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Predictors of Success on the New York State Earth Science Regents Examination

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PREDICTORS OF SUCCESS ON THE NEW YORK STATE

EARTH SCIENCE REGENTS EXAMINATION

THESIS

by
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INTRODUCTION

Statement of the Problem

The 1970 New York State Earth Science Regents Syllabus, which is the edition currently in place in the majority of New York State schools, states that Regents earth science is "most frequently offered to selected and able ninth grade students who display an interest in science". (Bureau of Curriculum Development, 1970, p. vii) Prior to 1986, schools that offered the Regents Earth Science course to their more able, eighth and ninth graders exhibited higher examination scores than did schools that used the course for their less able students in grades ten to twelve. One city school abandoned the Regents Earth Science course after requiring it for all ninth graders with the result of having a large portion of failures. (McGuire, 1985)

In order to accommodate the changes mandated by the Regents Action Plan, starting in the 1985-86 school year, districts in New York State adopted earth science as the ninth grade course. One significance of this fact is that many students who wish a Regents diploma will take Regents Earth Science in grade nine regardless of their ability level. The problem investigated in this research was to determine if there were any variables that could be used as objective predictors for the success of ninth grade students on the Regents Earth Science examination. Possible predictors studied were eighth grade California Achievement Test scores

in reading, math, language, science and study skills and the final eighth grade average in math, English and science. But first let us look at the changes that prompted most schools to encourage the use of Regents Earth Science as the primary ninth grade science course.

Changes Caused by the Regents Action Plan

With the advent of the New York State Regents Action Plan in 1985, students are required to successfully complete two Regents science courses in order to obtain a Regents diploma. Prior to the 1985-1986 school year, only one unit of science was required to obtain a Regents diploma and that one unit could be a science nine course of the individual school district's choice. It did not necessarily require a Regents examination. Furthermore, prior to the Regents Action Plan, only one three-unit sequence, in any subject, was required for a Regents diploma. If science was the course that the student selected for his or her sequence, a ninth grade science course that did not require a Regents examination could be used to fulfill the first of the three units. Presently a student enrolled in a Regents program must complete two three-unit sequences and, if science is one of the two choices, the student must complete three Regents sciences. (Bureau of Science Education, Fall 1990)

Another change generated by the Regents Action Plan was the mandate that passing the Regents Competency Test in science is a graduation requirement starting with the class that entered grade nine in 1987 (the 1991 senior class). A Regents science examination or other

State Education Department approved test such as an advanced placement test may be substituted for the Regents Competency Test. (Bureau of Science Education, Fall 1990) The Regents Competency Test covers three years of instruction in science to be taken in grades seven, eight and nine. Students have their first opportunity to take the test at the end of grade nine. If they do not pass the test they must be provided with remediation and given the opportunity to repeat the course as many times as required in order to receive a passing score. The Regents Competency Test is based on the core understandings and process skills of the Middle School/Junior High school blocks that include studies in life science, physical science and earth science. Because earth science provides an opportunity for a Regents examination, most schools reserve that course for grade nine.

Eleven Year State Record

Interestingly, although the number of students taking the course in New York State during each of the last five years is approximately double that of the previous six years, there has not been an increase in the average percent that have failed during that time as revealed in Table 1. This may be due, in part, to the fact that less than fifty percent of the ninth graders, statewide, are taking Regents earth science. About forty-one percent of the ninth graders in New York State took the 1990 examination. (Bureau of Educational Data Systems, October 1990) One might conclude that the less able students do not take the course. Although the State Education Department has been reluctant to define what is intended

<u>TABLE 1</u>

PERCENTAGE OF PUPILS PASSING

EARTH SCIENCE EXAMINATIONS

JUNE 1980 - JUNE 1990

Year	Number Written	Percent Passing
1980	37,264	79.3
1981	35,785	79.3
1982	35,322	81.2
1983	35,336	82:4
1984	37,000	80.0
1985	38,898	83.4
1986	62,932	76.3
1987	74,152	79.0
1988	73,294	81.8
1989	76,524	83.4
1990	77,644	84.0

<u>Note:</u> From <u>An Update on Science Education,</u> Bureau of Science

Education, State Education Department. Albany, New York. Spring 1991

by "more able", various authors of the syllabus have suggested that it could mean anywhere from ten to twenty-five percent of any given class with most favoring the upper ten to fifteen percent. (Briggs, 1991) The fact is that there has been much evidence in the past five years to indicate that a greater percentage than this can be successful. As previously mentioned, seeking objective criteria to identify these individuals has been the focus of this research.

Skills Required

Regents earth science requires higher levels of cognitive skills than those to which most ninth grade students are accustomed. Using the process-of-inquiry, students must possess many skills. These include, but are not limited to, the following:

The students must be able to: (Bureau of Curriculum Development, 1970)

1. demonstrate math skills in solving for unknowns
2. demonstrate a degree of precision in measurement
3. create and interpret models that represent natural phenomena
4. extrapolate from and interpolate within a set of data
5. construct graphs using appropriate scales

Hardworking students who have been successful in the past using memorization, attention to detail and good organizational skills may not succeed in Regents earth science. Regents earth science requires that students be comfortable with divergent modes of problem solving and possess the ability to understand mathematical and conceptual models.

Limitations

Although an attempt was made to include in the study all of the one-hundred thirty-two students that took the earth science Regents examination at the school used in this research, this was not possible because of incomplete data on many of them. Ultimately one-hundred four students were included in the study with twenty-eight students eliminated for one of the following reasons:

1. Missing file - one student

2. Upper classman - one student

3. Transfer students with inadequate eighth grade records - eleven students

4. Failure to complete part or all of the CAT tests - fifteen students

This research had a limited scope of variables studied. Variables included in the study were percent scores on the California Achievement Test taken in the eighth grade in reading, mathematics, language, science and study skills. Also studied were the final eighth grade averages for English, mathematics and science. No attempt was made to include variables such as socioeconomic status of the individual pupils or subjective variables such as student attitudes, interests or teacher recommendations.

The choice of the standardized test to be used as possible predictors was an easy one. The California Achievement Test was utilized as the standardized test because that was the test given by the school district studied.

Summary

Since the 1985-86 school year, many school districts have been offering Regents earth science as the primary ninth grade course and encouraging as many ninth grade pupils as possible to enroll. This has resulted in increased numbers of students taking the course which was originally intended for only "selected high-ability ninth year pupils, with drive, interest and science aptitude". (Templeton, 1966) Various sources consider this to be the upper ten to twenty-five percent of a given class with most leaning toward the low end of this range. High order thinking and math skills are essential to mastery of the course. Teachers are sometimes pressured to accept students for which the course is inappropriate. Changes fostered by the Regents Action Plan greatly increased the number of average and even below average students enrolled in the course. This research focused on the examination of a limited number of objective variables to determine if any of them could be used as predictors of probable success on the earth science Regents examination.

Chapter II

LITERATURE SURVEY

This chapter reports on a brief history of the development of earth science in New York State and Regents examinations in general. Also covered are discussions regarding the use of predictors in other studies and background information on California Achievement Tests.

Earth Science History

Earth science may have been the first science to be included in the secondary curriculum when it was introduced as another subject, geography, as one of the "classical" subjects of the twentieth century. (McGuire, 1985) Regents reports indicate that geology has been a continuous part of the curriculum at various locations and using various titles since 1836. Prior to World War II, the State Education Department initiated an earth science course with about 1500 students taking an earth science Regents examination in 1941. In 1958, a group of geology and earth science educators began meeting to develop the Earth Science Curriculum Project (ESCP). Funding for the project was provided by National Science Foundation. The purpose of the project which continued to develop during the early and mid 1960's was to improve the content and, more importantly, the method of earth science teaching. Memorization was replaced by scientific thinking skills and laboratory activities Learning by inquiry became the favored method of teaching earth science.

In 1965, under the direction of Hugh Templeton, Chief of the Bureau

of Science Education, a revision of the earth science syllabus was begun utilizing materials and resources developed by ESCP including the science teacher centers in New York State. (McGuire, 1985) According to the Science Letter written in 1966 by Templeton, the Regents earth science course was *"not"* intended for average ninth graders but instead was designed for selected, better than average ninth graders with an interest in science. The course underwent further revisions until the syllabus was finalized and published in 1970 along with an extensive supplement. Since 1986, with widespread use of the course for the ninth grade students, many have felt that it is necessary to again revise the syllabus and that process is currently taking place.

Regents examinations have been the trademark of high school education in New York State for over a century. In recent years, about one-half of the graduating seniors have received Regents diplomas. The Regents examinations have several purposes which include: (New York State Education Department, 1987)

1. the establishment and maintenance of standards for subject generally studied in New York State

2. a means to provide a valid and reliable final examination in those subjects

3. an instrument to predict the success of post secondary education

4. to serve as motivation for student achievement.

In 1986 Regents examinations were provided in twenty-one commonly

taught subjects. Sixty percent of the students in grades nine through twelve take at least one Regents examination each year.

In New York State a total of 77,644 students took the earth science Regents examination in June 1990 and of this total eighty-four percent passed the exam. (The State Education Department/Bureau of Testing Programs, Oct. 1990) The total taking the exam represents 41.1 % of the average grade enrollment (ninth grade) which would translate into 34.6 % of the average grade enrollment taking and passing the examination. The percent of the average grade enrollment tested is determined by dividing the number of students taking an exam by the average enrollment in grades nine through twelve.

Contrasting with these results is physics which appears to attract the smallest number of students of the Regents sciences. Of the 37,340 students that wrote the physics examination in 1990, 90.5 % passed the exam. However that number represents only 19.8 % of the average enrollment taking and passing the examination. Thus while 6.5 % more of the students taking the physics examination passed it than passed the earth science examination, there was only about one half the number of students taking physics as those that took earth science. Physics is most often taken by eleventh and twelfth grade pupils while earth science is taken most often by ninth grade students. It appears that one half of the students who take earth science do not take physics and one might assume that many of those who were unsuccessful in earth science were among this number thus enhancing the possibility for a greater success

rate on the physics test.

This paper is concerned about the success of students on the earth science Regents examinations and possible predictors of that success. Many researchers have studied predictors and their reliability to measure achievement in a variety of situations and some of these will be discussed on the following pages. There appears to be a total lack of study of predictors for success in the Regents earth science examination.

Use of Predictors

Mississippi is an example of a state that annually assesses the achievement of its state curriculum objectives by using a Basic Skills Assessment Program at grades three, five, eight and eleven. Because these tests are related to the unique set of objectives for the state, they allow for the assessment of the relationship of demographic factors. Mississippi is recognized as a poor state with a large non-white population. An interesting finding during a study of mathematics achievement in all the schools in Mississippi in 1985-86 (Jones and others, 1988) revealed that economic factors such as the percent of students receiving a free lunch was often a better predictor of success than previous mathematics achievement.

A study was conducted by the Rancho Santiago Community College District in California to assess the relationship between reading placement tests and subsequent classroom performance. The College Board Assessment and Placement Test was administered to students that entered the college during the fall and spring semester of 1985 and the fall

of 1986. An analysis was done on the relationship between course grades received and the placement scores. Furthermore, a "fair" number of students that had scored less than 25% on the reading portion of the placement test received course grades of "C" or better. The study concluded that placement scores were not reliable predictors of classroom performance in many subjects. (Kessler, 1987)

Researchers Harpole and Gifford (1985) conducted a study to relate personal, cognitive and school variables to physics achievement. Using the Student Background Questionnaire, developed by the researchers, and the Mississippi State Physics Competition Test as instruments, fourteen different variables were studied to determine their simple correlation to physics achievement. The sample studied consisted of four-hundred and thirty-five students of which sixty percent were male. Multiple regression was used to determine which combination of variables would serve as the best predictor. A Pearson-product moment was computed independently for each variable. Students who performed best in the Mississippi State University Physics Competition Test tended to be male students with high composite American College Test (ACT) and high science ACT scores. In addition they were likely to have taken calculus and have come from a high school that offered several physics classes where laboratory experiments were performed in small groups as opposed to demonstrations. Interestingly, as the level of the math course completed increased, physics achievement also seemed to increase.

A study was conducted in the Oklahoma Public City Schools to

compare the achievement of upper, middle and lower socioeconomic groups in the Earth Science Curriculum Project. (Henson, 1970) Three-hundred eighteen ninth grade students were given the following examinations:

1. pretest in science achievement
2. post-test in science achievement
3. intelligence test
4. attitude scale

An analysis of covariance and the Duncan's Multiple Range Test was used to determine that there was a significant difference among the three groups. The t-test and multiple correlation was used to find the correlation between the students' intelligence and attitude and their post-test scores. The findings revealed that the upper socioeconomic group differed significantly from the middle and lower socioeconomic groups. There was no significant difference between the middle and lower groups. The t-test and multiple correlation studies indicated that intelligence was an influencing variable in science achievement whereas attitude showed no significant relationship to science achievement.

A study with a twofold purpose was conducted in Texas: (1) to determine the readability of the textbooks adopted for use in the ninth grade earth science and general science courses and (2) to determine how well prepared the teachers were to teach the science courses at that level. (Kline, 1966) The results of the study revealed that most of the textbooks were written at a high level that was not grade appropriate and

that only 4.5 percent of the teachers met the minimum standards of academic preparation suggested by the Earth Science Curriculum Project. Many of the texts are used by schools in New York State including Earth Science: The World We Live In by Namowitz and Spaulding. (1985) Using the Dale-Chal formula for predicting readability, this text had a measured reading level of ninth to tenth grade. The significance of this finding is that this is one of two earth science texts used at the school that was the focus of the research for this report.

A study was conducted in Connecticut public junior high schools to determine if meteorology and climatology taught using original data in a research approach would result in greater critical thinking than the same courses taught in a conventional manner not using a data-centered approach. (Agne, 1970) Sixty one classes, each from a different school, participated in the study. Classes were randomly assigned to either the control group, thirty one classes, or the experimental group, thirty classes. Using an experimental unit developed by the author, the experimental group worked with original climate data presented through an inductive approach. The Watson-Glaser Critical Thinking Appraisal form was used to analyze the results taking into consideration that there were two possible sources of any variance from the initial skill level. The possible sources of variance were the effect of the data-centered research approach method and the effect of the conventional textbook approach. The results showed that there was a significantly greater level of improvement in critical thinking for the experimental group using the data-

centered approach than there was for the control group not using that approach.

Early in 1986, the Commission on Standards for School Mathematics (in Idaho) made recommendations for a kindergarten through grade twelve math curriculum. (Hill, 1989) Included in the recommendation was that college bound students should complete four years of college preparatory math, including calculus, and students not planning on a college education should have three years of mathematics. Secondary mathematics studies start in the seventh grade with some students being placed in algebra. In view of the recommendations a study of a representative junior high school in Idaho was conducted to determine predictors of success in mathematics achievement. Predictor variables assessed included mathematics scores on the Iowa Tests of Basic Skills (ITBS), the Kern High School Test of Mathematics Achievement and the recommendations of the sixth grade teachers. To determine the achievement in the seventh grade mathematics program, the end of the year averages in mathematics and scores on end-of-the-year achievement tests were used. Using multiple regression techniques, results showed that a composite set of eight variables accounted for 71% of the variance in the math scores. The ITBS subtests on concepts, problem solving and computation showed a significant correlation to the first semester seventh grade mathematics scores.

California Achievement Tests

The California Achievement Test, forms E and F, are objective and

norm referenced tests designed to measure basic skills found in most curricula. (CTB/McGraw-Hill, 1986) The tests are offered in eleven overlapping levels for kindergarten through grade twelve. There are two locator tests, one for grades one through six and one for grades six through twelve, which may be used to determine the appropriate test level for different students in the same grade level. These locator tests consist of twenty vocabulary and twenty math items. In order to provide students with experience in taking standardized tests, schools may opt for one of four practice tests available.

Test preparation involves six steps. Step number one involves the reviewing of commonly used curriculum guides and textbooks to determine appropriate questions for various grade levels. Step two is to provide specification guidelines for the test contents so that format, vocabulary level and language would be appropriate for each skill and grade level. During step three, a staff of educators write test items. They write almost twice the number that will actually be used in the final edition. Throughout the development, procedures are utilized to minimize ethnic, racial, age and gender bias. This includes having tryout materials reviewed by responsible people representing various ethnic groups. The next step is to try out test items in several adjacent grade levels. Teachers administering the tests answer questionnaires regarding the content and instruction. Step five involves the review of the tryout data and compilation of the questions to be used on the standardized version of the test. This standardized test is then administered to representative

schools across the United States to provide normative data. After completing the preceding five steps, the final step is to prepare the final edition of the tests, the manuals, the practice tests, locator tests, answer sheets and other related materials. The specific objectives of many of the subtests will be discussed in chapter three to show their relationship as possible predictor variables for the earth science Regents examination.

Summary

Earth science has been part of the high school curriculum in some form since the early 1800's. The most recent earth science syllabus in New York State, published in 1970, is not intended for average ninth graders. A search of the literature did not show any evidence that any study had been undertaken to determine predictors of success on the earth science Regents exam.

It did show, however, that predictors have been used in many other situations. In Mississippi, for example, a study of mathematics achievement revealed that economic factors are better predictors than previous mathematics achievement. A study at Rancho Santiago Community College showed that placement scores were not accurate predictors of performance in many subjects. An Idaho study showed that a composite set of eight variables could be used to predict success in seventh grade mathematics.

The CAT is a standardized test that is prepared using procedures to insure that it will be free of ethnic, racial, age and gender bias. It has the capability of testing in many different subject areas and at all grade levels.

Because this test is designed to measure basic skills and is used at the school that was the site of this study, many of the subtests were useful as possible predictors.

Chapter III

DESIGN

This chapter will report on the group studied for this project and give a brief overview of the makeup of the earth science Regents examination as well as the selection of possible predictors for success on that examination. It will also describe the gathering of the data and explain how the data was analyzed.

The Study Group

Since the focus of this project was to determine factors that might predict the probability of passing the earth science Regents examination, the first step was to select a large group of high school students that had recently completed the exam. The students studied for this project attended a Rochester suburban school district located approximately ten miles west of the city. The high school population consisted of 930 pupils (6/14/90) with approximately 95.3% of these being white. The ninth grade class studied, (class of 1993), consisted of 260 pupils. Of this number 28 pupils received free lunches and 7 pupils received reduced price lunches. One hundred and thirty-two pupils, approximately one half of the class, took the 1990 earth science Regents exam. Seventeen students from this class had taken the 1989 Regents examination as "advanced science" students. One student who took the examination was in grade 11 and therefore was eliminated from the study. Twenty-seven other students were eliminated from the study because of incomplete or missing data. Of

the one hundred four students who were ultimately included in the study, fifty were male and fifty-four were female. A grade of 65% is required in order to successfully pass the examination. Sixteen of the subjects studied, ten female students and six male students, received grades of less than 65% on the Regents examination.

The Earth Science Regents Examination

In order to select predictor of success on the earth science Regents examination, it was helpful to understand the composition of the examination. At the end of each school year, all Regents earth science students, who have completed a mandatory thirty laboratory hours, are eligible to take a statewide examination. The examination consists of a laboratory performance section and a two part written examination.

The performance sections consists of five laboratory type of activities that involve various types of measurement tasks using appropriate processes. This part is worth a total of ten points. The students must answer all fifty-five multiple choice questions on Part I of the written exam. This part, which includes questions from all fourteen topics in the earth science syllabus, is worth fifty-five points. In Part II, students get to choose seven of ten test groups of questions, five questions per group. These are worth thirty-five points.

The examination provides a booklet of reference tables and charts that the students should use to assist them in answering many of the questions. A few questions rely on low level cognitive skills of recall but most require higher order skills of analysis. Students must be capable of

the highest levels of critical reading comprehension in order to interpret many of the questions being asked. Other skills needed are sequencing skills, ability to make observations and draw conclusions, mathematical computation skills, inferential reasoning ability, establishing cause and effect relationships and the ability to read graphs and charts and use the information to answer related questions. (New York State Education Department, 1970)

Selection of the Predictors

After determining which subjects would be used for the study and analysis of the examination, the next step was the selection of the possible predictors. Previous academic performance seemed like an obvious choice for inclusion. Averages obtained in three areas the year prior to the study of earth science were used. These were English, mathematics and science. Next was the selection of standardized test scores to be used as possible predictors. The school used in the study administers the California Achievement Test (CAT) as a standardized test to measure achievement in basic skills. (CTB/McGraw-Hill, 1986) Since all predictor scores must be available prior to the start of the study of earth science, the scores received for form F, level 19 administered to the students during the spring of 1989 were the ones used in this study. The percent scores of five subtests of the California Achievement Test that appeared most relevant to this study were used. The first of these was the total % CAT score in reading. The score is derived from a group of

tests that measure vocabulary and reading comprehension skills. The students' ability to identify words with the same, opposite and multi meanings as well as the ability to infer missing words in a paragraph or sentence is an important part of the vocabulary component of this score. The reading comprehension assesses not only literal comprehension (who, what, where, when) and sequencing skills, but also inferential and critical comprehension skills. These skills such as drawing conclusions, identifying cause and effect and predicting outcome from reading material are important in learning earth science. The next score included was the total % CAT score in mathematics. Since earth science involves basic math computations and an understanding of number sentences, measurement and math problem solving, the assessment of these skills seemed important. Total language was the third CAT score included. This score demonstrates the students' abilities in both language mechanics and expression. The fourth score included was the CAT score in study skills. This test emphasizes skills required to gather and process information with an added focus on notetaking and outlining. The last score was the CAT in science, which demonstrates the students' knowledge of the language, concepts or methods used to communicate and inquire about six areas of science including earth science.

Procedures Used to Gather and Interpret Data

After the population to be studied was identified and possible predictors were selected. the author of this study spent several days at the study school gathering and recording data from the students' cumulative

folders relative to the scores to be included in the study. Following completion of this task, the data was entered into an IBM computer at the school using the GB-STAT program for statistics. (GB-STAT, 1990) Nine variable scores for each subject were entered. The first variable entered was the score on the 1990 earth science Regents examination. This was the dependent variable. The other eight independent variables were entered in the following order: CAT scores in reading, mathematics, language, study skills and science and the final 1989 averages in English, mathematics and science. After all data was entered, it was sorted so that the earth science Regents scores would be in rank descending order. This data was then printed including an arbitrary subject number for each student. To determine which predictor or predictors would be most useful to determine success on the earth science Regents examination, the multivariant procedure of forward stepwise multiple regression was used. This tool was useful because the dependent variable, earth science Regents score, was continuous rather than a discrete variable. The data entered can be found on Table 2.

The abbreviations used at the headings of the columns for Table 2 and for other tables used in this paper are listed below:

OBS = Subject number

ESREG = Earth science Regents examination score

CATRE = California Achievement Test in reading

CATMA = California Achievement Test in mathematics

CATLA = California Achievement Test in language

CATSS = California Achievement Test in study skills

CATSC = California Achievement Test in science

AVEEN = Final eighth grade average in English

AVEMA = Final eighth grade average in mathematics

AVESC = Final eighth grade average in science

I. Q. = Innate intellectual ability

SEX = gender of the subject

TABLE 2

STUDENT SCORES FOR SELECTED VARIABLES

OBS	ESREG	CATRE	CATMA	CATLA	CATSS	CATSC	AVEEN	AVEMA	AVESC	IQ	SEX
1	97	75	98	70	93	97	81	85	90	122	0
2	97	83	99	96	74	99	96	92	96	123	1
3	97	88	95	94	97	90	98	96	96	130	1
4	97	89	99	96	93	99	93	94	92	138	1
5	96	97	99	99	97	99	98	95	95	133	1
6	96	73	98	77	97	80	94	92	92	133	1
7	95	91	98	99	83	94	96	96	96	116	1
8	95	88	98	98	83	94	85	92	86	135	0
9	94	91	96	88	83	94	94	93	93	107	0
10	94	85	99	92	93	99	83	94	91	125	0

OBS	ESREG	CATRE	CATMA	CATLA	CATSS	CATSC	AVEEN	AVEMA	AVESC	IQ	SEX
11	94	78	96	69	62	85	89	88	92	108	0
12	94	96	97	83	83	97	91	92	95	125	1
13	92	91	99	99	83	85	96	98	96	127	1
14	92	98	98	90	93	99	95	87	92	137	1
15	91	70	98	86	54	90	94	94	95	106	1
16	91	91	99	78	83	85	95	95	95	127	1
17	90	95	98	93	74	94	95	94	96	134	1
18	90	48	79	57	44	94	78	88	86	128	0
19	90	98	99	96	83	94	97	96	97	137	1
20	89	73	98	89	93	80	95	97	96	128	1

OBS	ESREG	CATRE	CATMA	CATLA	CATSS	CATSC	AVEEN	AVEMA	AVESC	IQ	SEX
21	89	98	95	89	83	99	93	94	90	128	0
22	89	72	99	86	93	90	93	92	87	109	0
23	88	78	96	69	93	85	91	91	92	119	1
24	87	78	96	71	97	80	91	91	88	131	0
25	86	78	84	63	93	75	78	86	83	112	0
26	86	59	99	77	54	80	90	92	91	113	1
27	85	96	51	86	83	94	86	83	86	123	0
28	85	90	98	81	83	99	90	92	87	101	1
29	84	83	94	57	62	94	84	84	86	117	0
30	84	98	86	61	74	99	86	85	82	103	0

OBS	ESREG	CATRE	CATMA	CATLA	CATSS	CATSC	AVEEN	AVEMA	AVESC	IQ	SEX
31	83	89	38	90	93	94	76	80	77	115	0
32	81	88	88	69	74	49	82	84	89	110	0
33	81	62	85	56	37	75	80	85	78	98	0
34	81	81	74	74	62	94	86	85	89	133	0
35	81	73	85	70	54	94	86	85	82	115	1
36	81	54	93	70	62	80	83	90	85	118	0
37	80	74	55	53	62	75	82	85	82	91	0
38	80	74	98	56	93	97	84	90	86	113	1
39	80	82	71	47	62	66	75	78	74	110	0
40	80	90	89	75	93	94	90	88	81	137	0

OBS	ESREG	CATRE	CATMA	CATLA	CATSS	CATSC	AVEEN	AVEMA	AVESC	IQ	SEX
41	79	69	98	77	62	97	92	94	92	115	1
42	79	49	83	70	54	75	82	84	87	117	0
43	79	91	69	55	74	85	82	86	86	114	0
44	78	79	75	52	26	80	79	76	80	108	1
45	78	63	91	84	74	85	90	90	88	115	1
46	78	70	91	52	74	85	79	80	86	109	0
47	78	66	79	63	54	80	82	86	84	112	1
48	77	84	95	88	83	99	90	85	90	125	1
49	77	94	89	62	74	97	77	86	86	125	0
50	75	83	95	93	83	90	90	89	82	131	1

OBS	ESREG	CATRE	CATMA	CATLA	CATSS	CATSC	AVEEN	AVEMA	AVESC	IQ	SEX
51	74	55	85	68	54	58	74	86	83	112	0
52	74	70	70	67	62	75	79	88	87	105	0
53	74	88	85	55	93	85	82	92	91	114	0
54	74	80	88	48	54	75	84	90	85	103	0
55	74	76	40	33	54	4	78	70	78	100	0
56	74	45	62	38	31	80	79	78	82	115	0
57	73	98	93	99	93	90	93	90	85	115	0
58	73	89	96	84	74	99	93	92	88	125	0
59	73	58	66	57	54	66	84	84	81	111	1
60	73	84	63	54	83	71	75	77	75	115	0

OBS	ESREG	CATRE	CATMA	CATLA	CATSS	CATSC	AVEEN	AVEMA	AVESC	IQ	SEX
61	72	66	88	77	54	66	87	88	84	112	1
62	72	55	62	77	62	75	87	86	87	105	1
63	72	63	77	77	74	99	82	89	83	106	0
64	71	85	63	75	74	97	88	76	78	91	0
65	71	91	77	83	83	80	87	86	88	126	0
66	71	79	68	76	74	80	88	83	85	110	1
67	70	70	82	60	44	61	73	82	71	116	0
68	70	81	88	82	54	66	84	81	77	107	1
69	70	61	81	51	74	80	83	84	83	105	1
70	69	61	87	38	54	66	78	83	89	114	0

OBS	ESREG	CATRE	CATMA	CATLA	CATSS	CATSC	AVEEN	AVEMA	AVESC	IQ	SEX
71	68	79	90	92	74	80	91	86	83	118	1
72	68	75	99	95	74	94	91	93	91	116	0
73	68	69	86	67	74	94	88	87	89	132	1
74	68	62	90	76	54	66	91	90	90	106	1
75	68	59	89	80	97	85	84	84	80	127	1
76	68	72	51	45	37	85	72	76	78	94	0
77	67	70	84	62	44	85	81	80	78	105	0
78	67	75	77	43	74	90	86	84	77	115	1
79	67	74	86	56	62	80	72	82	79	114	1
80	67	49	82	66	74	85	81	83	87	108	1

OBS	ESREG	CATRE	CATMA	CATLA	CATSS	CATSC	AVEEN	AVEMA	AVESC	IQ	SEX
81	67	65	97	74	83	54	88	91	89	113	1
82	66	65	85	55	62	80	82	88	86	105	1
83	66	78	46	71	54	94	78	71	74	101	1
84	66	55	36	53	44	61	72	81	75	84	0
85	65	68	99	92	74	85	92	93	88	113	1
86	65	75	59	58	74	94	82	81	87	121	1
87	65	55	93	47	44	80	86	86	82	103	1
88	64	61	68	86	54	90	84	86	83	112	1
89	64	75	97	72	83	85	85	88	80	113	0
90	64	58	68	43	83	80	84	80	84	96	1

OBS	ESREG	CATRE	CATMA	CATLA	CATSS	CATSC	AVEEN	AVEMA	AVESC	IQ	SEX
91	64	48	70	51	54	71	77	81	86	104	0
92	64	75	88	88	74	75	89	89	84	107	1
93	62	28	81	43	54	75	82	88	88	111	1
94	61	77	71	67	44	99	78	81	77	90	0
95	61	51	75	75	93	61	80	80	83	102	1
96	61	91	58	89	62	90	83	82	81	107	0
97	60	35	82	75	62	58	72	80	78	115	0
98	59	66	84	74	74	54	89	87	80	102	1
99	56	59	89	50	62	46	85	87	72	106	1
100	56	73	82	43	44	61	86	83	81	110	1

OBS	ESREG	CATRE	CATMA	CATLA	CATSS	CATSC	AVEEN	AVEMA	AVESC	IQ	SEX
101	54	74	99	88	83	80	83	89	80	112	1
102	52	80	82	69	74	75	84	79	76	107	1
103	52	43	71	45	21	75	77	83	82	107	0
104	50	58	83	55	44	58	67	78	68	99	0

Chapter IV

ANALYSIS OF DATA

In any statistical analysis there are three main phases. (Bennett, 1978) They are as follows:

1. the collection of data

2. the extraction of information from the data

3. the interpretation of the results.

Because this study consisted of multiple variables with continuous numerical values, multiple regression techniques were used to extract information from the data. The advantage of multiple regression is that it eliminates bias.   If each independent variable had been analyzed independently of the others, it would negate the effects that the variables have on each other. Even so it is possible that the results of this study are biased to some extent by the effect of some omitted regressor such as class size.

All data used in this study with the exception of IQ and gender, which were added later, were based on the percent of 100. After inputting the data of 104 subjects, a correlation matrix was obtained using GB-STAT. This matrix did not take into account the gender or IQ of the students. See Table 3 for the correlation matrix. Studying the correlation matrix it was noted that the highest correlation with the earth science Regents examination scores were science average, .67; mathematics average, .55; English average, .51 and the CAT reading score .51.

TABLE 3

CORRELATION MATRIX OF SELECTED VARIABLES.

	1 ES REG.	2 CAT RE	3 CAT MA	4 CAT LA	5 CAT SS
ES REG	1	.50651**	.39212**	.43102**	.43763**
CAT RE	.50651**	1	.20587*	.48457**	.52397**
CAT MA	.39212**	.20587*	1	.45242**	.39484**
CAT LA	.43102**	.48457**	.45242**	1	.56065**
CAT SS	.43763**	.52397**	.39484**	.56065**	1
CAT SC	.44417**	.44038**	.29895**	.46682**	.35339**
AVE EN	.51481**	.46402**	.59774**	.67301**	.52294**
AVE MA	.54656**	.28735**	.75018**	.61297**	.4789**
AVE SC	.66965**	.30208**	.56097**	.50398**	.44638**

	6 CAT SC	7 AVE EN	8 AVE MA	9 AVE SC
ES REG	.44417**	.51481**	.54656**	.66965**
CAT RE	.44038**	.46402**	.28735**	.30208**
CAT MA	.29895**	.59774**	.75018**	.56097**
CAT LA	.46682**	.67301**	.61297**	.50398**
CAT SS	.35339**	.52294**	.4789**	.44638**
CAT SC	1	.41435**	.40267**	.42241**
AVE EN	.41435**	1	.75413**	.73103**
AVE MA	.40267**	.75413**	1	.76985**
AVE SC	.42241**	.73103**	.76985**	1

** $p < .01$ * $p < .05$

Furthermore it can be seen that the average in science had an especially high correlation to the averages in mathematics, .77 and English, .73 and a high correlation to the other variables, .42 to .56 with the exception of a somewhat low correlation to the CAT score in reading, .30. This would suggest that most of the variables have much in common with the science average and may therefore offer little unique information in predicting success in the Regents earth science examination.

In order to determine the validity of the previous statement, the multivariate method of forward stepwise regression was used, again using the GB-STAT program. This allowed the writer to study the straight-line relationship among the variables and to determine which of the available variables would be most useful as predictors for success on the earth science Regents examination. All nine variables were used in the analysis with the earth science Regents score as the dependent variable and all of the others used as independent variables. The results revealed that the average in science would be most useful in this prediction and its usefulness could be strengthened with the addition of the CAT reading score as noted by the increase in the multiple R value. See Table 4 for the forward stepwise regression data. Using the B coefficient one could predict that for every 1 point in the science average there will be a 1.08 point increase on the earth science Regents examination on average. Likewise for every 1 point increase on the CAT reading score, there will be a 0.26 point (about a quarter of a point) increase on the earth science Regents examination score on average Because the remaining variables

TABLE 4

FORWARD STEPWISE REGRESSION

CURRENT REGRESSION SUMMARY TABLE

DEPENDENT VARIABLE: ES REG

MULTIPLE R   = .6696
STD ERR EST = 8.9212
          F = 82.9265

IND VAR	B COEF	STD ERR(B)	T-VALUE	PROB
AVE SC	1.270695	.139539	9.1064	<.0001

CONSTANT
-32.24123

CURRENT REGRESSION SUMMARY TABLE

DEPENDENT VARIABLE: ES REG

MULTIPLE R   = .7418
STD ERR EST = 8.0954
          F = 61.7898

IND VAR	B COEF	STD ERR(B)	T-VALUE	PROB
CAT RE	.263637	.055126	4.78241	<.0001
AVE SC	1.078802	.132827	8.121826	<.0001

CONSTANT
-35.40184

CURRENT REGRESSION SUMMARY TABLE

DEPENDENT VARIABLE: ES REG

MULTIPLE R   = .7471
STD ERR EST = 8.0643
          F = 42.105

IND VAR	B COEF	STD ERR(B)	T-VALUE	PROB
CAT RE	.293174	.059208	4.951577	<.0001
AVE EN	-.246277	.184567	-1.334348	.1851
AVE SC	1.251721	.185207	6.758502	<.0001

CONSTANT
-31.35506

had such high inter-correlations with the variables already in the prediction equation to the average in science, they add no increase to the R value in the forward stepwise regression. The predictors that are highly correlated can not be sorted out clearly and their effect is already captured in the science average. Therefore their inclusion would have no effect upon increasing the multiple R.

At this point of the study, the author became concerned about the importance of IQ as an innate variable and the effect that it might have on the other variables. Using a program, Statistical Analysis System, a routine was written to remove the portion of the scores that was explainable by IQ. Using the IQ as the independent variable and each of the other scores, one at a time, as dependent variables, residuals were calculated for each score. These residual scores made it possible to retain only the part of the score that could not be explained by IQ. These residual scores were then used in both a correlation matrix and a stepwise regression for the dependent variable earth science Regents examination score. See Tables 5 and 6. At this time student gender was also added to the model.

Interestingly the same variables, that appeared to be the best predictors in the earlier model that had not been adjusted for IQ, continued to be the best predictors in this model which had been adjusted for IQ. In addition there was a high inverse correlation for gender in this new model. Recall that gender was not included in the earlier model.

TABLE 5

CORRELATION MATRIX FOR SELECTED VARIABLES WITH ADJUSTMENT FOR I.Q.

Correlation

CORR	CATRER	CATMAR	CATLAR	CATSSR	
CATRER	1.0000	0.0106	0.3597	0.4057	Residual
CATMAR	0.0106	1.0000	0.2682	0.1822	Residual
CATLAR	0.3597	0.2682	1.0000	0.4045	Residual
CATSSR	0.4057	0.1822	0.4045	1.0000	Residual
CATSCR	0.3333	0.1211	0.3320	0.1817	Residual
AVEENR	0.3354	0.4645	0.5635	0.3561	Residual
AVEMAR	0.1019	0.6617	0.4738	0.2827	Residual
AVESCR	0.1106	0.3958	0.3147	0.2247	Residual
SEX	-0.1292	0.2283	0.1804	0.0807	
ESREGR	0.3790	0.1676	0.2184	0.2176	Residual

Correlation

CORR	CATSCR	AVEENR	AVEMAR	AVESCR	
CATRER	0.3333	0.3354	0.1019	0.1106	Residual
CATMAR	0.1211	0.4645	0.6617	0.3958	Residual
CATLAR	0.3320	0.5635	0.4738	0.3147	Residual
CATSSR	0.1817	0.3561	0.2827	0.2247	Residual
CATSCR	1.0000	0.2674	0.2432	0.2607	Residual
AVEENR	0.2674	1.0000	0.6674	0.6312	Residual
AVEMAR	0.2432	0.6674	1.0000	0.6768	Residual
AVESCR	0.2607	0.6312	0.6768	1.0000	Residual
SEX	-0.0140	0.4406	0.2126	0.2028	
ESREGR	0.2920	0.3367	0.3669	0.5302	Residual

Correlation

CORR	SEX	ESREGR	
CATRER	-0.1292	0.3790	Residual
CATMAR	0.2283	0.1676	Residual
CATLAR	0.1804	0.2184	Residual
CATSSR	0.0807	0.2176	Residual
CATSCR	-0.0140	0.2920	Residual
AVEENR	0.4406	0.3367	Residual
AVEMAR	0.2126	0.3669	Residual
AVESCR	0.2028	0.5302	Residual
SEX	1.0000	-0.1447	
ESREGR	-0.1447	1.0000	Residual

TABLE 6

STEPWISE REGRESSION FOR DEPENDENT VARIABLE EARTH

SCIENCE REGENTS GRADE WITH ADJUSTMENT FOR I.Q.

Step 1   Variable AVESCR Entered   R-square = 0.28109628   C(p) = 19.51470796

	DF	Sum of Squares	Mean Square	F	Prob>F
Regression	1	2929.13411893	2929.13411893	39.88	0.0001
Error	102	7491.26042947	73.44372970		
Total	103	10420.39454839			

Variable	Parameter Estimate	Standard Error	Type II Sum of Squares	F	Prob>F
INTERCEP	0.00000000	0.84035094	0.00000000	0.00	1.0000
AVESCR	1.01317692	0.16043275	2929.13411893	39.88	0.0001

Bounds on condition number: 1,   1

Step 2   Variable CATRER Entered   R-square = 0.38497737   C(p) = 4.24491546

	DF	Sum of Squares	Mean Square	F	Prob>F
Regression	2	4011.61606119	2005.80803060	31.61	0.0001
Error	101	6408.77848720	63.45325235		
Total	103	10420.39454839			

Variable	Parameter Estimate	Standard Error	Type II Sum of Squares	F	Prob>F
INTERCEP	0.00000000	0.78110654	0.00000000	0.00	1.0000
CATRER	0.23394768	0.05664158	1082.48194227	17.06	0.0001
AVESCR	0.94463335	0.15004287	2515.06785052	39.64	0.0001

Bounds on condition number: 1.012385,   4.049538

Step 3   Variable SEX Entered   R-square = 0.42904518   C(p) = -1.08117258

	DF	Sum of Squares	Mean Square	F	Prob>F
Regression	3	4470.82007375	1490.27335792	25.05	0.0001
Error	100	5949.57447464	59.49574475		
Total	103	10420.39454839			

Variable	Parameter Estimate	Standard Error	Type II Sum of Squares	F	Prob>F
INTERCEP	2.25764862	1.11015899	246.05276327	4.14	0.0446
CATRER	0.20990913	0.05552514	850.29437323	14.29	0.0003
AVESCR	1.03578760	0.14894734	2877.14532497	48.36	0.0001
SEX	-4.34806401	1.56507821	459.20401256	7.72	0.0065

Bounds on condition number: 1.06885,   9.511341

All variables in the model are significant at the 0.1500 level.
No other variable met the 0.1500 significance level for entry into the model.

Summary of Stepwise Procedure for Dependent Variable ESREGR

The parameters in this analysis showed that for every 1 point increase in the eighth grade average in science, there will be a corresponding increase in the earth science Regents examination score of 1.04 point on average. For every 1 point increase in the CAT reading score there will be an increase of 0.21 point, nearly one-quarter of a point, on the earth science Regents examination score on average. The dummy variable, gender, on the other hand, will result in a drop of 4.35 points on average for a higher value. In this case 0 = male and 1 = female and thus the female students, on average, would score approximately four points lower than male students with otherwise comparable scores. All values for the three variables deemed to be the best predictors were statistically significant at the 1% level with prob.>F values of: Average in science, 0.0001; CAT in reading, 0.003 and sex, 0.0065. This indicates that a different sample would give a parameter estimate that is significantly different less that 1% of the time.

The R^2 which is about .429 indicates that about 43% of the earth science Regents score is explained by the three variables eighth grade final science average, CAT in reading and gender and all the other variable captured within these. The other 57% is probably explained by factors such as IQ, economic status, parents' education and student attitude.

Summary

The findings of this study revealed that predictors of success on the earth science Regents examination are possible. In this instance, using a forward stepwise regression, objective independent variables such as the previous year's science average together with the performance on the CAT in reading may be used as predictors. By adding gender to the independent variables, these predictors are further strengthened.

Chapter V

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

Summary

This study was undertaken to determine if there were possible objective measures to predict success on the earth science Regents examination. The 1970 curriculum was not intended for average ninth grade students but, according to Hugh Templeton, former Chief of the Bureau of Science Education, was designed for selected better than average ninth graders. However no insight has been given as to how to select these students.

With the advent of the Regents Action Plan during the 1985-86 school year many average ninth graders have taken the exam and the success rate of the percent passing has not shown any significant change. Nevertheless, on the average, approximately 19.1% of those taking the examination do not pass it and approximately one-half of all ninth grade students do not even take the earth science Regents course. This paper focused on a statistical analysis of several objective criteria as possible predictors for success on the earth science Regents exam.

The population used for this study was moderate in size, 104 subjects, and consisted of a group of heterogeneous individuals. These individuals were not so heterogeneous, however, that different groups within the sample would be liable to yield different results if factor analysis were carried out on them individually. This is because a group deemed to

be the most talented had been drawn from the pool one year prior to this study and took Regents earth science as advanced eighth graders. The majority of less able students were also removed from the pool and placed in a "local" program during their ninth year. This left primarily students with various abilities within a moderate range.

The independent variables chosen for study were the final eighth grade averages in mathematics, science and English and California Achievement Test scores in reading, mathematics, language, study skills and science. All of these scores were based on 100%. Later in the study IQ and gender were added as independent variables. The distribution of the variables were continuous and reasonably normal with only one subject markedly skewed on one variable. The variables were not linear combinations of each other (eg. an aggregate mark made up of any two of the other marks already included in the study).

Conclusion

After collecting the data, an initial correlation matrix and forward stepwise regression were done utilizing the GB-STAT program. This revealed that the average in science and the California Achievement Test in reading and all the variables captured by these two independent variables could explain nearly 55% of the Regents examination score. However, since the innate variable of IQ undoubtedly plays a large part in these results, further study was done using a Statistical Analysis System program to remove that part of each variable, one at a time, that could be attributed to IQ. The residual scores for each variable were then put into a

correlation matrix and a forward stepwise regression which revealed that the same independent variables, the final average in science and the CAT in reading were still the best predictors although slightly less strong than before. The final results, using the residuals, showed that for each 1 point increase in science average the earth science Regents examination score would increase 1.04 points on average and for each 1 point increase in the CAT reading score it would increase by approximately .21 points on average. Furthermore it was discovered that females would have approximately a 4 point drop, on average, on the Regents examination. Together these three variables could be used to explain about 43% of the Regents exam score. The results of this study should prove useful when assisting students in the selection of the ninth grade science course that they may choose. Students that have a high final average for eighth grade science combined with a high CAT score in reading should definitely be encouraged to study Regents earth science. Conversely students scoring low in both of these areas might be well advised to study "local" earth science or another science course.

Recommendations for further study

Many objective and all subjective variables were omitted in this study. Other studies could focus on factors such as family income, parents' education, class size, instructional methods, teacher's experience teaching in the area, teacher's education and student attitude. There is also a need to determine what scores for the eighth grade science average and the California Achievement Test in reading would, on the

average, indicate probable success on the earth science Regents examination.

For the past three years work has been done on the revision of the earth science syllabus. There is a need for that work to continue because it is impossible, in this writer's opinion, to adequately cover all fourteen of the required topics in the current curriculum. As part of his research on the relevance of the current earth science syllabus, John Winter (1989) surveyed over 1400 teachers to determine how they perceived the present syllabus. Over 60% of the responding teachers made comments about concerns they have about the syllabus.

Since Regents earth science is now used by so many schools as their predominant ninth grade course, it is important that some modifications be made to accommodate the average ninth grader.

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APPENDIX A

THE UNIVERSITY OF THE STATE OF NEW YORK
THE STATE EDUCATION DEPARTMENT
ALBANY, NEW YORK 12224

WARREN W. KNOX
ASSISTANT COMMISSIONER
FOR INSTRUCTIONAL SERVICES
(GENERAL EDUCATION)

August 1966

BUREAU OF SCIENCE EDUCATION
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The Science Letter

TO: Administrators of Secondary Schools and Guidance Counselors

SUBJECT: IS THE REGENTS EARTH SCIENCE COURSE DESIGNED FOR AVERAGE NINTH GRADERS?

No - The Regents earth science course is *not* designed for average ninth graders. Nevertheless, for over 18 years, schools in New York State have found from experience that *selected* ninth year pupils with *better than average academic ability* have successfully taken the course on an advanced placement basis.

The Regents earth science course, however, is a senior high school science course and is designed for the benefit of senior high school pupils who have the necessary academic ability to do the work of the course successfully. Moreover, the State Education Department has recommended over the years that if the course is offered to ninth year pupils, only selected high-ability pupils be placed in the course and that the selection be based upon pupil drive, interest, aptitude and performance in previous science courses.

In The Science Letter of March 1949 and in subsequent letters, the attention of school administrators has been invited to offering the Regents earth science course to these high-ability ninth year pupils. The last of these letters was dated January 1959 and any quotations appearing in this letter have been taken from the 1959 letter.

> "This device [of offering Regents earth science to selected
> ninth graders] seems to do much to meet the growing desire to
> offer challenging programs to our more able students without adding
> to the pupils' schedules and without increasing teacher load. For
> this reason, we feel that it is timely to bring the situation up
> to date and to review some of the conditions for those who might
> consider the introduction of earth science for more able ninth year
> science students."

We are also anxious to insure that the Regents earth science course is not overused to the detriment of those for whom it was not, and is not, designed. Some schools have apparently lost sight of the fact that, in the view of the State Education Department, the course is a senior high school course on an equal standing with biology, chemistry and physics. Regents earth science may be used for a major sequence and as one of the units submitted for a science endorsement on a Regents Diploma.

The Regents earth science course is *not* designed for *average* ninth year pupils. It is, in effect, used by superior ninth year students as an advanced placement course. Misunderstandings here can lead to unfortunate placement of ninth year pupils.

(OVER)

It is possible to arrange the blocks of the experimental Science 7, 8, 9 syllabus in such a way that those ninth year pupils not enrolled in the Regents earth science course on an advanced placement basis can be enrolled in a ninth year science course made up mainly of the earth science blocks taken from the Science 7, 8, 9 syllabus. The pupils enrolled in the non-Regents course can be tested locally and, if successful, receive credit for ninth year general science.

Some schools appear to have lost sight of the value of the Regents earth science course in the senior high school years and we must emphasize that
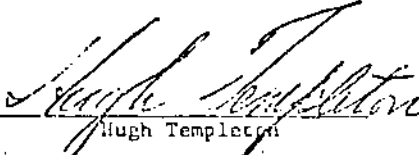
"This letter is not to be construed as relegating earth science to the ninth year level. More upper class students could profit by a course in earth science . . . but it does seem unfair to the subject and to some of the pupils to expect all of them to reach Regents examination level in earth science. Some could profit by a less difficult course. This becomes a matter of local guidance."

There should be a local senior high school earth science course for those whose abilities are obviously not at a level sufficient to cope with the Regents earth science course.
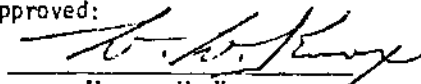
Reference is made to the 1962 reprint of the Earth Science Syllabus, the 1963 Earth Science Handbook, the 1964 guide, Field Identification of Rocks, and the 1961 resource unit, Exploring Space.

Summary

1. The Regents earth science course is a senior high school course and is *not* designed for average ninth grade pupils.

2. Only selected high-ability ninth year pupils, with drive, interest and science aptitude, should be enrolled in the Regents earth science course.

3. Only those upper class pupils who have the academic ability to cope with a Regents senior high school science course should be enrolled in the Regents earth science course.

4. A locally devised senior high school earth science course should be offered to those pupils who cannot cope with the Regents earth science course.

Hugh Templeton

Approved:

Warren W. Knox

APPENDIX B

The University of the State of New York

REGENTS HIGH SCHOOL EXAMINATION

EARTH SCIENCE

Tuesday, June 19, 1990 — 1:15 to 4:15 p.m., only

The last page of the booklet is the answer sheet. Fold the last sheet along the perforations and, slowly and carefully, tear off the answer sheet. Then fill in the heading of your answer sheet.

All of your answers are to be recorded on the separate answer sheet. For each question, decide which of the choices given is the best answer. Then on the answer sheet, in the row of numbers for that question, circle with pencil the number of the choice that you have selected. The sample below is an example of the first step in recording your answers.

SAMPLE: 1   ②   3   4

If you wish to change an answer, erase your first penciled circle and then circle with pencil the number of the answer you want. After you have completed the examination and you have decided that all of the circled answers represent your best judgment, signal a proctor and turn in all examination material except your answer sheet. Then and only then, place an X in ink in each penciled circle. Be sure to mark only one answer with an X in ink for each question. No credit will be given for any question with two or more X's marked. The sample below indicates how your final choice should be marked with an X in ink.

SAMPLE: 1   ⊗   3   4

The *Earth Science Reference Tables,* which you may need to answer some questions in this examination, are supplied separately. Be certain you have a copy of these reference tables before you begin the examination.

When you have completed the examination, you must sign the statement printed at the end of the answer sheet, indicating that you had no unlawful knowledge of the questions or answers prior to the examination and that you have neither given nor received assistance in answering any of the questions during the examination. Your answer sheet cannot be accepted if you fail to sign this declaration.

DO NOT OPEN THIS EXAMINATION BOOKLET UNTIL THE SIGNAL IS GIVEN

Part I

Answer all 55 questions in this part. [55]

Directions (1-55): For *each* statement or question, select the word or expression that, of those given, best completes the statement or answers the question. Record your answer on the separate answer sheet in accordance with the directions on the front page of this booklet.

1 Scientists often use classification systems in order to
1 extend their powers of observation
2 organize their observations in a meaningful way
3 make direct comparisons with standard units of measurement
4 make more accurate interpretations

2 As shown below, an empty 1,000.-milliliter container has a mass of 250.0 grams. When filled with a liquid, the container and the liquid have a combined mass of 1,300. grams.

EMPTY
Mass = 250.0 g

FILLED
Mass = 1300. g
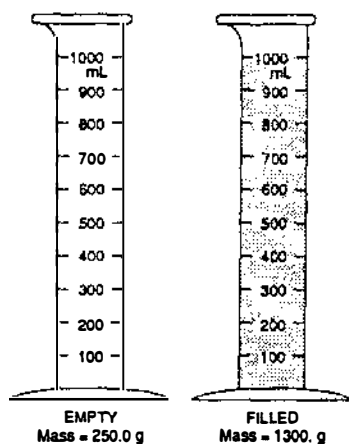
What is the density of the liquid? [Refer to the *Earth Science Reference Tables*.]
(1) 1.00 g/mL   (3) 1.30 g/mL
(2) 1.05 g/mL   (4) 0.95 g/mL

3 A student observed a freshly dug hole in the ground and recorded statements about the sediments at the bottom of the hole. Which statement is an inference?
1 The hole is 2 meters deep.
2 Some of the particles are rounded.
3 The sediments were deposited by a stream.
4 Over 50% of the sediments are the size of sand grains or smaller.

4 Which diagram illustrates the process that best cleans the atmosphere?
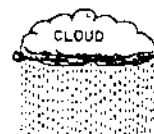
5 How does the position of Polaris appear to change as an observer travels due north from the Equator?
1 The angle of Polaris above the northern horizon decreases.
2 The angle of Polaris above the northern horizon increases.
3 Polaris appears to move westward.
4 Polaris appears to move eastward.

6 According to the *Earth Science Reference Tables*, as altitude within the troposphere increases, the amount of water vapor generally
1 decreases, only
2 increases, only
3 remains the same
4 decreases, then increases

7 In an activity to determine the circumference of a globe, a student used the equipment shown in the diagram below.
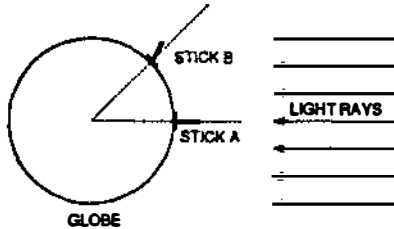
What is the most probable source of error?
1 Stick A is pointed directly into the light.
2 The distance between the sticks is too small.
3 The light rays are not bright enough.
4 Stick B does not make a 90° angle with the surface of the globe.

8 The polar circumference of the Earth is 40,008 kilometers. What is the equatorial circumference?
(1) 12,740 km   (3) 40,008 km
(2) 25,000 km   (4) 40,076 km

9 In the diagram below, the arrows represent the paths of moving fluids on the surface of the Earth.
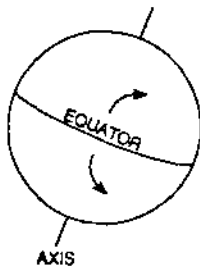
Which statement best explains why the fluid is deflected?
1 The Earth is rotating on its axis.
2 The axis of the Earth is tilted.
3 The Earth is revolving around the Sun.
4 The Earth is moving away from the Sun,

10 Diagrams A through D below represent phases of a planet as seen by an observer on Earth using a telescope. The diagram is drawn to scale.
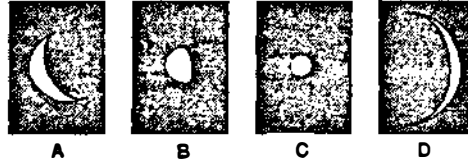
Which is the most logical conclusion about this planet?
1 The planet has a slower orbital velocity than the Earth.
2 The planet is closest to the Earth at position C.
3 The apparent diameter of the planet varies throughout the year.
4 The planet does not rotate on its axis.

11 The day and the year, as units of time, are based upon motions of
1 the Earth   3 the Sun
2 the Moon   4 distant stars

12 Which type of surface would most likely be the best reflector of electromagnetic energy?
1 dark-colored and rough
2 dark-colored and smooth
3 light-colored and rough
4 light-colored and smooth

13 The diagram below shows a container of water that is being heated.
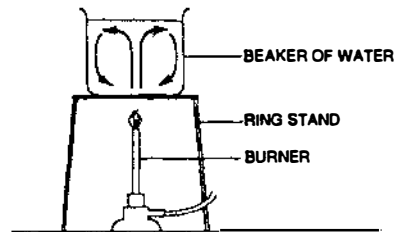
The movement of water shown by the arrows is most likely caused by
1 density differences
2 insolation
3 the Coriolis effect
4 the Earth's rotation

14 The diagram below represents four positions of the Earth as it revolves around the Sun.
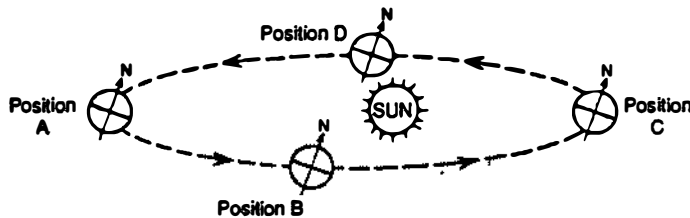
(NOT DRAWN TO SCALE)

At which position is the Earth located on December 21?
(1) A
(2) B
(3) C
(4) D

15 Which process requires the addition of energy to water?
1 freezing of water
2 cooling of water
3 vaporization of water
4 condensation of water

16 Most of the energy in the Earth's atmosphere comes from
1 the rotation and revolution of the Earth
2 the rotation of the Earth and wind from the Earth
3 radioactive decay of elements and radiation from the Earth
4 radiation from the Earth and insolation from the Sun

17 According to the *Earth Science Reference Tables*, what is the air temperature shown on the station model below?

70 ⬛ 021
8 +8
50
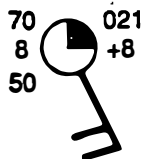
(1) 8°F
(2) 21°F
(3) 50°F
(4) 70°F

18 On which date does the maximum duration of insolation occur in the Northern Hemisphere?
1 March 21
2 June 21
3 September 23
4 December 21

19 According to the *Earth Science Reference Tables*, if the dewpoint temperature is −10°C, the saturated vapor pressure will be
(1) 1.4 mb
(2) 2.6 mb
(3) 10.0 mb
(4) 12.2 mb

20 The rate of evaporation from the surface of a lake would be increased by
1 a decrease in wind velocity
2 a decrease in the amount of insolation
3 an increase in the surface area of the lake
4 an increase in the moisture content of the air

21 Which event will most likely occur in rising air?
1 clearing skies
2 cloud formation
3 decreasing relative humidity
4 increasing temperature

22 The air temperature is 10°C. Which dewpoint temperature would result in the highest probability of precipitation?
(1) 8°C
(2) 6°C
(3) 0°C
(4) −4°C

23 The graph below shows the average temperature of the Earth during the past 250,000 years and the beginning and end of the most recent glacial and interglacial stages.
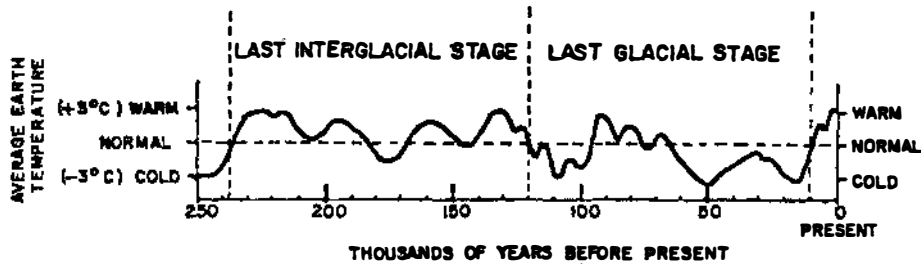
According to the graph, the duration of the last glacial stage was from
(1) 250,000 years ago to 240,000 years ago
(2) 240,000 years ago to 120,000 years ago
(3) 120,000 years ago to 10,000 years ago
(4) 10,000 years ago to the present

24 Which map best represents the normal air circulation around a high-pressure air mass located over central New York State?
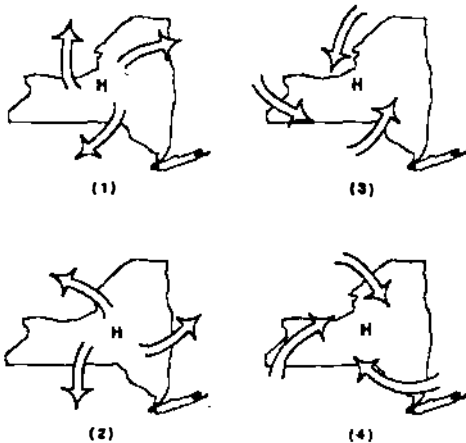
25 Most infiltration of precipitation will occur when the Earth's soil is
1 unsaturated and impermeable
2 unsaturated and permeable
3 saturated and impermeable
4 saturated and permeable

26 The diagram below represents several locations on the surface of the Earth. Each location is at sea level and is surrounded by ocean water.
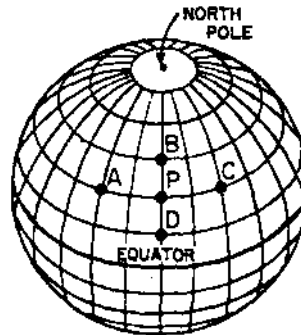
The average annual air temperature at point P is most likely higher than the average annual air temperature at point
(1) A
(2) B
(3) C
(4) D

27 For which movement of earth materials is gravity not the main force?
1 sediments flowing in a river
2 boulders carried by a glacier
3 snow tumbling in an avalanche
4 moisture evaporating from an ocean

28 The map below shows the general path of ocean currents in a portion of the Northern Hemisphere. Locations A, B, C, and D are at the shoreline.

Key
— — ▶COLD OCEAN CURRENT
————▶WARM OCEAN CURRENT

NORTH
↑
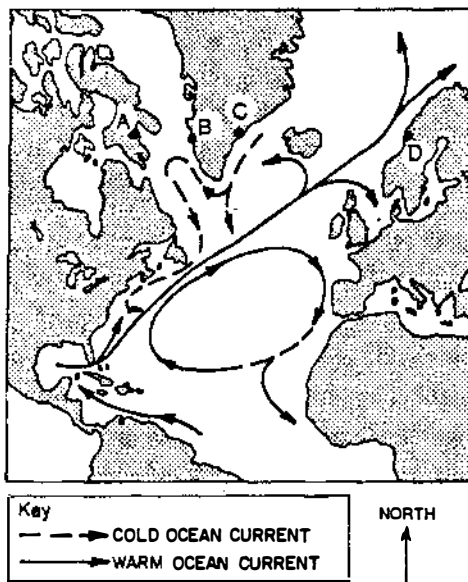
Which location most likely has the warmest climate?
(1) A   (3) C
(2) B   (4) D

29 Particles of soil often differ greatly from the underlying bedrock in color, mineral composition, and organic content. Which conclusion about these soil particles is best made from this evidence?
1 They are residual sediments.
2 They are transported sediments.
3 They are uniformly large-grained.
4 They are soluble in water.

30 Which change in the climate of New York State would most likely cause the greatest increase in chemical weathering of local bedrock?
1 lower temperature in winter
2 lower humidity in winter
3 higher atmospheric pressure in summer
4 greater precipitation in summer

31 The diagram below shows the positions of the cities of Seattle and Spokane, Washington. Both cities are located at approximately 48° North latitude, and they are separated by the Cascade Mountains.
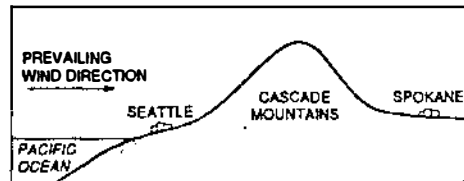
How does the climate of Seattle compare with the climate of Spokane?
1 Seattle — hot and dry
  Spokane — cool and humid
2 Seattle — hot and humid
  Spokane — cool and dry
3 Seattle — cool and humid
  Spokane — warm and dry
4 Seattle — cool and dry
  Spokane — warm and humid

32 Which graph best represents the relationship between stream erosion and the kinetic energy of a stream?
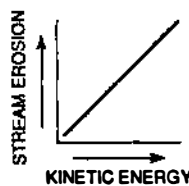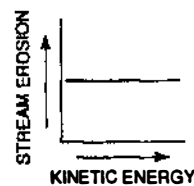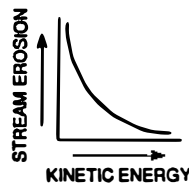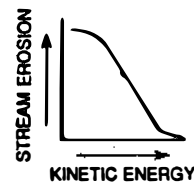
33 The diagram below represents a vertical cross section of sediments deposited in a stream.
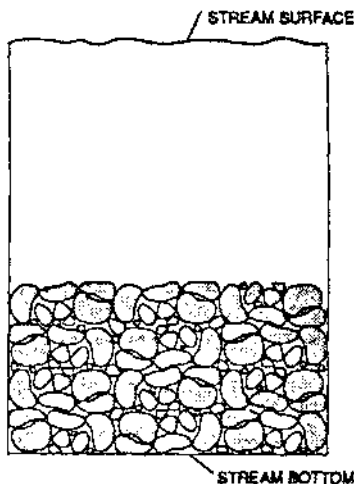
Which statement best explains the mixture of sediments?
1 The velocity of the stream continually decreased.
2 The stream discharge continually decreased.
3 The particles have different densities.
4 Smaller particles settle more slowly than larger particles.

34 According to the *Earth Science Reference Tables*, what are the four most abundant elements, by volume, in the Earth's crust?
1 oxygen, potassium, sodium, and calcium
2 hydrogen, oxygen, nitrogen, and potassium
3 aluminum, iron, silicon, and magnesium
4 aluminum, calcium, hydrogen, and iron

35 A river carrying pebbles, sand, silt, and clay flows into the ocean. The sediments are sorted by size as they are deposited at different distances from shore. Which sedimentary rock will most likely form from the sediment deposited farthest from shore? [Refer to the *Earth Science Reference Tables*.]
1 conglomerate   3 siltstone
2 sandstone   4 shale

36 According to the *Earth Science Reference Tables*, which sedimentary rock is composed of fragmented skeletons and shells of sea organisms compacted and cemented together?
1 shale   3 sandstone
2 limestone   4 gypsum

37 Sand collected at a beach contains a mixture of pyroxene, olivine, amphibole, and plagioclase feldspar. According to the *Earth Science Reference Tables*, the rock from which this mixture of sand came is best described as
1 dark-colored with a mafic composition
2 dark-colored with a felsic composition
3 light-colored with a mafic composition
4 light-colored with a felsic composition

38 The diagram below represents a conglomerate rock. Some of the rock particles are labeled.
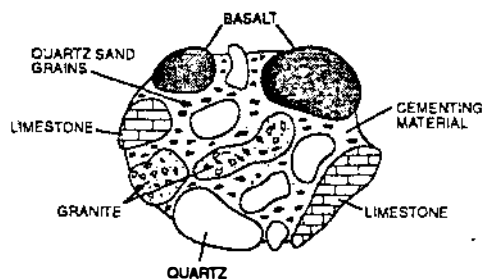
Which conclusion is best made about the rock particles?
1 They are the same age.
2 They originated from a larger mass of igneous rock.
3 They all contain the same minerals.
4 They have different origins.

39 According to the *Earth Science Reference Tables*, at 4,500 kilometers below the surface of the Earth, the pressure is estimated to be
(1) 1.4 million atmospheres
(2) 2.0 million atmospheres
(3) 2.8 million atmospheres
(4) 3.1 million atmospheres

40 The diagram below shows one side of an oceanic ridge and a portion of the ocean floor.

KEY

OCEANIC CRUST (BASALT)

MANTLE

DIRECTION OF PLATE MOVEMENT
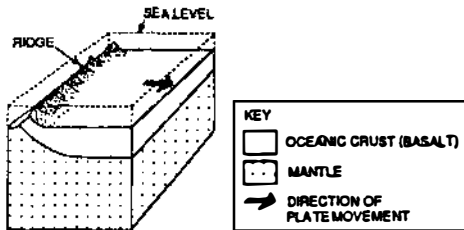
Which graph best illustrates the age of the basalt as the distance from an oceanic ridge increases?

(1)

(3)

(2)

(4)
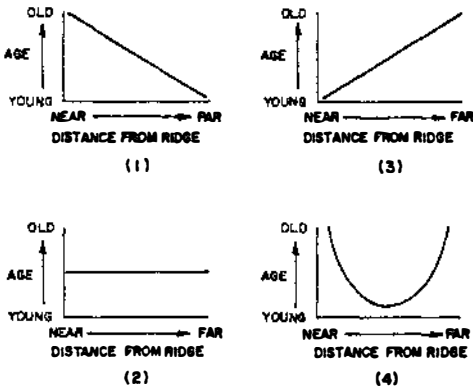
41 The diagrams below show cross sections of exposed bedrock. Which cross section shows the *least* evidence of crustal movement?

(1)

(3)

(2)

(4)
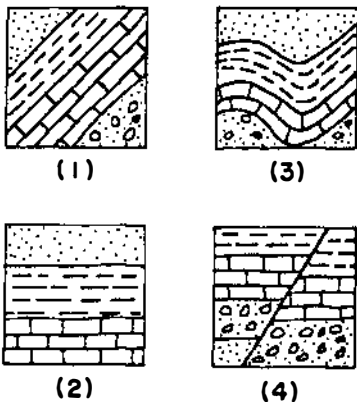
42 An igneous rock contains large mineral crystals. The best conclusion to make about this rock is that it
1 contains plagioclase and pyroxene
2 is felsic and has a low density
3 once contained small crystals which eroded
4 cooled slowly as it formed

43 According to the *Earth Science Reference Tables*, a comparison of the bedrock at Syracuse, New York, with the bedrock at Massena, New York, best supports the observation that
1 no fossils are found in the bedrock of these areas
2 both areas have sedimentary bedrock of the same age
3 both areas have sedimentary bedrock, but the bedrock at Syracuse is younger
4 the bedrock at Massena contains salt and gypsum, but the bedrock at Syracuse does not

44 The best evidence of crustal movement would be provided by
1 dinosaur tracks found in the surface bedrock
2 marine fossils found on a mountaintop
3 weathered bedrock found at the bottom of a cliff
4 ripple marks found in sandy sediment

45 Trilobite fossils from different time periods show small changes in appearance. These observations suggest that the changes may be the result of
1 evolutionary development
2 a variety of geologic processes
3 periods of destruction of the geologic record
4 the gradual disintegration of radioactive substances

46 Why are ancient volcanic ash deposits important to geologists?
1 They are easily dated using carbon-14.
2 They form resistant rock layers containing fossils.
3 They indicate areas where major earthquakes occurred.
4 They serve as good geologic time markers.

47 The diagram below represents a cross section of a portion of the Earth's crust.
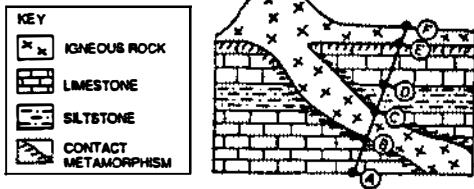
Which graph best indicates the relative age of the rock units along line *AF*?
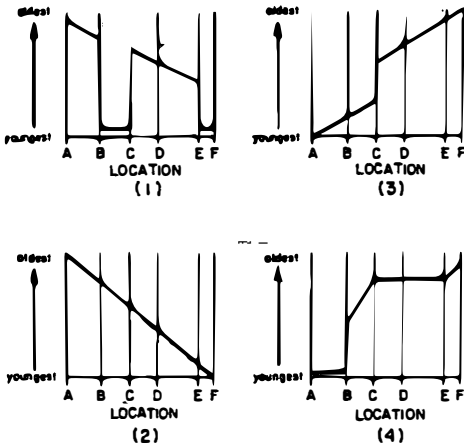
48 Which radioactive substance shown on the graph below has the longest half-life?
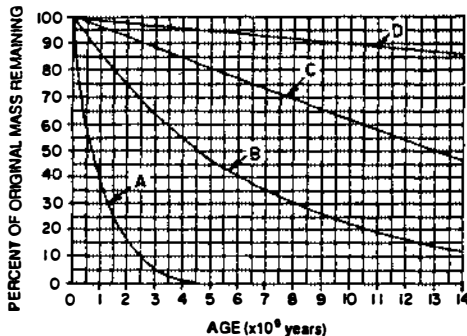
(1) *A* (3) *C*
(2) *B* (4) *D*

49 According to the *Earth Science Reference Tables*, near the end of which era did the dinosaurs become extinct?
1 Precambrian 3 Mesozoic
2 Paleozoic 4 Cenozoic

50 According to the *Earth Science Reference Tables*, the surface bedrock of the Tug Hill Plateau is composed primarily of
1 sedimentary rocks of Devonian age
2 sedimentary rocks of Ordovician age
3 igneous rocks of Cambrian age
4 intensely metamorphosed rocks of Middle Proterozoic age

51 Which characteristic of a landscape is usually the most difficult to observe?
1 gradient of a stream 3 profile of the land
2 type of soil 4 rate of erosion

52 The diagram below shows a geologic cross section of the rock layers in the vicinity of Niagara Falls in western New York State.
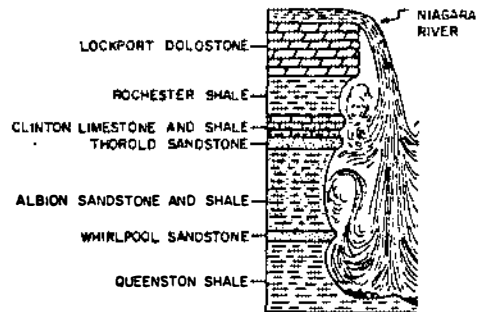
Which statement best explains the irregular shape of the rock face behind the falls?
1 The Lockport dolostone is an evaporite.
2 The Clinton limestone and shale contain many fossils.
3 The Thorold sandstone and the whirlpool sandstone dissolve easily in water.
4 The Rochester and Queenston shale and the Albion sandstone and shale are less resistant to erosion than the other rock layers.

53 The diagram below represents a surface stream drainage pattern.
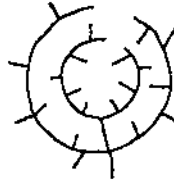
Which geologic cross section represents a landscape region most likely to produce this drainage pattern?
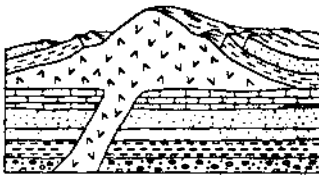
(1)
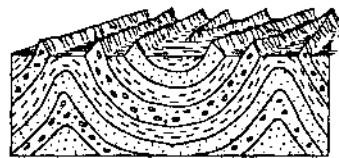
(3)

(2)
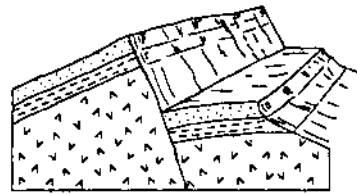
(4)

54 The well-defined boundaries of New York State's several distinct landscape regions are based on
1 differences in bedrock composition and structure
2 extreme differences in climate
3 varieties of vegetation
4 rate of sediment deposition

55 The process of developing and implementing environmental conservation programs is most dependent on
1 the availability of the most advanced technology
2 the Earth's ability to restore itself
3 public awareness and cooperation
4 stricter environmental laws

Part II

This part consists of ten groups, each containing five questions. Choose seven of these ten groups. Be sure that you answer all five questions in each group chosen. Record the answers to these questions on the separate answer sheet in accordance with the directions on the front page of this booklet.   [35]

Group 1

If you choose this group, be sure to answer questions 56–60.

Base your answers to questions 56 through 60 on your knowledge of earth science, the *Earth Science Reference Tables*, and the diagram below. The diagram shows equal masses of four different earth materials at different temperatures.

GRANITE
Temperature = 10.°C

IRON
Temperature = 20.°C

WATER
Temperature = 30.°C

DRY AIR
Temperature = 40.°C

Mass = 10. g
Volume = 3.7 mL

Mass = 10. g
Volume = 1.3 mL

Mass = 10. g
Volume = 10. mL

Mass = 10. g
Volume = 8,300 mL
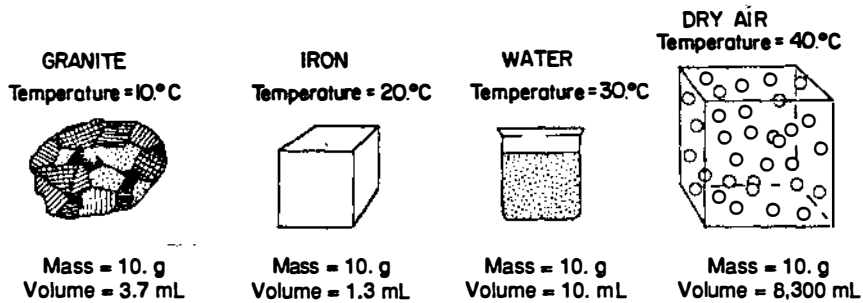
(not to scale)

56 How much heat is needed to raise the temperature of the iron sample to 30.°C?
 (1) 11 cal   (3) 30. cal
 (2) 22 cal   (4) 33 cal

57 If 100 calories of heat is added to each sample, the *smallest* change in temperature will occur in the
 1 granite   3 water
 2 iron   4 dry air

58 Which statement best describes the relationship between a heat sink and a heat source if the samples are placed in contact with each other?
 1 The water will be a heat sink for the iron.
 2 The iron will be a heat sink for the granite.
 3 The granite will be a heat source for the dry air.
 4 The dry air will be a heat source for the water.

59 Convection currents may be produced most easily in the samples of
 1 water and dry air   3 granite and iron
 2 water and granite   4 iron and dry air

60 Which material has the greatest density?
 1 water   3 granite
 2 iron   4 dry air

Group 2

If you choose this group, be sure to answer questions 61–65.

Base your answers to questions 61 through 65 on the maps below and on the next page, the *Earth Science Reference Tables*, and your knowledge of earth science. Figure 1 represents a topographic map of a landscape region. Contour lines show elevations in meters. Figure 2 represents the generalized bedrock geology map of the same region. Points A through J represent the same locations on both maps.
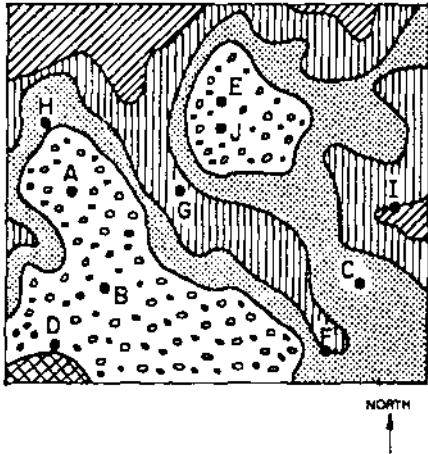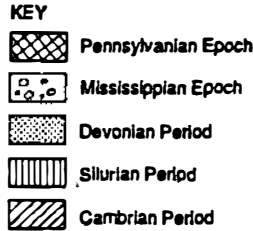
FIGURE 1 - TOPOGRAPHIC MAP

FIGURE 1 SCALE
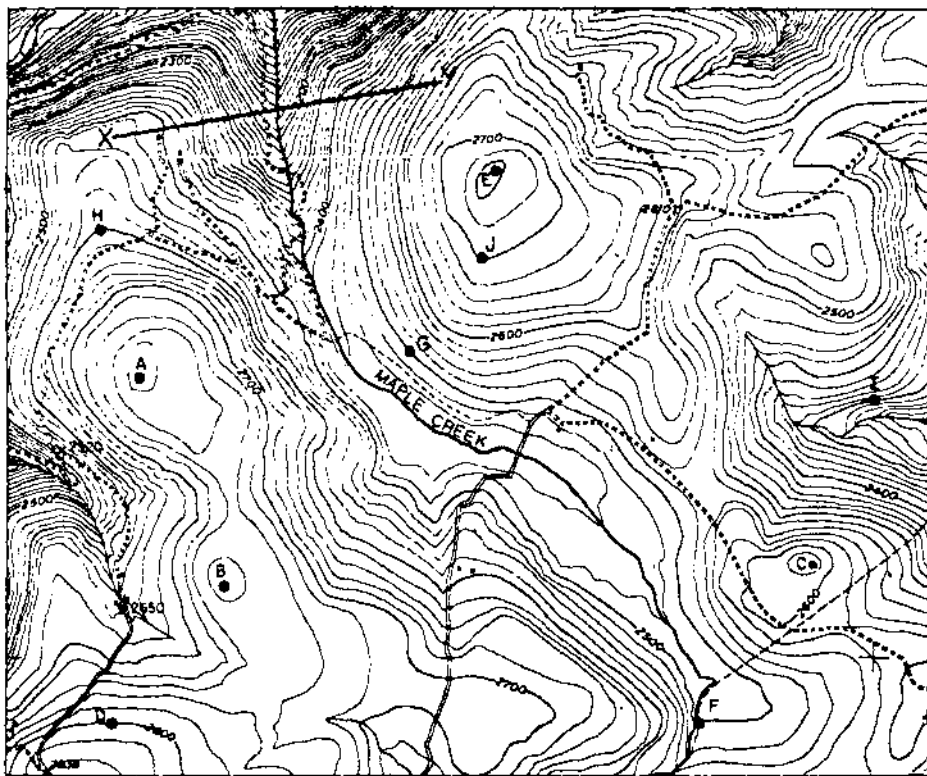
NORTH

FIGURE 2 - BEDROCK GEOLOGY MAP

KEY

⊠ Pennsylvanian Epoch

▫ Mississippian Epoch

░ Devonian Period

▥ Silurian Period

▨ Cambrian Period

NORTH

61 Which of these locations has the highest elevation on the topographic map (figure 1)?
(1) A   (3) C
(2) B   (4) D

62 Toward which general direction does Maple Creek flow?
1 northwest   3 southeast
2 northeast   4 southwest

63 Which two locations are most likely to have fossilized seed ferns in their surface bedrock?
(1) A and F   (3) C and G
(2) B and E   (4) H and I

64 Which formula should be used to find the gradient of the hillslope from point J to point G?

1 gradient $= \dfrac{(2700\ m - 2500\ m)}{0.48\ km}$

2 gradient $= \dfrac{(2700\ m + 2500\ m)}{0.48\ km}$

3 gradient $= \dfrac{0.48\ km}{(2700\ m - 2500\ m)}$

4 gradient $= \dfrac{0.48\ km}{(2700\ m + 2500\ m)}$

65 Which diagram best represents the elevation profile along the straight line between points X and Y?

(1)

(2)

(3)

(4)
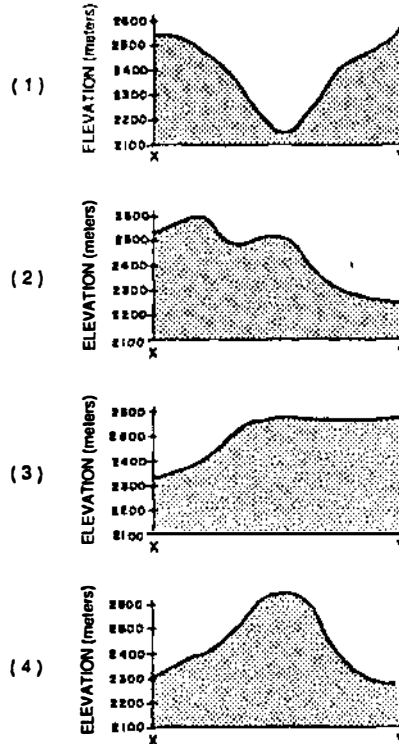
Group 3

If you choose this group, be sure to answer questions 66–70.

Base your answers to questions 66 through 70 on your knowledge of earth science and the satellite photograph below. In the satellite photograph, a tropical storm (white cloud swirl) is centered in the Gulf of Mexico. An outline of the southeastern United States and the latitude-longitude system have been drawn on the photograph.
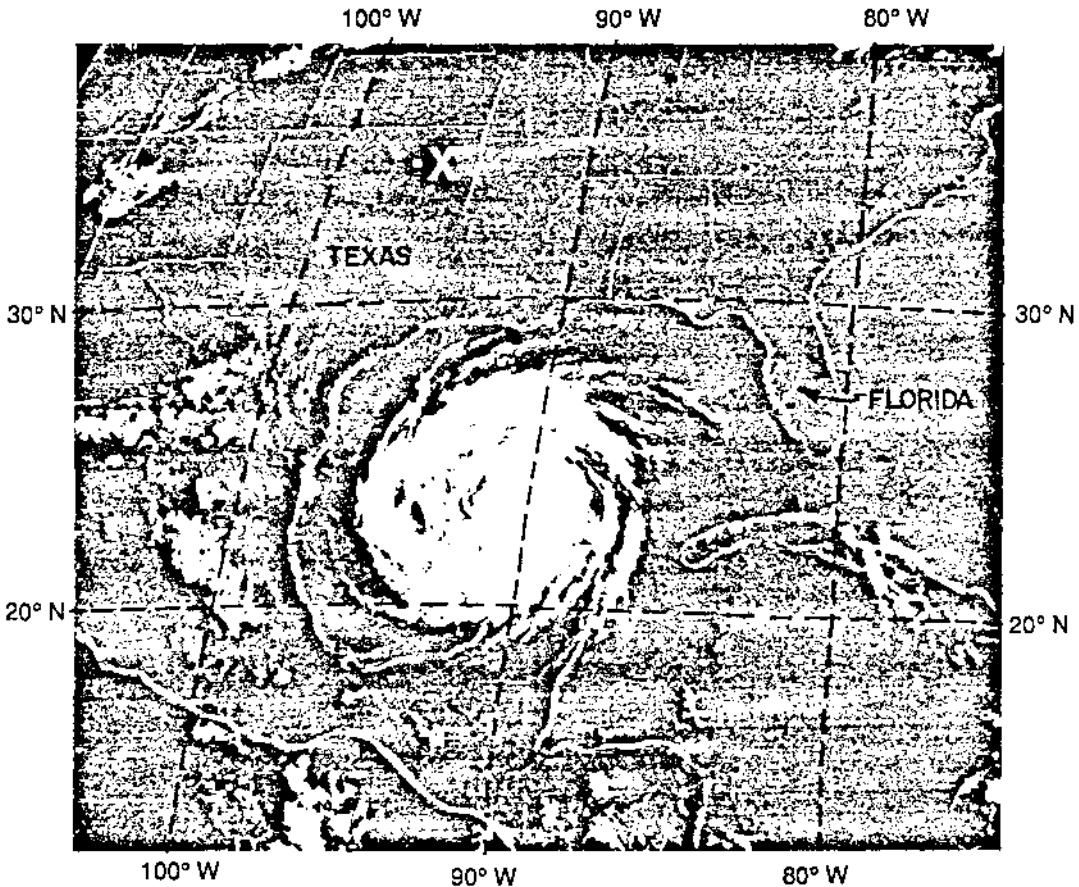

66 The center or eye of the tropical storm on the satellite photograph is closest to
(1) 25° N, 88° W　　(3) 24° N, 91° W
(2) 91° N, 24° W　　(4) 88° N, 25° W

67 What type of air mass would most likely be associated with the storm in the satellite photograph?
1 warm and moist　　3 cold and moist
2 warm and dry　　4 cold and dry

68 Which map best represents the surface air-pressure field of this tropical storm? [The solid lines represent isobars.]

(1)

(3)

(2)

(4)
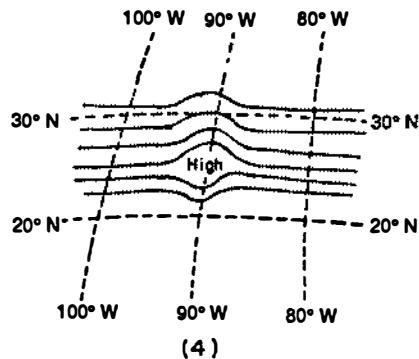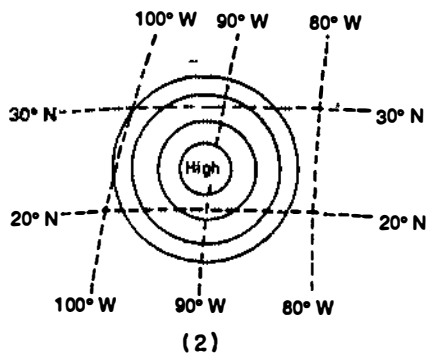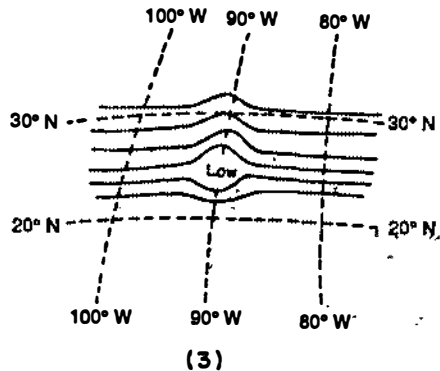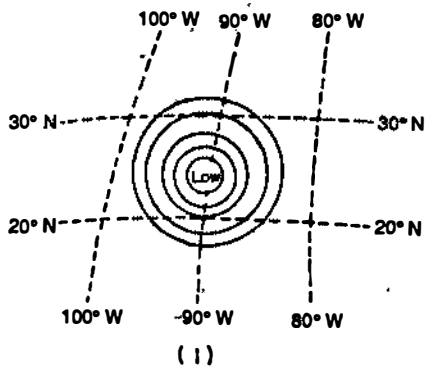
69 At the time this photograph was taken, the weather conditions at point X could be described as

1 partial cloud cover with scattered precipitation

2 heavy precipitation associated with the storm

3 heavy cloud cover but no precipitation

4 clear skies and sunny

70 What is the primary source of moisture for this storm?

1 transpiration from tropical jungles

2 evaporation of ocean water

3 evaporation of river water

4 melting of southern glaciers

Group 4

If you choose this group, be sure to answer questions 71–75.

Base your answers to questions 71 through 75 on your knowledge of earth science and the water budget data and climate classification chart below. The water budget data are for a location in the south central United States. The values shown are in millimeters of water.

WATER BUDGET DATA

Month	J	F	M	A	M	J	J	A	S	O	N	D	Yearly Totals
Precipitation (P)	125	102	118	128	127	94	85	84	80	72	104	104	1223
Potential Evapo-transpiration (E_p)	8	10	31	65	112	151	176	160	114	64	23	10	924
$P - E_p$	117	92	87	63	15	-57	-91	-76	-34	8	81	94	—
Changes in Storage ($\triangle St$)	0	0	0	0	0	-57	-43	0	0	8	81	11	—
Storage (St)	100	100	100	100	100	43	0	0	0	8	89	100	—
Actual Evapo-transpiration (E_a)	8	10	31	65	112	151	128	84	80	64	23	10	766
Deficit (D)	0	0	0	0	.0	0	48	76	34	0	0	0	158
Surplus (S)	117	92	87	63	15	0	0	0	0	0	0	83	457

CLIMATE CLASSIFICATION CHART

Climate Type	Total Yearly P/E_p Ratio
Humid	Greater than 1.2
Subhumid	0.8 to 1.2
Semiarid	0.4 to 0.8
Arid	Less than 0.4

71 During which month is soil moisture recharge taking place?
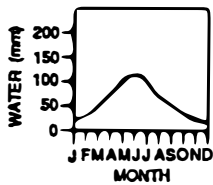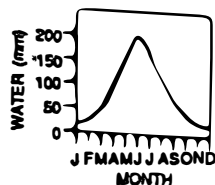 1 February   3 September
  2 June   4 November

72 A deficit occurs during the summer because the soil moisture storage is
(1) 100 mm and P is greater than E_p
(2) 100 mm and E_p is greater than P
(3) 0 mm and P is greater than E_p
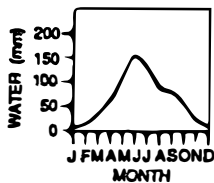(4) 0 mm and E_p is greater than P

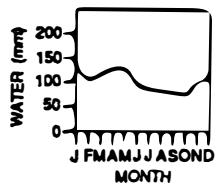73 Which graph best represents the actual evapo-transpiration (E_a) for this location?

(1)

(3)

(2)

(4)

74 The potential evapotranspiration (E_p) of this area depends primarily on the
1 amount of precipitation
2 average air temperature
3 storage capacity of the soil
4 amount of actual evapotranspiration

75 According to the climate classification chart, the climate of this location is
1 humid   3 semiarid
2 subhumid   4 arid

Group 5

If you choose this group, be sure to answer questions 76–80.

Base your answers to questions 76 through 80 on your knowledge of earth science and the *Earth Science Reference Tables.*

76 What is the dewpoint temperature when the air temperature is 19°C and the wet-bulb temperature is 13°C?
(1) 25°C   (3) 8°C
(2) 13°C   (4) 6°C

77 A student's measurement of the mass of a rock is 30 grams. If the accepted value for the mass of the rock is 33 grams, what is the percent deviation (percent of error) of the student's measurement?
(1) 9%   (3) 30%
(2) 11%   (4) 91%

78 At which temperature could water vapor in the atmosphere change directly into solid ice crystals?
(1) 20°F   (3) 10°C
(2) 40°F   (4) 100°C

79 What is the half-life of carbon-14?
(1) 5.6 years   (3) 5,600 years
(2) 560 years   (4) 5,600,000 years

80 An air pressure of 1023 millibars is equal to how many inches of mercury?
(1) 30.10   (3) 30.19
(2) 30.15   (4) 30.21

Group 7

If you choose this group, be sure to answer questions 86–90.

Base your answers to questions 86 through 90 on your knowledge of earth science, the *Earth Science Reference Tables*, and the bar graphs below. The graphs show the percentages by volume of the sediment sizes that are found in four different sediment deposits, *A, B, C,* and *D*.

DEPOSIT A

DEPOSIT C
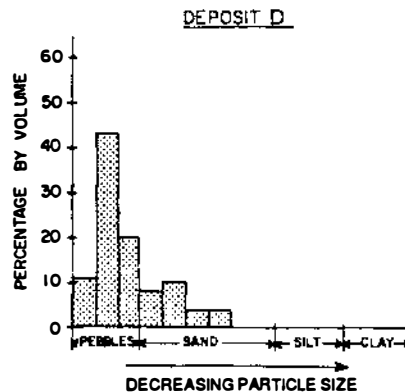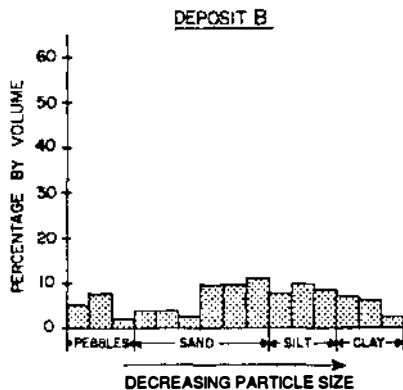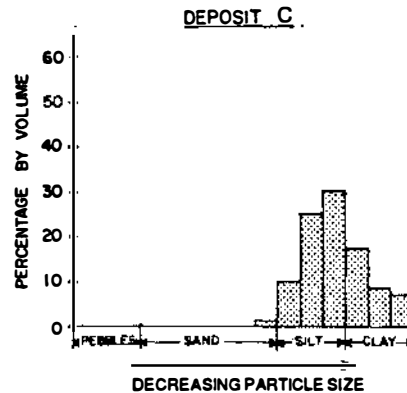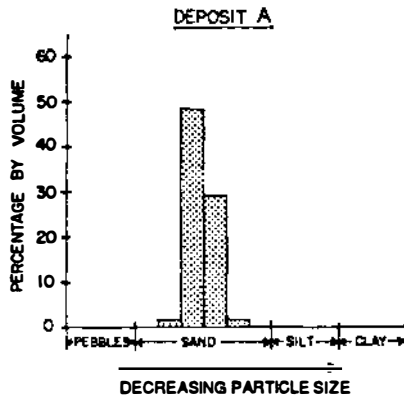
DEPOSIT B

DEPOSIT D

86 What is the total percentage of silt in deposit *B*?
 (1) 5%
 (2) 9%
 (3) 27%
 (4) 48%

87 What was the most probable agent of erosion that deposited the unsorted sediments in deposit *B*?
 1 a stream
 2 a glacier
 3 wind
 4 ocean waves

88 Which deposits contain particles 0.001 centimeter in diameter?
 (1) *A* and *B*
 (2) *A* and *D*
 (3) *B* and *C*
 (4) *C* and *D*

89 Which deposit contains the highest percentage of sediments that would stay in suspension for the longest time before settling?
 1 deposit *A*
 2 deposit *B*
 3 deposit *C*
 4 deposit *D*

90 By which processes could these sediment deposits become sedimentary rocks?
 1 compaction and cementation
 2 erosion and deposition
 3 melting and solidification
 4 pressure and recrystallization

Group 8

If you choose this group, be sure to answer questions 91–95.

Base your answers to questions 91 through 95 on your knowledge of earth science, the *Earth Science Reference Tables*, and the table of minerals below. The table shows the physical properties of nine minerals.

Mineral	Color	Luster	Streak	Hardness	Density (g/mL)	Chemical Composition
biotite mica	black	glassy	white	soft	2.8	$K(Mg,Fe)_3(AlSi_3O_{10})(OH_2)$
diamond	varies	glassy	colorless	hard	3.5	C
galena	gray	metallic	gray-black	soft	7.5	PbS
graphite	black	dull	black	soft	2.3	C
kaolinite	white	earthy	white	soft	2.6	$Al_4(Si_4O_{10})(OH)_8$
magnetite	black	metallic	black	hard	5.2	Fe_3O_4
olivine	green	glassy	white	hard	3.4	$(Fe,Mg)_2SiO_4$
pyrite	brass yellow	metallic	greenish-black	hard	5.0	FeS_2
quartz	varies	glassy	colorless	hard	2.7	SiO_2

Definitions

Luster: the way a mineral's surface reflects light
Streak: color of a powdered form of the mineral
Hardness: resistance of a mineral to being scratched
(soft — easily scratched; hard — not easily scratched)

Chemical Symbols

Al	— Aluminum	Pb	— Lead
C	— Carbon	Si	— Silicon
Fe	— Iron	K	— Potassium
H	— Hydrogen	S	— Sulfur
Mg	— Magnesium		
O	— Oxygen		

91 Which mineral has a different color in its powdered form than in its original form?
1 pyrite 3 kaolinite
2 graphite 4 magnetite

92 Which mineral contains iron, has a metallic luster, is hard, and has the same color and streak?
1 biotite mica 3 kaolinite
2 galena 4 magnetite

93 Which mineral is commonly found in granite?
1 quartz 3 magnetite
2 olivine 4 galena

94 Why do diamond and graphite have different physical properties, even though they are both composed entirely of the element carbon?
1 Only diamond contains radioactive carbon.
2 Only graphite consists of organic material.
3 The minerals have different arrangements of carbon atoms.
4 The minerals have undergone different amounts of weathering.

95 Which mineral would most likely be weathered most after being placed in a container and shaken for 10 minutes?
1 pyrite 3 magnetite
2 quartz 4 kaolinite

Group 9

**If you choose this group, be sure to answer questions 96–100.**

Base your answers to questions 96 through 100 on your knowledge of earth science, the Earth Science Reference Tables, and the map below. The map shows three circles used to locate an earthquake epicenter. Five lettered locations, A, B, C, D, and E, are shown as reference points. Epicenter distances from three locations are represented by r_1, r_2, and r_3.

SCALE   NORTH

0   1   2   3

$\times 10^3$ KILOMETERS
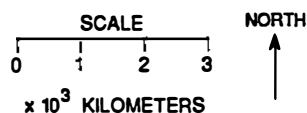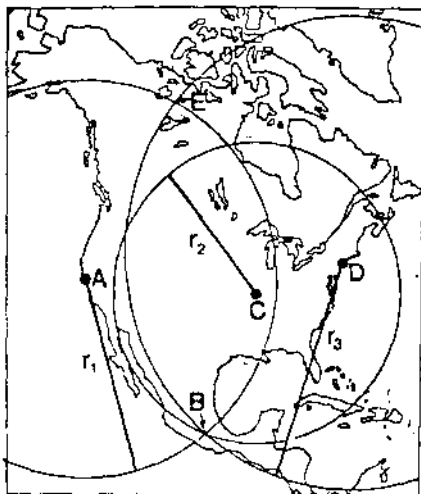
96 At which location was the difference in time of arrival of P-waves and S-waves greatest?
  (1) A   (3) C
  (2) B   (4) D

97 At which location could the seismogram below have been recorded?

P-waves   S-waves

10:12:00   10:15:40
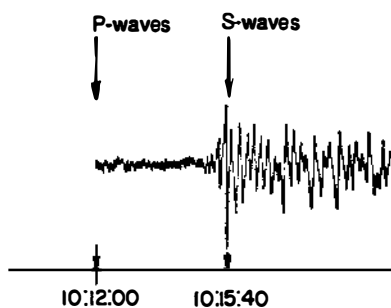
  (1) A   (3) C
  (2) B   (4) D

98 The earthquake epicenter is located at point
  (1) A   (3) C
  (2) B   (4) E

99 Location D is about 3,500 kilometers from the epicenter. What was the S-wave travel time to location D?
  (1) 5 minutes 10 seconds
  (2) 6 minutes 20 seconds
 (3) 7 minutes 40 seconds
  (4) 11 minutes 30 seconds

100 On another day, location A records the arrival of compression waves (P-waves), but not shear waves (S-waves), from a distant earthquake. Which statement best explains why shear waves were not received?
  1 Shear waves are not transmitted through the Earth's outer core.
  2 Shear waves are stopped by the iron and nickel inner core.
  3 Shear waves are transmitted through all parts of the Earth.
  4 Shear waves are faster than compression waves.

Group 10

If you choose this group, be sure to answer questions 101-105.

Base your answers to questions 101 through 105 on your knowledge of earth science, the *Earth Science Reference Tables*, and the diagrams below. The diagrams show cross sections of the Earth's crust at four widely scattered locations, *A* through *D*. Numbers 1 through 10 represent fossils located in the rock layers. (The numbers do *not* represent the relative ages of the fossils.) The rock layers have not been overturned.
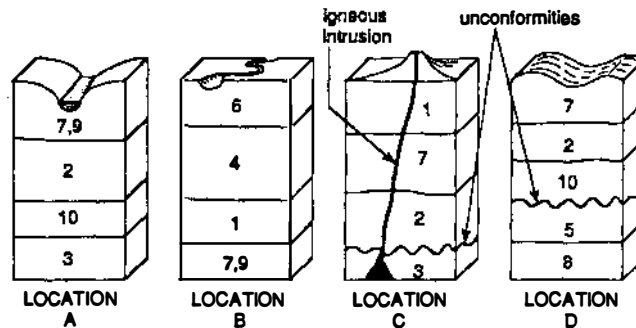
101 What is the most likely cause of the unconformities at locations *C* and *D*?
1 volcanic activity   3 faulting
2 human activity   4 uplift and erosion

102 Which location most likely contains the youngest fossil?
(1) *A*   (3) *C*
(2) *B*   (4) *D*

103 What is the relative age of the igneous intrusion at location *C*?
1 younger than the layer containing fossil 10
2 older than the layer containing fossil 7
3 the same age as the layer containing fossil 1
4 the same age as the layer containing fossil 9

104 Index fossils such as 7 are useful for correlating rocks because the fossils
1 are found only in sedimentary rocks
2 contain radioactive carbon-14, which is used for relative dating
3 represent organisms that lived for a relatively short period of geologic time in widespread areas
4 represent organisms that lived close to the Earth's surface for a relatively long period of time

105 Fossil 8 represents the earliest fish. How many millions of years ago was the rock layer containing this fossil probably formed?
(1) 560   (3) 300
(2) 450   (4) 275