. (One mould between each pair of buddies.)

Bring yardstick or tape measure, cold chisel, work sheets.

You are responsible for remaining in view of the supervisors and knowing the whereabouts of your buddy at all times.

3 Ordovician outcrops we will be visiting are:

1. The Gunton Member - rocks found there are 435,000,000 years old.

2. Stoney Mountain member was formed 450,000,000 years ago.

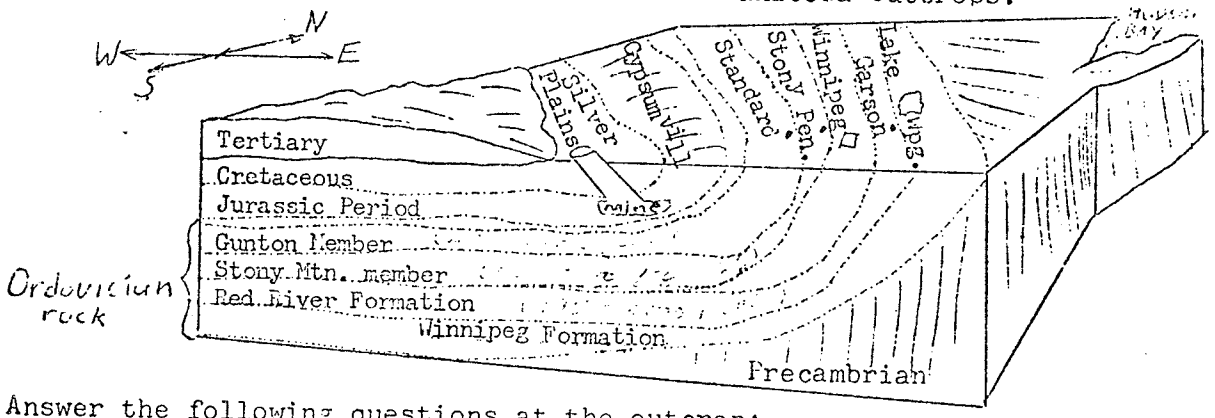
3. The rock of the Red River formation outcrops at Garson (475,000,000 years old). During all the time these rocks were being formed Manitoba was covered by a sea about 500 feet deep. In fact the $CaCO_3$ (Calcium Carbonate is the chemical name for limestone) that settled out of that sea is called Tyndall stone because it is shipped from Tyndall, Man. This is the same rock that forms on the bottom of your kettle at home.

Find the vertebrates on the family tree - page 365. 450,000,000 years ago sea animals up to but not including vertibrates had evolved so the main fossils found in Ordovician rock will be of mollusks or lower animals. Exoskeletoned animals that will not decay will be found most often. No land, plants or animals had developed yet.

A, B, or C FIELD TRIP WORK SHEET. Answer these questions before the field trip.

1. From the diagram, name the strata of rock under the formation we are going to visit. What happened to the rocks that used to cover this outcrop? Which rock was deposited first and which rock is oldest. What event might have occurred that would make this inference incorrect?
2. If we removed all the rock above the precambrian layer, what shape would be left? Make an inference about the Manitoba landscape during precambrian period. Are the layers you removed horizontal or do they slope with the hill? Make an inference concerning this observation.
3. Most of Manitoba is covered with glacial till and Glacial lake clay. Which would be on top? What event uncovered this outcrop? Why? Check the inference by observing these layers you are about to visit.
For a more detailed scale cross section see P.248 of the Canadian Geotechnical Journal. (Ph. 946-7444).

Manitoba Outcrops.



Answer the following questions at the outcrop:

1. Write the names of some of the fossils you found. In what position did you find them? What does this position mean?
2. Which animals were most common? Is random sampling useful here? What factors could make your inferences wrong?
3. Is the rock above and below this strata of a different kind. Why?
4. Describe the porosity, colour, texture and hardness of the rock. Does this rock appear to have been formed from the (a) molten state, (b) heat and pressure, (c) settling out? Describe the process that took place to form this rock.
5. How high is the wall of the quarry? *

AFTER THE FIELD TRIP.

(a) Name the rock you found. (CO_2 is released when HCl is placed on limestone and Gypsum dissolves in water).
(b) At what rate was the rock deposited (see P.502 text). Calculate the time required to deposit the wall you observed. (* above)
(c) State salinity, temperature and movement of the water during deposition. (see text P.504).

Fossils may appear plentiful but so are fossil hunters. Take only the number you really want to study.

GARSON SUPPLEMENTARY WORK SHEET.

FACTS: With the following information about some of the animals which lived during Ordovician times, answer all questions as you come to them.

CORALS: were very common during this period and they survived in the limey seas. Horn corals and large colonial forms were abundant. They had not reached their peak in the Ordovician period. The horn corals were very very long and thick. Many corals are found fossilized whole in an upright position. (1) What can you infer about the movements of the Ordovician Sea from this fact? (i.e. was it calm or rough.)

BRACHIOPODS: Those in the Ordovician Period had stronger and limeyier shells than before. (2) What happened to these? They were extremely common and had gone under great evolutionary change, having kidneys, nervous systems, etc. The brachiopods were a most successful race, with more than 200 species still alive today. (3) Why?

PELECYPODS: were quite rare and had one large wing on the side of their beaks. Mussels began to make an appearance. Most ordovician pelecypods were preserved as molds in sandstone, making them very difficult to identify. (4) Why? (5) How do we know so much about them?

GASTROPODS: were becoming more abundant but were not at their peak. Shells were quite thin, probably made of aragonite which is not easily preserved. (6) How do we know they were scarce? (7) Why might we be wrong?

CEPHALOPODS: reached their peak during Ordovician times. They included some of the largest and most powerful animals of the time. There were both straight and coiled shells with the straight being most dominant. (8) Why are most of them extinct today? (9) Which ones do exist today? (10) Why?

CRINOIDS: were very abundant so that in some parts, entire rock layers are made up of their bodies.

TRILOBITES: reached the height of their development during Ordovician times. Some reached the length of 24 inches. They were the most powerful species during the Paleozoic times. Their body was covered with a strong shield joined in the middle section which enabled the creatures to roll themselves into a ball to protect their soft underside. The presence of feelers on their bodies tells us that the animal wandered on muddy sea floors searching for food. The situation of their eyes on the upper side of their head tells us that the animal received its light from above, and lived in fairly shallow water so that the light could penetrate to the bottom. Some species had compound eyes. Most had as many as 24 legs used both for swimming and walking. Trilobite food varied with species, some were predatory, others scavengers, vegetarians, or some became burrowers, living on food in the sand.

Note: Trilobites had a habit of rolling up into a ball for protection and are often found fossilized that way. (1) What could have happened to them?

VERTEBRATES: First primitive vertebrates began to make an appearance. Evidence of scales and plates leads us to believe they were fishes. The scales were covered with an enamel-like substance. No complete fossil has ever been found.

N.B. Fossils found at Garson are 450,000,000 to 500,000,000 years old. (12) Would fossils found in Winnipeg sandstone be older or younger? (13) Would fossils found in Stony Mountain or Stonewall shale be older or younger? Stony Mountain is a mixture of limestone and red, grey and green shale. Stonewall is more limestone. What event occurred to cause the presence of mud that turned to shale?

SILVER PLAINS INFORMATION SHEET.

In past ages when a large body of sea water was cut off from the ocean, the water gradually evaporated and deposited its minerals. When 80% of the water was evaporated the $CaSO_4$ ($2H_2O$) or gypsum settled out, Na C l (salt) was not dropped until 93% of the water was gone.

During the Jurassic period a deep basin was eroded from the Ordovician rock. This basin was filled with gypsum near the end of the Jurassic period. The Silver Plains gypsum deposits are connected to the Gypsumville deposits to the north. Gypsumville deposits are on the surface and open quarrying is used.

The room and pillar method of mining is used at Silver Plains. An adit, or sloping mine shaft was begun in 1963 on a 1-4 slope. The 20 million ton gypsum reserve was reached and production started in 1964.

Anhydrite is $CaSO_4$. When exposed to moisture it will in time take up two molecules of water and become gypsum, $CaSO_4(2H_2O)$. In this reaction the volume is increased 33% and the resulting pressure is said to account for the hummocky appearance of many gypsum areas. Pure gypsum is white and when in the crystalline form is transparent.

Gypsum is subjected to crushing, drying, pulverizing, separating and grinding processes. At this stage it is called Land Plaster.

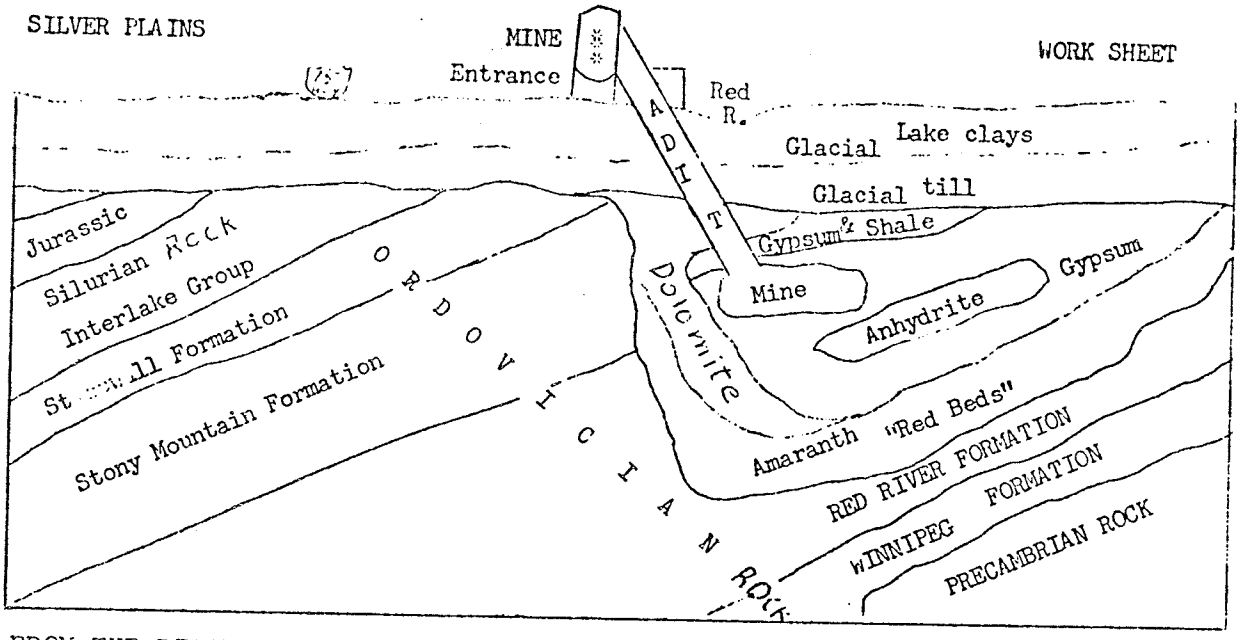
Boiling or "calcining" is done in large steel kettles driving of 75% of the moisture in the gypsum. At this it is called half-hydrate or Plaster of Paris. It derived its name "Plaster of Paris" from the fact that it was first produced in large quantities in the vicinity of Paris, France. Calcined gypsum is now called "Stucco", or simply "Plaster".

Additional information:

1. Geology of the Silver Plains Gypsum Deposit - A Master's Thesis by W.A. Lambe (1964), available from the University of Manitoba.

2. Gypsum - Anhydrite Deposits of Manitoba. A Manitoba Mines Branch Publication #58-2, by B. Bannatyne (1959), available from the Mines Branch.

The superior qualities of gypsum as a fireproof building material are due to the fact that the temperature of the unexposed side of the gypsum slab cannot exceed 212° F while there is any water or crystallization in the gypsum. The application of fire vaporizes the water of crystallization, and as the gypsum slowly calcines, the cellular structure fills with steam.



FROM THE DIAGRAM:

1. Infer the order in which all the rocks on the diagram were deposited.
2. Why are the glacial lake clays on top of the glacial till?
3. List the Ordovician rocks in order of deposition. What could make this inference wrong?

FROM DIAGRAM AND INFORMATION SHEET.

4. Draw ///// through the basin that was eroded from the Ordovician rock in which the water was trapped during the Jurassic period.
5. Explain how the basin of water may have been cut off from the main body.
6. How long ago was the gypsum deposited? (Text P.207)

FROM THE INFORMATION SHEET.

7. What would you expect to find deposited on top of the layer of gypsum?
8. Write the chemical formula for (a) Anhydrite and (b) Gypsum.
9. Why is Plaster of Paris called half-hydrate? What might be a better name? Why?
10. What happens to Plaster of Paris when water is added to it?
11. What happens to gypsum when it is heated? What would happen if a building made of gypsum started on fire?
12. Why are pillars left in the Silver Plains Mine? You are allowed to pick up rocks as you are guided through the mine. What would you expect to happen if you heated the gypsum in a test tube?

This mine is operated by a private company. They are conducting this tour as a favour to us. Please be courteous to the employees.

The men with jack hammers are drilling holes in which dynamite is to be placed. The trucks are electrical. As the truck drives into the mine the cord is unwound. When the truck returns to the entrance with a load of gypsum it automatically gathers up its own cord. The gypsum is crushed at the entrance then carried up the adit on a conveyer belt to an overhead tank * that can drop its load into trucks.

THE ST.JAMES-ASSINIBOIA SCHOOL DIVISION NO.2

Golden Gate Junior High School

BRUCE AVENUE AT RITA STREET
Winnipeg, Manitoba R3J 0V8

October 26, 1973

TO WHOM IT MAY CONCERN

I have used the geology activity sheets on an experimental basis and found them to be very helpful. They increased student understanding by helping to make a number of terms clear, (e.g. decay). Also the level of interest increased because of the field trips suggested. I found that the activities accomplished the objectives that were outlined for each sheet. I had no prior knowledge of the questions used in pre or post-testing.

Sincerely,

Miss J. Batza.

Bruce Junior High School
Booth and Bruce.
September 11, 1973

Dear Mr. Gary Rogers;
(Golden Gate)

This letter is to certify that: (1) the objectives of the chapter, "Life in the Past," were taught by myself as recommended by the Manitoba Department of Education during the designated experimental period; (2) the pre and post tests were administered according to the instructions accompanying each test.

Yours sincerely
B.A., B.ED.

THE ST.JAMES-ASSINIBOIA SCHOOL DIVISION NO.2

Westwood Collegiate

360 Rouge Road

Winnipeg, Manitoba R3K 1K3

September 12, 1973.

Mr. Garry Rogers
Golden Gate Junior High School

This letter is to certify that,

1. The objectives of the chapters (Life in the Past) were taught as recommended by the Manitoba Dept. of Education during the designated experimental period.

2. The pre and post tests were administered according to the instructions accompanying each test.

G. DeBlonde, PhD

GD/pl

TO WHOM IT MAY CONCERN

The Activity Sheet Format was used to formulate objectives for a Dental Assisting Course. The step-by-step procedure as outlined by the Activity Sheet Format gave me a better idea of why and how objectives should be written out. All general objectives and specific objectives were begun with a verb showing what the student would be doing to demonstrate that he had learned the required concepts. I felt that the concept to begin each objective with "After completing this activity the student should be able to" was repetitous and was not used.

Yours truly,

F. Ross Taylor
Department Head,
Dental Assisting.

THE MACMILLAN COMPANY OF CANADA LIMITED

70 Bond Street

Toronto, Ontario, Canada
M5B 1X3

Book Publishers

Area Code: 416
Telephone: 362-7651

† MACMILCO: TORONTO

January 29, 1974

Mr. Garry W.J. Rogers
Street
Winnipeg, Manitoba

Dear Mr. Rogers:

In response to your letter of January 12, we are pleased to grant you permission to include the chapter "Life in the Past" from BUILDING SOIL OF MINE in the appendix of your Masters thesis, and to use some material from the Record Book associated with the chapter in preparation of the tests used to evaluate the test chapter. We ask only that you credit your source and note that the material is reprinted by permission of The Macmillan Company of Canada Limited.

Thank you for checking with us.

Yours sincerely,

Joice Perkin
Permissions Editor

APPENDIX "C"

TEST CONSTRUCTION

1. Letters of confirmation
   (a) Receipt of standardized tests
   (b) Recruiting of teachers
   (c) Construction of tests
2. Curriculum
3. Work book exercises

Department of
Ed·u·ca·tion
Government of the Province of Alberta

Executive Building, 10105 - 109 Street, Edmonton, Alberta T5J 2V2

Telephone: 425-8717 AC403, TELEX: ALTAEDCOMM, TWX: ED ADMIN EDM

May 2, 1973

Mr. Garry W.C. Rogers
Golden Gate Junior High School
330 Bruce Avenue
WINNIPEG 12, Manitoba

Dear Mr. Rogers:

We have on file a letter from you addressed to Mr. Wood regarding Grade IX Science Taxonomies and test items. As Mr. Wood is no longer in our employ, I have taken the liberty to respond to your request.

Unfortunately, present policy does not permit distribution of Grade IX departmental examinations administered in recent years, since their security remains necessary in view of on-going activities and research in the testing area. However, we are enclosing a 1965 and 1966 Grade IX Science Departmental examination that was based on the Taxonomy that you referred to, and trust that they might be useful for your purposes.

Sincerely,

Ray L. Allers
Examinations Development Officer

RLA/btk
Enclosures

O had
— good

INDEX TO ACHIEVEMENT TESTS — SCIENCE

No.	Name of Test	Level	Publisher
1	B.S.C.S. Achievement Test	Grades 1 - 4	Harcourt Brace & World Inc.
2	Chemical Achievement Test Study		W. H. Freedman & Company,
4	B.S.C.S. Comprehensive (Science)	Grade 10	Psychological Corporation
21	C.E.E.B. Advanced Placement Exams.	2nd Year University	Educational Testing Service
30	Co-operative Science Test - Physics	Grades 7 - 9	Educational Testing Service
55	Introductory Physical Science (IPS)	Grades 1 - 3	Educational Services Inc.
56	Content Evaluation Series - Science	Grades 7 - 9	Houghton Mifflin Co.
64	New Co-operative Science Test - Physics, Gen. Science, Biology, Chemistry,	Grades 8 - 12	Educational Testing Service
72	B.S.C.S. Quarterly Achievement Tests	High School	The Psychological Corporation
75	S.T.E.P. Battery - Science #990	Grades 4 - 12	Educational Testing Service
77	S.T.E.P. Series II	Levels 1 to 4	Educational Testing Service
80	S.T.E.P. Battery - Science #967	Grades 4 - 12	Educational Testing Service
87	Science	Grade 9	Man. Department of Education
88	Science Plus Analysis	Grade 9	Man. Department of Education
93	Tests of Academic Progress - Science	Grades 9 - 12	Houghton Mifflin Co.
94	Tests of Basic Experiences - Science	Kindergarten	California Test Bureau
96	Test of Science Knowledge (TOSK)	Grades 8 - 12	Psychological Corporation
97	Tests of Physical Science Study Comm.	Series O & S	Educational Testing Service
98	Tests of Physical Science Study Comm.	Series N	Educational Testing Service
99	Tests of Physical Science Study Comm.	Form F	Educational Testing Service
100	Tests of Physical Science Study Comm.	Advanced	Educational Testing Service
101	Tests of Understanding Science (TOUS)	Form W	Educational Testing Service
134	Physical Science Study Comm.	Form F	Educational Testing Service
137	Stanford Achievement Test, Science	Adv. Grades 7 - 9	Guidance Centre
138	Stanford Achievement Test, Science	Intermediate	Guidance Centre

Province of Manitoba
Department of Education
Planning and Research

408 -- 1181 Portage Avenue
Winnipeg, Manitoba
R3C 0V8

March 2, 1973.

Wm G Rogers
Glenlawn Collegiate High
33 Lanark Avenue
Winnipeg, Man
R3T 0B2

Dear Sir:

Thank you for the interest expressed in your recent letter concerning the matter of specimen test samples.

The demand for this service has far exceeded our supply of tests and as a result we are able to fill only part of your order.

We are enclosing specimen test samples as follows:

#- 138

If your request has not been completely filled, the balance of the order will follow as soon as the tests presently on loan are returned to our office.

Please return these sample tests within two weeks of receipt in order that the tests may be available for loan to other schools.

Thank you.

Yours truly,

(for) A.A. Tingley
Administrative Officer

Enclosure

Province of Manitoba
Department of Education
Planning and Research

408 – 1181 Portage Avenue
Winnipeg, Manitoba
R3C 0V8

January [illegible], 1972

Mr. [illegible]
Golden Gate Junior High
330 [illegible] Avenue
Winnipeg, Man.
R3T 6W8

Dear Sir:

Thank you for the interest expressed in your recent letter concerning the matter of specimen test samples.

The demand for this service has far exceeded our supply of tests and as a result we are able to fill only part of your order.

We are enclosing specimen test samples as follows:

87 and # 88

If your request has not been completely filled, the balance of the order will follow as soon as the tests presently on loan are returned to our office.

Please return these sample tests within two weeks of receipt in order that the tests may be available for loan to other schools.

Thank you.

Yours truly,

(for) A.A. Tingley
Administrative Officer

Enclosure

Province of Manitoba
Department of Education
Planning and Research

408 – 1181 Portage Avenue
Winnipeg, Manitoba
R3C 0V8

Mrs. G. Rogers
Golden Gate School
330 Dumoulin Ave.
Winnipeg, Man.
R3J 0V8

February 16, 1973

Dear Sir:

Thank you for the interest expressed in your recent letter concerning the matter of specimen test samples.

The demand for this service has far exceeded our supply of tests and as a result we are able to fill only part of your order.

We are enclosing specimen test samples as follows:

#3c and #137

If your request has not been completely filled, the balance of the order will follow as soon as the tests presently on loan are returned to our office.

Please return these sample tests within two weeks of receipt in order that the tests may be available for loan to other schools.

Thank you.

Yours truly

(for) A.A. Tingley
Administrative Officer

Enclosure

Please return test in its own envelope

Province of Manitoba
Department of Education
Planning and Research

408 – 1181 Portage Avenue
Winnipeg, Manitoba
R3C 0V8

March 6, 1973

Dear Sir:

Thank you for the interest expressed in your recent letter concerning the matter of specimen test samples.

The demand for this service has far exceeded our supply of tests and as a result we are able to fill only part of your order.

We are enclosing specimen test samples as follows:

56.

If your request has not been completely filled, the balance of the order will follow as soon as the tests presently on loan are returned to our office.

Please return these sample tests within two weeks of receipt in order that the tests may be available for loan to other schools.

Thank you.

Yours truly,

(for) A.A. Tingley
Administrative Officer

Enclosure

To whom it may concern:

The final half hour of the science section of the St. James-Assiniboia April Inservice 1973 was allotted to Garry Rogers so he could explain and recruit volunteers for the presentation and testing of his thesis. All teachers in attendance were asked to participate as experimental or control group teachers. Each Grade IX teacher was given an envelope addressed to Garry Rogers and was asked to forward any test items or tests related to "Life in the Past" so that a pretest and a post-test could be constructed.

Yours truly,

Gary Winfield
(Inservice Chairman)
(Science Section)

Dear Teacher,

I would appreciate your cooperation in the preparation of the testing part of my thesis. I am going to teach the experimental groups and solicit the aid of another teacher to teach the control groups.

It is necessary to have my tests made up by an independent groups or person. The tests will remain sealed and stored until they are to be used.

I need 2 objective tests prepared for the chapter "Life in the Past". One test is to be administered April 1, the other April 30. A multiple choice test with 4 choices for each question would be ideal. Even better would be a multiple choice you have used revised and corrected.

The test need not be complete, even a few questions would be helpful. Two similar questions that test the same topic would facilitate the production of two similar tests required as a pre-test and post-test.

The next 3 pages contain the part of the Junior High Curriculum relevant to Grade IX. Since the curriculum is the main guide we are to follow, some questions should pertain directly to the specific or general objectives listed in it.

The "Table of Specifications" sheet is included as a grid to assist you in determining the proportion of marks to be allotted to each topic.

If you feel that any of these sheets would bias your questions please feel free to discard them and use your own methods.

Table of Specifications

CURRICULUM	Page from the Text: 177 178 179 180 181 182 183 184 185 186 187 188 189 190 191 192 193 194 195 196 197 198 199 200 201 202 203 204 205 206 207 208	TOTAL
PROCESSES 1		
PROCESSES 2		
PROCESSES 3		
PROCESSES 4		
PROCESSES 5		
PROCESSES 6		
PROCESSES 7		
PROCESSES 8		
PROCESSES 9		
PROCESSES 10		
PROCESSES 11		
PROCESSES 12		
PROCESSES 13		
PROCESSES 14		
Concepts		
General Objectives		
TOTAL		100

Row + column items and totals must be determined before work is begun on the table. The relative importance of each objective should be arrived at judgmentally in terms of proportion of space allotted to an area by the curriculum. (10 items per subscale - minimum)

The green numbers indicate the order of the steps used to prepare this sheet.

To whom it may concern:

The pretest and post-test were constructed from the following sources:

1) The curriculum
2) The grade 1X Exploring Science text and workbook and Teacher's Manual
3) Test items from all Standardized science tests available from the Manitoba Textbook Bureau
4) Test items received from grade 1X science teachers in St. James-Assiniboia School Division.

I had no knowledge of the methods or content that were to be used by either the control or experimental group teachers. The only instructions given me were that I should reject, accept or add any test items I felt were relevant and any test items that were similar on the two tests should be given the same number.

Yours truly,
George R. Nosyk
B.Sc. B.Ed. M.Ed.

* These 3 sheets contain the information from the Junior High program that is relevant to Grade IX

- 1 -

Grade IX

PHYSICAL	LIFE	EARTH
*How To Do Field Research		
*Doing Work	*Plant and Animal Communities	Weather and Its Causes
*Electric Power	*Mechanisms of Behaviour	*Climates and Microclimates
*Chemistry of Carbon	*Life in the Past	*Objects in Orbit
Electrons and Electronics	Supplying Our Cells	Record of the Rocks
Radiant Energy	*How Life Continues	Topographic maps
	Group Plants and Animals	
	Man and His Environment	

*Recommended Chapters

TEXTBOOKS

Exploring Science 7, 8, 9. Thurber and Kilburn,
The Macmillan Company of Canada Ltd.

OR

Exploring Science: Stage
Macmillan Company

In addition to
the curriculum

(a) Life

The Thurber and Kilburn, Exploring Science Series uses the discovery approach and in this light provides a suitable basic text for the teaching of Grades 7-9 Science. A major goal of the discovery approach is the development of intellectual independence. It seeks to raise thinking above mere memorization and recall. Pupils are expected to formulate their own problems, plan their own methods of attack, make their own observations, evaluate their own data and reach their own conclusions. This discovery approach encourages curiosity, observation, inquisitiveness and speculation. Careful thinking habits, and the ability to search for cause and effect are to make cautious conclusions are developed. Pupils must critically evaluate evidence and be critical of unsubstantiated statements, while remaining open-minded and tolerant of the opinions of others. In the discovery approach teachers no longer assume formalic roles, but rather provide guidance and inspiration to develop scientific thinking in their pupils.

...r and Row, 1966

(...laboratory manual)

...th Sciences. Navarra and Strabler.

... The Earth Science - Investigation.
... manual)

...: A Laboratory Approach. Marean et al.
...ison-Wesley, 1970.

Authorized by the Minister of Education
1972

TEACHING AND LEARNING OF SCIENCE THROUGH INQUIRY

Inquiry is a much used term in education; essentially it may be defined as the process of formulating and testing ideas. Inquiry implies an open classroom climate, a climate that encourages student participation and the expression of divergent points of view.

Inquiry teaching may go on in any classroom but it is ideally suited to the objectives of the science classroom. The inquiry skills of observing, classifying, communicating, measuring, inferring, predicting, formulating hypotheses, data interpretation and experimenting, are the processes of science. Inquiry is synonymous with the scientific method and should be the broad overriding objective of every Junior High Science class. Eventually the student will learn to:

a) Identify his problem.

b) Hypothesize in regard to a possible solution.

c) Design a means to verify the hypothesis.

d) Interpret his data and draw conclusions.

e) Extend his results to new problems.

The procedures of inquiry are not inborn, they must be taught and it is the science class that can review the act of inquiry until it becomes a natural procedure of investigation for students.

OBJECTIVES

The trends in science advocate a science curriculum which:

1. Develops in scope and sequence from Primary One to Grade Twelve.
2. Encourages scientific literacy or understanding of the major concepts of science at the level of comprehension of the learner.
3. Teaches the strategies of inquiry or the processes of science to enable students to investigate their environment.
4. Develops independent learning skills which will enable young people to adapt to a rapidly changing society.
5. Uses the resources of the community and other science materials to further understanding of environment, and
6. Emphasizes scientific principles, rather than factual subject matter.
7. Pupils should not need extensive notes. Their greatest value may be as a personal record of an activity or experiment. Duplicated notes and diagrams are to be discouraged.

OUTCOMES

As a result of a course in elementary and junior high science, the pupil should:

1. Demonstrate a developing interest in science. (More specifically in the chapter, a developing interest in geology or position ....)
2. Demonstrate an appreciation of science. Appreciations will be satisfying emotional responses and will relate to such things as: the role of science in our daily lives, the orderliness of nature, and the contribution of science to solving world problems.
3. Demonstrate the abilities associated with inquiry.
4. Acquire an integrated body of basic scientific information, organized into meaningful conceptual patterns.
5. Acquire manipulative skills in the use of apparatus in order to conduct independent investigations.
6. Demonstrate both individual initiative and co-operative work habits using a variety of resource materials.

TEACHING SUGGESTIONS

1. This program features pupil activity, pupil discovery and the gradual development of concepts. There is very little room for the lecture method, copious blackboard notes, or rote learning. It cannot be taught without apparatus and a place to use it. The activities and experiments must actually be performed to be of any value.
2. Time allotments are as recommended by the Elementary Curriculum Seminar, Grades four to nine, 12%. (1% equals about 15 minutes per week).
3. Teach for gradual development of concepts rather than for memorization of isolated facts.
4. Be aware of the scientific processes involved and make the development of these deliberate, rather than incidental.
5. Plan your units so that the pupils will perform most of the experiments. Make certain they will be able to plan some of their own activities and do some independent research.
6. It is permissible to take the units in any order. However, if several units in one year are closely related, it may be easier to take them in order and obtain the benefit of a gradual build-up of knowledge.

INFERENCES FROM INCOMPLETE REMAINS (Text: pp. 180-181)

YOUR INFERENCES FROM PHOTOS OF FOSSILS	INFERENCES GIVEN BY THE TEXTBOOK	YOUR COMMENTS
1.		
2.		
3.		
4.		
4a.		
5.		
6.		
7.		
8.		
9.		
10.		

Why are you able to make more trustworthy inferences about some fossils than others?

How Fossils Are Formed

FOSSILIZATION (Text: pp. 182-185)

KIND OF FOSSILIZATION	METHOD OF FOSSILIZATION
1. Original remains	
2.	
3.	
4.	
5.	

FOSSILIZATION OF SPECIMENS PROVIDED BY TEACHER FOR STUDY

NAME OR NUMBER	TYPES OF FOSSILIZATION	INFERENCES ABOUT HISTORY OF SPECIMEN

A CLAM'S EXTERIOR and INTERIOR OF A CLAM (Text: pp. 186-187)

Label the following:

A. Oldest part of shell
B. Newest part of shell
C. Front of shell when the animal is in motion
D. The hinge
E. Bulges showing periods of little growth

Label the following:

P. Attachment of muscles that close the shells
Q. Attachment of mantle
R. Position of the siphons
S. The hinge ligament
T. The hinge teeth

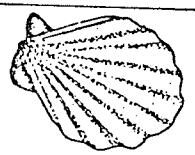
MOLLUSKS (Text: pp. 188-189)

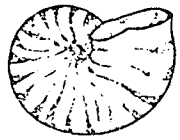
To which of the following groups do each of these shelled animals belong:

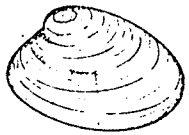
pelecypods

gastropods

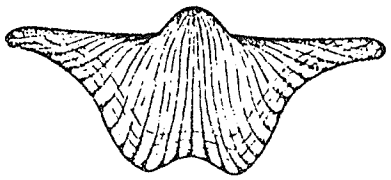
cephalopods







SYMMETRY OF SHELLS (Supplements Text: p. 190)



One of the two outlines shown above has bilateral (two-sided) symmetry, that is, half of the outline is the mirror image of the other half. Trace on thin paper the first of the two outlines. Try to fold the paper in such a way that the two halves on the outline appear together when the paper is held up to the light. Repeat the process with the other outline.

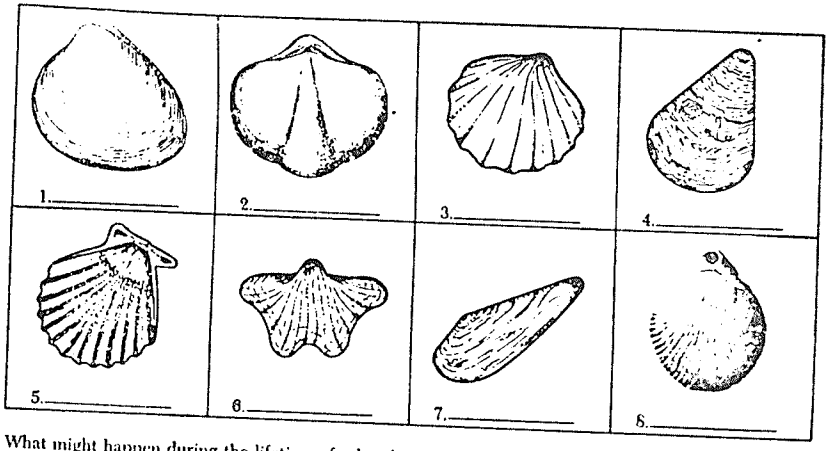
Which outline has bilateral symmetry?

Why is one half the outline said to be the mirror image of the other?

Which of the two outlines represents a brachiopod shell?

Which represents a pelecypod shell?

Identify the following as brachiopod or pelecypod shells.

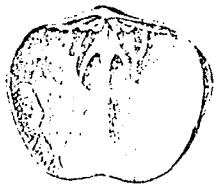


What might happen during the lifetime of a brachiopod to destroy the symmetry of its shell?

What might happen during the fossilization process to destroy the symmetry of a shell?

BRACHIOPODS & PELECYPODS (Supplements Text: p. 191)

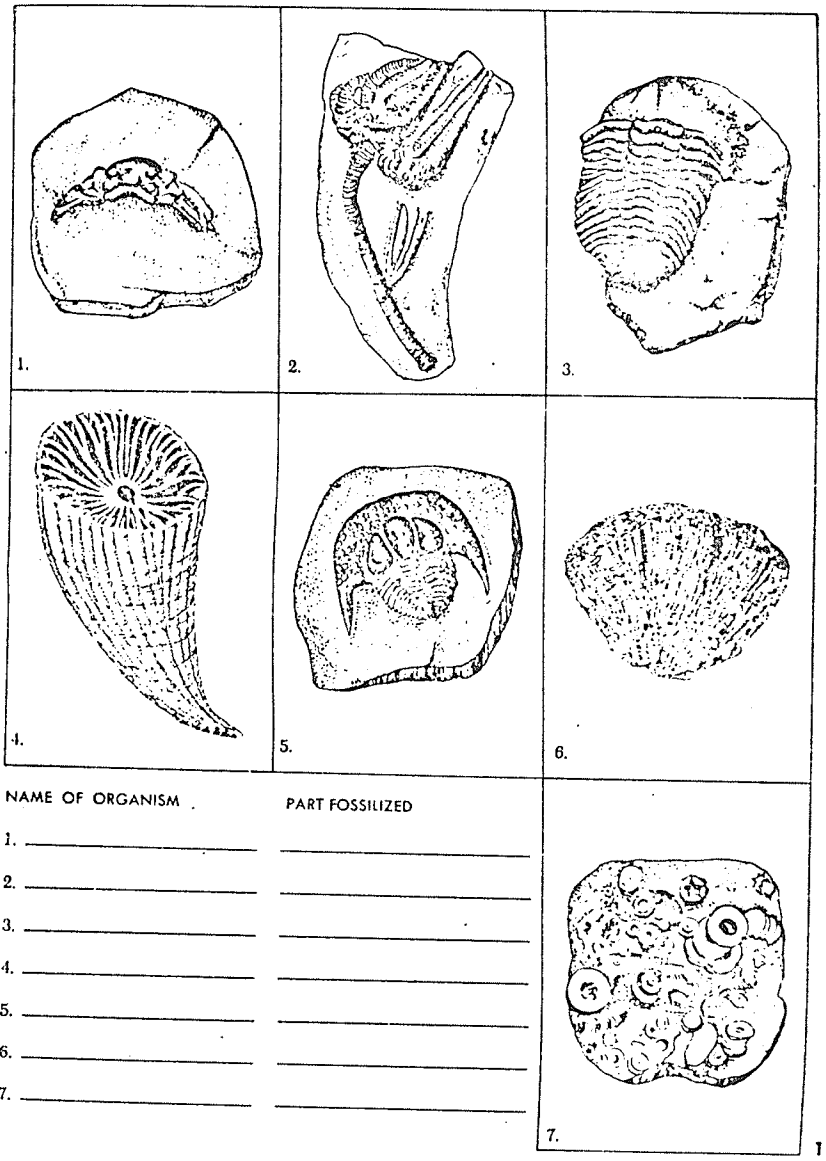
The diagram at the right shows the interior of a brachiopod shell. Label the following parts:
A – the oldest part of the shell
B – the youngest part of the shell
C – the location of the hinge
D – the location of the pedicle or support
E – scars showing attachments of the muscles



Pelecypods and brachiopods are often called "bivalves" because both have two shells or "valves." Nevertheless, the two groups of animals are not related. Fill in the following chart to summarize some of the important similarities and differences between the two types of animals. (Use a zoology book for additional information as desired.)

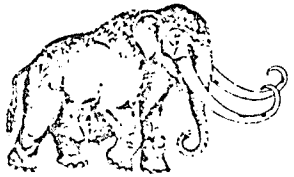
	PELECYPODS	BRACHIOPODS
1. Number of valves		
2. Type of symmetry		
3. Location of glands that produce valves		
4. Method of closing valves		
5. Method of opening valves		
6. Type of locomotion		
7. Way of obtaining food		
8. Way of obtaining oxygen		
9. Some relatives		
10.		
11.		
12.		

CORALS, CRINOIDS, and TRILOBITES (Text: pp. 192-195)



NAME OF ORGANISM	PART FOSSILIZED
1.	
2.	
3.	
4.	
5.	
6.	
7.	

RECONSTRUCTING A WOOLLY MAMMOTH (Supplements Text: pp. 196-197)

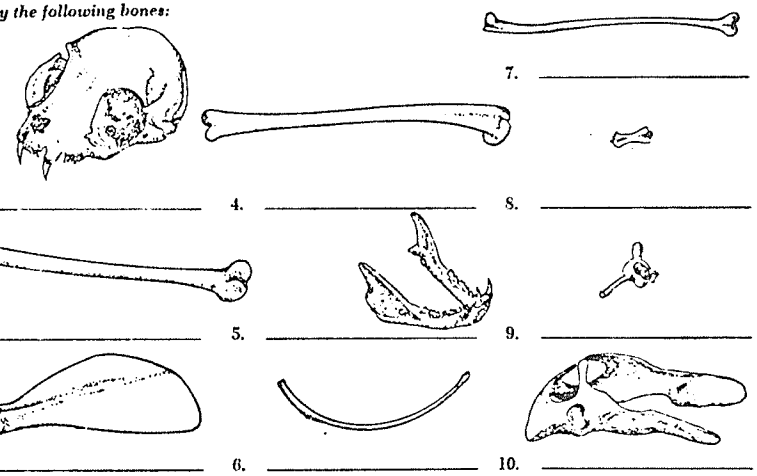


The painting in the text shows a woolly mammoth as the artist believed it looked. Parts of this restoration are based upon the direct evidence of fossils. Parts, however, are based upon inferences from living elephants. Explain in the table below how you believe the characteristics listed were determined. (Some of the direct evidence may be supported by inferences.)

CHARACTERISTIC	DIRECT EVIDENCE (Based on actual remains)	SECONDARY EVIDENCE (Based on inferences from living forms)
Four-footed		
Overall length		
Overall height		
Head shape		
Trunk shape and size		
Way of holding trunk		
Tusk size and shape		
Position of tusks		
Position of eyes		
Shape and size of eyes		
Position of ears		
Ear size and shape		
Length of legs		
Shape of legs		
Main body shape		
Tail length		
Hairy coat		
Color of hair		
Type of gait		

INFERENCES FROM BONES (Text: p. 199)

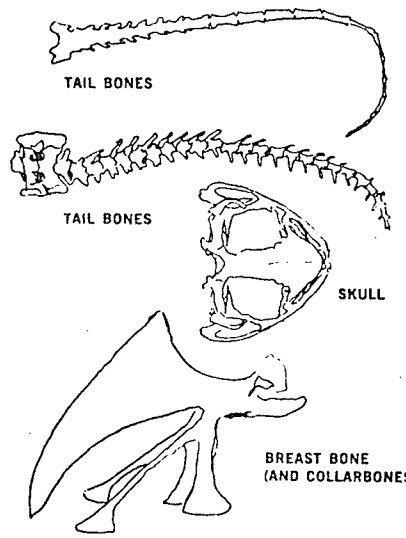
Identify the following bones:



1. _____ 4. _____ 8. _____
2. _____ 5. _____ 9. _____
3. _____ 6. _____ 10. _____

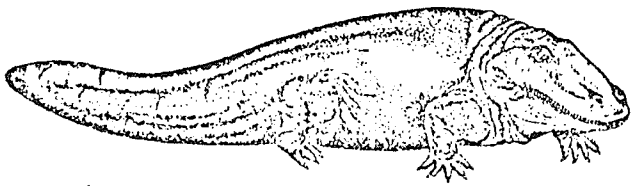
What parts of animals do the above bones represent?

What inferences can you make from the parts of skeletons shown below and in the text?



1. _____
2. _____
3. _____
4. _____

EARLY AMPHIBIANS AND BIRDS (Text: pp. 200-201)



What are some inferences you can make from the amphibian skeleton?

Use of tail

Speed in water

Gait on land

Speed on land

Type of food

Source of oxygen

What are some bird-like and some unbird-like characteristics of the bird skeleton?

Bird-like characteristics

Unbird-like characteristics

What is the basis for the reconstruction of the amphibian?

Head shape

Size of mouth

Type of teeth

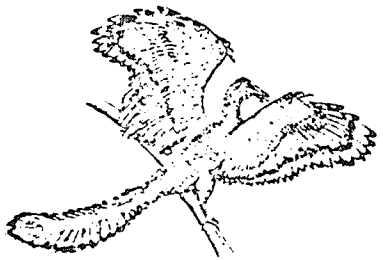
Location of eyes

Type of eyes

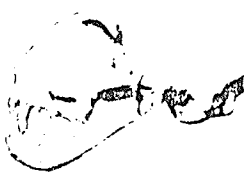
Shape of tail

Type of skin

What is the basis for six structures of the reconstructed bird?

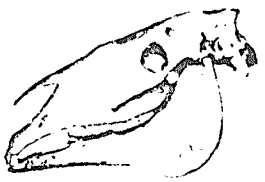


INFERENCES ABOUT HABITS (Supplements Text: pp. 202-204)



1. _____

2. _____



3. _____

4. _____

5. _____

6. _____

1-6 Frank White

7. _____

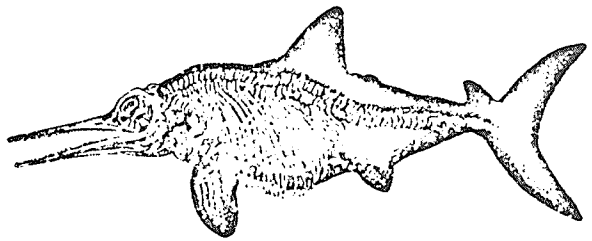
Courtesy of the American Museum of Natural History

8. _____

Courtesy of the American Museum of Natural History

What inferences can you make about the eating habits of the six modern animals and the two extinct dinosaurs shown above and in the text?

What inferences about habits can you make from the fossil skeleton of a reptile shown below?



APPENDIX "D"

TESTS

1. Pre-test (Prior knowledge test)
2. Post-test (labelled "Chapter test")
3. Letters from publishers

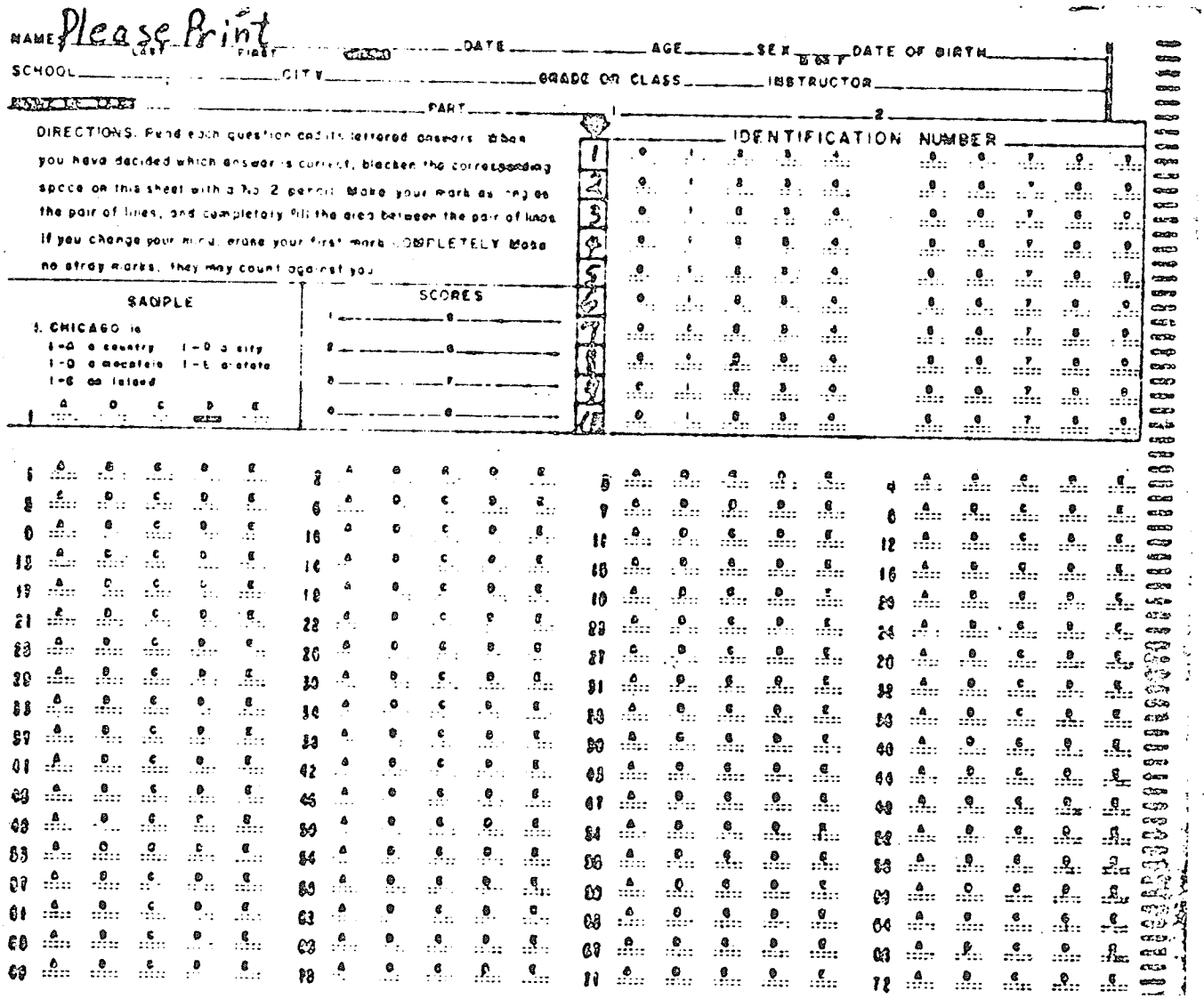
Enclosed you will find a transparency with one group of choices under the heading IDENTIFICATION NUMBER circled thus: 0 1 2 3 4

Would you please have each student in the first class that writes the test fill in:

0 1 2 3 4

Each student in the second class fills in 0 1 2 3 4 and so on.

Please ask your students to find numbers 1, 2 & 3 on the IBM score sheet and point out that the numbers are across the sheet, NOT down the columns.



PLEASE DO NOT INTERPRET ANY CHOICES OR QUESTIONS FOR YOUR STUDENTS.

If there is any confusion concerning the set of choices that should be used for a question please point out the correct set of choices and remind him/her that the choices are always found to the right or below the question.

GENERAL SCIENCE TEST.

This is a test to find out how much general knowledge you have of science. No marks are deducted for guessing so fill in a choice for EVERY question.

Read each question carefully.
Think of the answer.
Find the BEST answer in the choices.
Fill YOUR choice in the correct space on the IBM answer key.

1. Carcasses of animals today disappear because they are:
   (a) buried
   (b) caused to disappear
   (c) eaten by bacteria.
   (d) burned

2. The eye sockets in the skull of a frog are located on what part of its head?
   (a) top
   (b) bottom
   (c) side
   (d) back

3. Scientists most often learn new facts by:
   (a) making observations and doing experiments.
   (b) writing down everything they do.
   (c) working alone
   (d) debating with their friends.

4. I would rather study:
   (a) chemicals
   (b) rocks
   (c) plants and animals
   (d) fossils

5. Fossils show us:
   (a) the order in which strata of sedimentary rocks were laid down.
   (b) that climates have changed
   (c) that plants and animals have developed gradually to their present form
   (d) the lengths of time gaps between successive strata.
   (e) all of these

6. Before man landed on the moon the names of the elements found on the surface were:
   (a) probable
   (b) fact
   (c) speculation
   (d) false
   (e) All of these

7. The term evolution means that:
   (a) fossils are very old
   (b) life began in the sea
   (c) living things are constantly changing
   (d) man descended from the ape

8. Of the following plants, the one believed to have appeared the earliest is the:
   (a) fern
   (b) horsetails
   (c) club mosses
   (d) oaks

9. Which of the following is not a MOLLUSK:
   (a) snail
   (b) clam
   (c) oyster
   (d) crabs
   (e) squid

10. Of the following animals, the one believed to have appeared latest is:
   (a) flying reptile
   (b) dinosaur
   (c) amphibian
   (d) earthworm
   (e) all of these

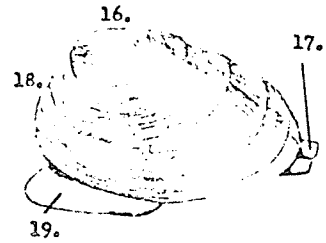
11. An example of an animal that lived in a tube-like shell is the:
   (a) trilobite
   (b) cephalopod
   (c) polyp
   (d) crinoid
   (e) all of these

12. A theory is
   (a) a theological statement
   (b) a form of superstition
   (c) an unproven explanation
   (d) a definite law.

13. After man landed on the moon the names of the elements found were:
   (a) probable
   (b) fact
   (c) speculation
   (d) false

14. The amount of flesh on a fossil animal & body can be determined by:
   (a) bone size
   (b) muscle scars
   (c) present day relations
   (d) all of these
   (e) none of these

15. All bare rocks whether on a mountain or in a desert or stream are:
   (a) made of sandstone
   (b) slowly wearing away
   (c) changing to granite
   (d) turning black in colour



Which choice best describes the part of the animal nearest to each number?

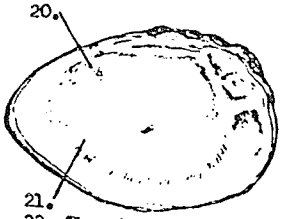
(A) The oldest part of the shell

(B) The newest part of the shell

(C) The front of the animal when moving

(D) The siphon

(E) The foot



(A) Attachment of the muscles that close the shells

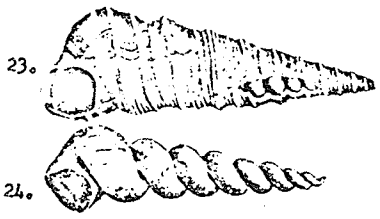
(B) Attachment of the mantle

(C) Position of the siphons

(D) The hinge ligament

(E) The hinge teeth

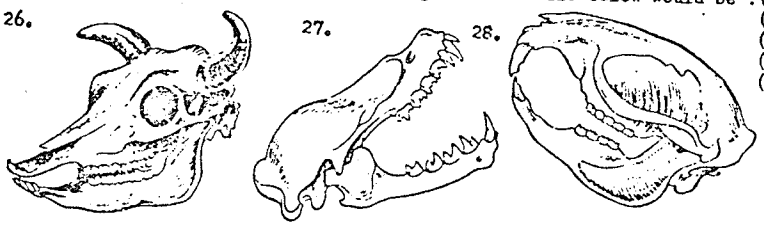
22. The above are the shells of a : (A) Clam
(B) Snail
(C) Nautilus
(D) All of these

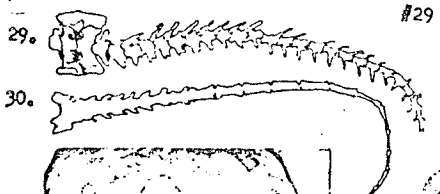


What type of fossil is #23 & #24?
(A) Internal mould
(B) External mould
(C) Internal cast
(D) External cast
(E) Original remains

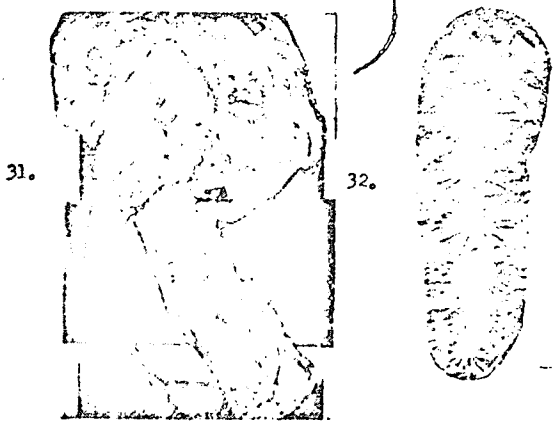
25. The above are the fossils of a : (A) Clam
(B) Snail
(C) Nautilus
(D) All of these

The main food of the animals that belong to the skulls below would be : (A) Leaves
(B) Grass
(C) Meat
(D) Fruit
(E) Bark





#29 & #30 are the tail bones of: (A) Fish
(B) Cat
(C) Bird
(D) Alligator



The fossils to the left represent what types of fossilization ?

(A) Petrification

(B) Original remains

(C) Moulds and casts

(D) Carbonization

There is an IBM sheet and 3 question sheets to this test. This is page 3.

33. From animal footprints we can learn its:
(a) gait
(b) weight
(c) habitat
(d) all of these

34. The science course I prefer is:
(a) physics
(b) geology
(c) chemistry
(d) biology

35. Much coal-bearing sedimentary rock was found during the period called:
(a) Devonian
(b) Cretaceous
(c) Carboniferous
(d) Pre-Cambrian

36. Geology is important because it allows me better to understand:
(a) my origin
(b) evolution
(c) the development of organisms through the ages
(d) the structure and origin of rocks
(e) all of these

37. At university I plan to major in:
(a) English
(b) Science
(c) Mathematics
(d) History

38. Fossils of many animals are not found today because they were:
(a) buried
(b) burned
(c) caused to disappear
(d) eaten by bacteria

39. If the statement, "The fossil is a clam" is made by an expert, the statement would be an
(a) observation
(b) inference
(c) hypothesis
(d) guess

40. Scars on bones indicate:
(a) injury to an animal
(b) rupture to the bone
(c) rupture of blood vessels
(d) attachment of muscles

41. Fossils might tell us something about:
(a) how water evaporates
(b) plants that lived long ago
(c) storms and bad weather
(d) the size of the moon

42. The climate during the carboniferous period could be described as:
(a) hot and wet
(b) an ice age
(c) cold and wet
(d) a hot desert climate

43. If bones from a prehistoric animal are missing a geologist will:
(a) study skeletons of related animals
(b) make inferences about the missing bones
(c) try and find the same fossil animal with a complete set of
(d) all of these. (e) none of these (bones.

44. Two agents in the process of layering sedimentary rocks are:
(a) wind and water
(b) plants and animals
(c) glaciers and human beings
(d) contraction and expansion

45. An organic sedimentary rock consisting of altered remains of plants is:
(a) sandstone
(b) limestone
(c) gypsum
(d) coal

46. Birds evolved from:
(a) reptiles
(b) cartilagenous fish
(c) dinosaurs
(d) apes

47. The part of the past in which I am most interested is:
(a) yesterday
(b) years ago
(c) hundreds of years ago
(d) millions of years ago

48. Which of the following does not belong in the group?
(a) nautilus
(b) snail
(c) clam
(d) trilobite

49. Paleontology is the study of:
(a) fossils
(b) cells
(c) tissues
(d) classification

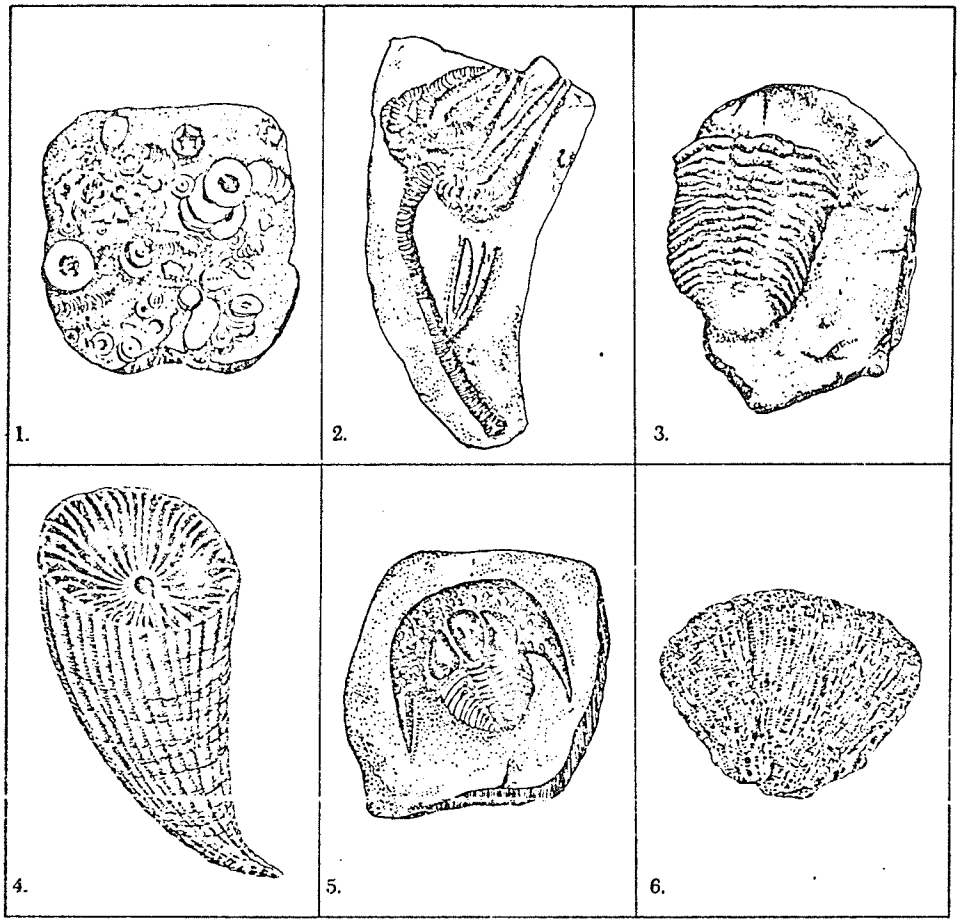
50. Inference means:
(a) to interfere
(b) to guess
(c) to memorize
(d) a factual statement

SCIENCE TEST

Choose the BEST answer. Answer EVERY question.

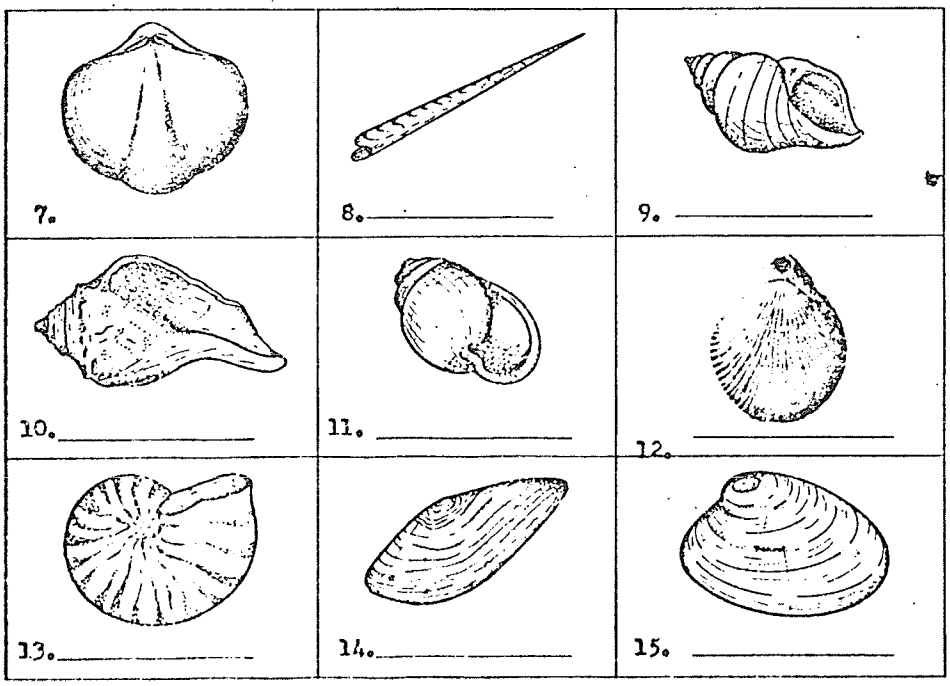
Some choices are used more than once.

To answer the following questions, examine the picture then find the answer in the choices to the right. Fill in YOUR choice in the correct space on the answer key.

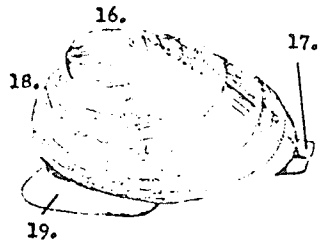


(A) Solitary coral
(B) Colonial coral
(C) Crinoid
(D) Shark teeth
(E) Trilobite

Choose the answers for questions #7 to #15 from the following choices:
(A) Cephalopod
(B) Pelecypod
(C) Gastropod
(D) Brachiopod



Page 2.



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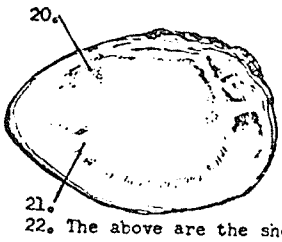
(E) The foot



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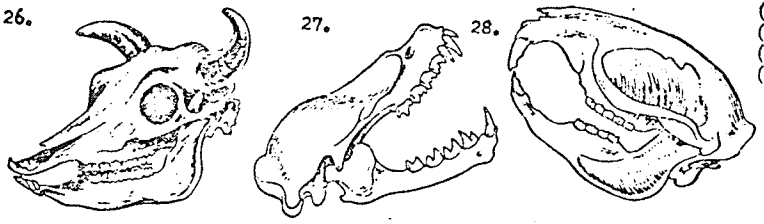
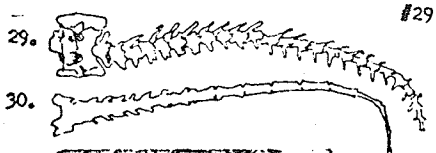
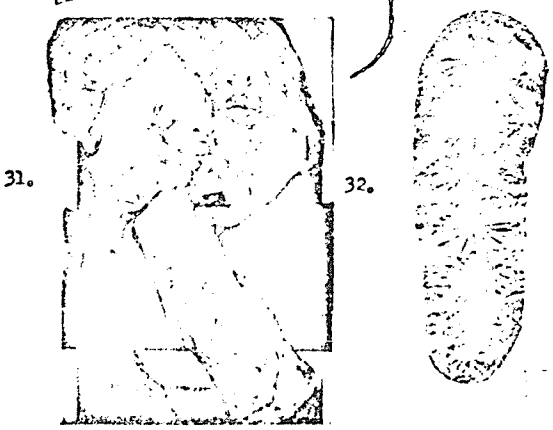




#29 & #30 are the tail bones of: (A) Fish
(B) Cat
(C) Bird
(D) Alligator



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d) biology

35. Much coal-bearing sedimentary rock was formed in the period called:
a)Devonian
b) Cretaceous
c) Carboniferous
d) Pre-Cambrian. e) Mesosoic

36. Geology is important because it allows me better to understand:
a) My origin
b) evolution
c) The development of organisms through the ages
d) The structure and origin of rocks.
e) all of these

37. At university I plan to major in:
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b) Science
c) Mathematics
d) History

38. Fossils of many animals are not found today because:
a) buried
b) eaten by bacteria
c) burned
d) caused to disappear

39. The statement, "The fossil at the right is a clam" if made by an expert, would be:
a) observation
b) inference
c) hypothesis
d) speculation

40. Fossils show us:
a) the order in which strata of sedimentary rocks were laid down.
b) that climates have changed.
c) that plants and animals have developed gradually to their present form.
d) the lengths of time gaps between successive strata.
e) all of the above.

41. Fossils might tell us something about:
a) how water evaporates
b) plants that lived long ago
c) storms and bad weather
d) the size of the moon

42. The most interesting aspect of the chapter, "Life in the past" was the:
a) information
b) fossils I examined
c) activities
d) knowledge I gained about the past.

43. If bones from a prehistoric animal are missing a geologist will:
a) Study skeleton of related animals.
b) Make inferences about the missing bones
c) Try and find the same fossil animal with a complete set of bones
d) none of these
e) all of these

44. The eye sockets of a frog are located on which part of its skull?
a) top
b) bottom
c) side
d) back

45. The amount of flesh on a fossil animal's body can be determined by:
a) bone size
b) muscle scars d) all of these
c) present day relations
e) none of these

46. Birds evolved from: a) Dinosaurs b) Reptiles c) Cartilagenous fish d) Apes

47. The part of the past in which I am most interested is:
a) Yesterday
b) Hundreds of years ago
c) Thousands of years ago
d) Millions of years ago.

Read the following paragraph then answer questions 48, 49 and 50:
The sun is a round object in space that gives off heat because it is burning. Tests have been carried out on earth where materials identical to those in the sun have been burned. At the point when the energy liberated was equal to that of the sun, measurements were taken.

48. From the paragraph we can accept the fact that the sun is:
a) round b) in space c) giving off heat d) all of these

49. From the paragraph we know that on the sun we will probably find:
a) all the elements that were tested c) Iron
b) the same elements found on earth d) only elements that will burn

50. One might speculate that the sun contains:
a) More elements than are known on earth
b) Uranium
c) living matter
d) wood

XEROX EDUCATION GROUP—CANADA

MEMORANDUM

Ginn and Company
35 Mobile Drive
Toronto M4A 1H6 Ontario

TO Mr. G. Rogers

LOCATION Winnipeg, Manitoba

FROM Sharlene Phillips

DATE September 24, 1973

SUBJECT: Your letter of September 19, 1973

Dear Mr. Rogers:

I am writing concerning your request for further information on the book "Science Learning and the Problem Reader" by George G. Mallinson.

Unfortunately, I am unable to supply any further information than what you already have. I have looked through all our reference books available and was unsuccessful.

I trust you will be able to find the information required from another source.

Yours truly,

(Mrs.) S. Phillips
Customer Relations
XEG-Canada
:sp

APPENDIX "E"

COMPUTER PRINT-OUTS

Point biserial correlation of

(a) C_1 and C_2 combined

(b) E_1 and E_2 combined

AUGUST 13 1973

STATISTICAL REPORT 409

PAGE NO. 1

G ROGERS

COURSE: PRE GROUP B

QUESTION NUMBER	CORRECT RESPONSE	A 1	B 2	C 3	D 4	E 5	NO REPLY	MULTIPLE RESPONSE	DIFFICULTY LEVEL	POINT BISERIAL	PERCENTAGE CORRECT	PERCENTAGE WRONG
1	3	42	22	332	15	1	7	3	0.790	+ 0.117	79 %	21 %
2	1	177	3	223	10	0	5	2	0.420	+ 0.207	42	58
3	1	399	5	0	7	0	5		0.959	+ 0.213	96	4
4	4	124	41	157	83	6	7	2	0.197	+ 0.131	20	80
5	5	34	2	72	14	293	6	5	0.694	+ 0.324	69	31
6	1	127	33	197	5	47	7		0.305	+ 0.068	31	69
7	3	4	31	213	159	4	5		0.512	+ 0.313	51	49
8	1	273	36	77	22	1	7		0.656	+ 0.421	66	34
9	4	35	20	14	43	301	5	2	0.103	+ 0.059	10	90
10	1	45	28	68	242	27	6		0.108	+ 0.143	11	89
11	2	57	108	51	64	131	7	2	0.257	+ 0.175	26	74
12	3	73	3	321	15	0	4		0.771	+ 0.257	77	23
13	2	60	285	51	13	4	6	3	0.680	+ 0.298	68	32
14	4	102	45	14	136	110	9		0.326	+ 0.221	33	67
15	2	19	362	18	13	2	4	2	0.867	+ 0.337	87	13
16	1	260	56	19	33	5	9	6	0.612	+ 0.338	61	39
17	4	8	17	125	165	99	5	3	0.391	+ 0.433	39	61
18	3	73	98	158	77	5	7	2	0.377	+ 0.235	38	62
19	5	13	27	33	74	265	6	2	0.634	+ 0.342	63	37
20	1	161	57	80	63	47	9	1	0.387	+ 0.237	39	61
21	2	74	106	93	84	50	9		0.254	+ 0.136	25	75
22	1	312	53	20	24	1	6		0.750	+ 0.307	75	25
23	5	49	137	44	89	03	5	1	0.221	+ 0.112	22	78
24	1	121	59	110	55	63	9	1	0.290	+ 0.143	29	71
25	2	8	123	260	20	1	6	2	0.290	+ 0.154	29	71
26	2	39	321	37	6	10	6	3	0.766	+ 0.317	77	23

AUGUST 13 1973

STATISTICAL REPORT

G ROGERS

COURSE: PRE GROUP B

QUESTION NUMBER	CORRECT RESPONSE	A 1	B 2	C 3	D 4	E 5	NO REPLY	MULTIPLE RESPONSE	DIFFICULTY LEVEL	POINT BISERIAL	PERCENTAGE CORRECT	PERCENTAGE WRONG
27	3	10	10	374	7	10	5		0.899	+ 0.428	90 %	10 %
28	5	52	26	53	52	231	4	2	0.552	+ 0.213	55	45
29	4	64	88	10	246	3	8	3	0.584	+ 0.330	58	42
30	2	58	251	22	76	3	6		0.603	+ 0.311	60	40
31	2	93	156	107	55	2	5	2	0.370	+ 0.214	37	63
32	4	85	63	169	94	1	5	1	0.223	+ 0.066	22	78
33	4	26	94	10	273	8	7	2	0.651	+ 0.308	65	35
34	2	50	87	101	167	5	8	2	0.206	+ 0.111	21	79
35	3	18	76	220	92	4	8	2	0.528	+ 0.302	53	47
36	5	18	32	61	129	169	8	1	0.406	+ 0.323	41	59
37	2	91	125	95	56	14	37	2	0.298	+ 0.185	30	70
38	4	128	17	78	178	5	10		0.427	+ 0.184	43	57
39	1	141	57	176	37	0	6	1	0.338	+ 0.141	34	66
40	4	155	117	10	126	2	6		0.302	+ 0.259	30	70
41	2	7	384	10	8	1	6		0.923	+ 0.398	92	8
42	1	209	63	51	86	1	7		0.500	+ 0.317	50	50
43	4	66	41	24	246	32	8	1	0.591	+ 0.328	59	41
44	1	227	49	17	116	2	8	3	0.540	+ 0.236	54	46
45	4	71	159	58	118	1	9		0.283	+ 0.344	28	72
46	1	209	155	29	8	2	14		0.500	+ 0.184	50	50
47	4	74	63	82	181	4	13	1	0.432	+ 0.206	43	57
48	4	60	18	23	303	0	12		0.728	+ 0.313	73	27
49	1	171	47	94	91	1	14	2	0.408	+ 0.232	41	59
50	2	58	170	29	144	1	16	2	0.408	+ 0.218	41	59
AVERAGES											49	51

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G ROGERS

COURSE: E POST GROUP B

QUESTION NUMBER	CORRECT RESPONSE	A 1	B 2	C 3	D 4	E 5	NO REPLY	MULTIPLE RESPONSE	DIFFICULTY LEVEL	POINT BISERIAL	PERCENTAGE CORRECT	PERCENTAGE WRONG
1	3	52	137	137	14	5	25	1	0.371	+ 0.376	37 %	63 %
2	3	31	27	259	5	15	32		0.701	+ 0.583	70	30
3	5	3	6	13	4	316	27		0.856	+ 0.634	86	14
4	1	241	38	28	32	4	26		0.653	+ 0.529	65	35
5	5	5	12	25	118	193	21	5	0.514	+ 0.427	51	49
6	2	79	207	24	20	13	28	2	0.555	+ 0.506	56	44
7	4	33	69	40	196	2	29		0.531	+ 0.518	53	47
8	1	162	53	62	54	1	37		0.439	+ 0.360	44	56
9	3	48	59	217	22	3	24	4	0.579	+ 0.471	58	42
10	3	44	50	207	33	4	31		0.560	+ 0.523	56	44
11	3	50	60	198	30	3	28		0.536	+ 0.530	54	46
12	4	48	66	30	167	2	26		0.452	+ 0.457	45	55
13	1	186	40	84	36	1	23	1	0.501	+ 0.498	50	50
14	2	40	193	45	57	0	35	1	0.520	+ 0.523	52	48
15	2	51	190	42	55	2	30	1	0.514	+ 0.547	51	49
16	1	265	68	5	6	1	24		0.718	+ 0.434	72	28
17	4	2	2	21	302	19	24	1	0.818	+ 0.617	82	18
18	3	23	75	232	6	3	30		0.628	+ 0.438	63	37
19	5	1	6	4	15	321	23	1	0.867	+ 0.610	87	13
20	1	231	50	19	34	7	28		0.626	+ 0.444	63	37
21	2	37	218	47	34	20	13		0.590	+ 0.278	59	41
22	2	36	31	102	171	1	29	1	0.081	+ 0.061	8	92
23	5	23	150	15	65	89	27		0.241	+ 0.243	24	76
24	1	166	19	94	25	40	28	3	0.444	+ 0.243	44	56
25	3	100	67	161	18	2	22	1	0.433	+ 0.323	43	57
26	2	28	290	9	7	10	28	3	0.780	+ 0.524	78	22

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STATISTICAL REPORT

G ROGERS

COURSE: POST GROUP B

QUESTION NUMBER	CORRECT RESPONSE	A 1	B 2	C 3	D 4	E 5	NO REPLY	MULTIPLE RESPONSE	DIFFICULTY LEVEL	POINT BISERIAL	PERCENTAGE CORRECT	PERCENTAGE WRONG
27	3	5	4	319	3	8	30		0.864	+ 0.611	86 %	14 %
28	5	37	23	40	28	218	24	1	0.588	+ 0.303	59	41
29	4	30	48	7	261	2	23	2	0.704	+ 0.420	70	30
30	2	17	277	19	22	0	34		0.750	+ 0.455	75	25
31	2	35	249	16	38	0	32	1	0.674	+ 0.536	67	33
32	4	45	14	104	178	0	28		0.482	+ 0.425	48	52
33	4	7	6	71	260	3	26	4	0.696	+ 0.358	70	30
34	2	49	80	70	131	5	34		0.216	+ 0.248	22	78
35	3	6	17	222	68	31	26	1	0.598	+ 0.373	60	40
36	5	0	22	74	63	186	24		0.504	+ 0.272	50	50
37	2	81	129	79	39	4	40	3	0.341	+ 0.208	34	66
38	2	62	176	5	92	1	34	1	0.474	+ 0.318	47	53
39	1	133	132	31	43	1	31	2	0.355	+ 0.208	36	64
40	5	3	1	119	2	219	26	1	0.593	+ 0.251	59	41
41	2	3	348	5	2	1	10		0.943	+ 0.357	94	6
42	3	34	60	111	129	5	30		0.300	+ 0.214	30	70
43	5	44	62	3	14	218	30	2	0.588	+ 0.441	59	41
44	1	211	6	124	6	1	23	2	0.566	+ 0.356	57	43
45	4	46	84	15	175	25	23		0.476	+ 0.332	48	52
46	2	19	219	98	1	0	33	1	0.590	+ 0.412	59	41
47	4	64	69	32	168	2	34		0.455	+ 0.261	46	54
48	4	8	6	26	296	2	31		0.802	+ 0.495	80	20
49	1	83	76	3	185	0	22		0.224	+ 0.246	22	78
50	1	295	29	11	5	1	28		0.799	+ 0.465	80	20
AVERAGES											56	44

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G ROGERS

COURSE: (PPE GROUP A

QUESTION NUMBER	CORRECT RESPONSE	A 1	B 2	C 3	D 4	E 5	NO REPLY	MULTIPLE RESPONSE	DIFFICULTY LEVEL	POINT BISERIAL	PERCENTAGE CORRECT	PERCENTAGE WRONG
1	3	9	6	117	1	0			0.879	+ 0.190	88 %	12 %
2	1	44	4	80	5	0			0.330	+ 0.032	33	67
3	1	118	2	2	2	9			0.887	+ 0.218	89	11
4	4	43	19	42	28	2			0.210	+ 0.130	21	79
5	5	8	2	50	4	69			0.518	+ 0.269	52	48
6	1	40	18	68	1	6			0.300	+ 0.114	30	70
7	3	1	11	82	39	0			0.616	+ 0.381	62	38
8	1	90	7	28	8	0			0.676	+ 0.426	68	32
9	4	7	5	8	24	89			0.180	+ 0.226	18	82
10	1	18	9	31	69	6			0.135	+ 0.158	14	86
11	2	25	42	20	23	23			0.315	+ 0.263	32	68
12	3	24	4	93	12	0			0.699	+ 0.290	70	30
13	2	23	88	19	3	0			0.661	+ 0.394	66	34
14	4	31	11	16	48	27			0.360	+ 0.260	36	64
15	2	3	121	5	4	0			0.909	+ 0.317	91	9
16	1	98	24	6	4	1			0.736	+ 0.291	74	26
17	4	3	8	34	72	17		1	0.541	+ 0.399	54	46
18	3	15	31	58	28	1			0.436	+ 0.272	44	56
19	5	4	4	5	14	106			0.796	+ 0.252	80	20
20	1	56	28	22	17	10			0.421	+ 0.109	42	58
21	2	29	38	29	22	15			0.285	+ 0.048	29	71
22	1	106	9	9	8	1			0.796	+ 0.299	80	20
23	5	12	41	6	35	38	1		0.285	+ 0.125	29	71
24	1	27	16	42	13	35			0.203	+ 0.113	20	80
25	2	7	38	82	6	0			0.285	- 0.071	29	71
26	2	12	100	12	3	6			0.751	+ 0.188	75	25

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STATISTICAL REPORT

G ROGERS

COURSE: PRE GROUP A

QUESTION NUMBER	CORRECT RESPONSE	A 1	B 2	C 3	D 4	E 5	NO REPLY	MULTIPLE RESPONSE	DIFFICULTY LEVEL	POINT BISERIAL	PERCENTAGE CORRECT	PERCENTAGE WRONG
27	3	3	9	114	4	2	1		0.857	+ 0.357	86 %	14 %
28	5	6	10	27	16	73	1		0.548	+ 0.173	55	45
29	4	16	25	2	90	0			0.676	+ 0.115	68	32
30	2	13	90	10	18	0	2		0.676	+ 0.217	68	32
31	2	20	84	20	10	0		1	0.624	+ 0.022	62	38
32	4	22	7	68	36	0			0.270	+ 0.119	27	73
33	4	4	47	2	80	1		1	0.593	+ 0.088	59	41
34	2	22	27	28	53	4		1	0.203	+ 0.019	20	80
35	3	5	13	90	24	1			0.676	+ 0.268	68	32
36	5	3	11	20	49	50			0.375	+ 0.262	38	62
37	2	27	40	23	21	6	17	1	0.293	+ 0.137	29	71
38	4	39	12	12	68	0	2		0.511	+ 0.096	51	49
39	1	47	22	53	9	1	1		0.353	+ 0.170	35	65
40	4	52	33	5	34	8	1		0.255	+ 0.200	26	74
41	2	7	121	3	2	0			0.909	+ 0.223	91	9
42	1	58	19	24	31	0	1		0.436	+ 0.421	44	56
43	4	35	24	8	53	13			0.398	+ 0.246	40	60
44	1	81	13	4	34	0	1		0.609	+ 0.254	61	39
45	4	25	62	8	37	1			0.278	+ 0.282	28	72
46	1	72	44	14	2	0	1		0.541	+ 0.273	54	46
47	4	22	29	25	54	2	1		0.406	+ 0.279	41	59
48	4	10	6	9	106	1	1		0.796	+ 0.162	80	20
49	1	55	17	28	30	2	1		0.413	+ 0.261	41	59
50	2	28	56	0	46	1	2		0.421	+ 0.243	42	58
AVERAGES											51	49

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G ROGERS

COURSE: POST GROUP A

QUESTION NUMBER	CORRECT RESPONSE	A 1	B 2	C 3	D 4	E 5	NO REPLY	MULTIPLE RESPONSE	DIFFICULTY LEVEL	POINT BISERIAL	PERCENTAGE CORRECT	PERCENTAGE WRONG
1	3	10	60	49	4	4	1		0.382	+ 0.322	38 %	62 %
2	3	15	12	91	3	6	1		0.710	+ 0.478	71	29
3	5	5	3	15	1	104			0.812	+ 0.597	81	19
4	1	94	11	7	10	6			0.734	+ 0.495	73	27
5	5	4	1	13	34	78		2	0.601	+ 0.606	60	40
6	2	28	76	12	8	4			0.593	+ 0.514	59	41
7	4	18	28	17	63	0	2		0.492	+ 0.468	49	51
8	1	70	30	16	10	0	2		0.546	+ 0.553	55	45
9	3	13	22	79	11	0	3		0.617	+ 0.556	62	38
10	3	17	22	76	12	0	1		0.593	+ 0.466	59	41
11	3	16	26	69	13	2	3	1	0.539	+ 0.441	54	46
12	4	24	29	11	59	4	2	1	0.453	+ 0.431	45	55
13	1	61	16	32	15	2	2		0.476	+ 0.563	48	52
14	2	16	65	23	20	1	4	1	0.500	+ 0.484	50	50
15	2	19	58	28	18	3	2		0.453	+ 0.640	45	55
16	1	104	17	2	3	2			0.812	+ 0.307	81	19
17	4	2	0	5	118	3			0.921	+ 0.383	92	8
18	3	5	14	102	4	1	2		0.796	+ 0.432	80	20
19	5	2	3	1	3	120		1	0.929	+ 0.382	93	7
20	1	100	11	9	7	3		2	0.773	+ 0.489	77	23
21	2	7	74	24	19	3	1		0.578	+ 0.577	58	42
22	2	8	8	66	46	0	2	2	0.054	+ 0.125	5	95
23	5	14	58	9	19	24	5	1	0.179	- 0.037	19	82
24	1	56	13	33	7	18	1		0.437	+ 0.234	44	56
25	3	28	26	62	11	0	2	1	0.476	+ 0.175	48	52
26	2	9	106	6	4	3			0.828	+ 0.270	83	17

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STATISTICAL REPORT

G ROGERS

Control

COURSE: POST GROUP A

QUESTION NUMBER	CORRECT RESPONSE	A 1	B 2	C 3	D 4	E 5	NO REPLY	MULTIPLE RESPONSE	DIFFICULTY LEVEL	POINT BISERIAL	PERCENTAGE CORRECT	PERCENTAGE WRONG
27	3	2	0	121	3	2			0.945	+ 0.287	95 %	5 %
28	5	10	6	13	14	85			0.664	+ 0.298	66	34
29	4	14	9	2	103	0			0.804	+ 0.441	80	20
30	2	12	94	14	8	0			0.734	+ 0.401	73	27
31	2	10	103	10	5	0			0.804	+ 0.292	80	20
32	4	22	2	41	61	7			0.476	+ 0.261	48	52
33	4	5	5	41	76	1	1	1	0.585	+ 0.470	59	41
34	2	18	26	20	50	3	11		0.203	- 0.104	20	80
35	3	5	3	100	8	11	1		0.781	+ 0.430	78	22
36	5	5	8	20	30	63	2		0.492	+ 0.279	49	51
37	2	24	32	20	23	10	19		0.250	+ 0.237	25	75
38	2	25	85	3	13	0	2		0.664	- 0.002	66	34
39	1	32	60	23	12	0	1		0.250	- 0.061	25	75
40	5	5	4	46	2	71			0.554	+ 0.373	55	45
41	2	1	120	3	3	0	1		0.937	+ 0.314	94	6
42	3	27	23	11	41	13	13		0.085	- 0.043	9	91
43	5	42	21	0	3	62			0.484	+ 0.401	48	52
44	1	84	1	37	5	1			0.656	+ 0.338	66	34
45	4	12	36	11	63	6	1		0.492	+ 0.304	49	51
46	2	2	91	29	4	0	2		0.710	+ 0.504	71	29
47	4	32	23	11	43	11	9	1	0.335	+ 0.244	34	66
48	4	4	3	18	100	2	1		0.781	+ 0.237	78	22
49	1	38	33	4	51	1	1		0.296	+ 0.304	30	70
50	1	90	21	9	4	1	3		0.703	+ 0.323	70	30
AVERAGES											58	42

THE UNIVERSITY OF MANITOBA

DEPARTMENT OF PSYCHOLOGY

WINNIPEG, CANADA
R3T 2N2

January 25, 1974

Dear Mr. Rogers

Further to our recent telephone conversation I would like to make the following point:

1. You are essentially correct concerning the point-biserial. A high point-biserial correlation means that the students with a high overall mark answered the particular item correctly whereas the students with a low overall mark got the item wrong.

2. Your significant analysis of variance is telling you that the experimental groups in general did better than the control group.

3. The fact that the overall point biserials are the same for both groups does not necessarily indicate that the test is equally valid for the two groups. What it does tell you is that the items appear to be measuring whatever the total test is measuring to the same extent for the two groups. I think that only independent evidence can be brought to bear on the validity question.

I hope this has been some help to you.

Sincerely,

P.K.D.

Associate Professor.