

Findings Appendix 4: CSTEED Evaluation of STC/MS, Phase II

EVALUATION OF THE SCIENCE AND TECHNOLOGY CONCEPTS FOR MIDDLE SCHOOLS (STC/MS) PROGRAM, PHASE II

Prepared by

Stuart S. Yeh
Joseph J. Pedulla

With the assistance of Helena Miranda, James Cheng, and Aleta Estrada

Center for the Study of Testing, Evaluation, and Educational Policy
Boston College
Chestnut Hill, MA 02467

January, 2002

EXECUTIVE SUMMARY

This evaluation was conducted to assess student achievement in the Science and Technology Concepts for Middle Schools (STC/MS) program and the effectiveness of four instructional units developed by the National Science Resources Center (NSRC). The units included four key areas: 1. Earth in Space, 2. Electrical Energy and Circuit Design, 3. Light, and 4. Organisms. To determine the impact of the science curriculum units on student achievement in each specific content area, the Center for the Study of Testing, Evaluation and Educational Policy (CSTEED) developed a test for each unit. All of the tests included multiple-choice and short answer items that measured concepts specific to each unit.

To determine the effectiveness of a unit, the appropriate test was administered to two groups of comparable students following instruction. One student group received the inquiry-based instruction from the unit (the treatment group) while the other group did not (the control group). The sample for each unit varied but consisted of a minimum of 488 students in the treatment group and 74 students in the control group.

The posttest only evaluation design allowed for comparisons of student performance between treatment and control groups for each of the four units. Also, since most of the items used in constructing the tests were taken from previously existing assessments (TIMSS and NAEP), comparisons to international and/or national groups were possible.

The test results indicated that all four units were more effective in teaching science and technology concepts, compared to the more conventional forms of instruction in these areas; that is, the treatment groups outperformed the control groups for all four units. Consistent, statistically significant differences provided evidence to support the contention that the four curriculum units were more effective in teaching the scientific concepts assessed than were the more traditional instructional approaches employed with the control groups. Students exposed to the STC/MS curriculum also outperformed the national and international comparison groups. Together, this pattern of results suggests that all four of the curriculum units were very effective in teaching science and technology concepts to middle school students.

It must be noted that the design employed in this evaluation was quasi-experimental, not experimental. Given this fact, there are always plausible rival explanations for any differences (or lack of differences) found between the treatment and control groups. The conclusions drawn here must be interpreted within this context. To the extent possible, the treatment and control groups were comparable in all regards except that the treatment groups received instruction utilizing the newly developed units. Students were not randomly assigned to groups, however. To the extent that other unknown differences existed between the treatment and control groups, the statements linking the units to increased student achievement are weakened.

INTRODUCTION

The STC/MS curriculum, developed by the NSRC for use with middle school students and funded by the National Science Foundation consists of eight inquiry-based curriculum units in the life, physical, and earth sciences and technology. The Phase I evaluation of four of these curriculum units was completed in June 2000. The evaluation presented here reports findings regarding Phase II, the evaluation of four additional units: *Earth in Space*, *Electrical Energy and Circuit Design*, *Light*, and *Organisms – From Macro to Micro*.

EVALUATION DESIGN

The evaluation relied on data from tests written specifically for each curriculum unit by the evaluators (Appendices A-D), a survey of student attitudes (Appendix E), and, for comparison purposes, data from the National Assessment of Educational progress (NAEP) and the Third International Mathematics and Science Study (TIMSS).

Staff at CSTEEP worked with curriculum developers at NSRC to develop tests to measure the essential scientific principles to be covered by the science units. Each unit included both multiple-choice and open-response items specific to it. The tests were administered in English only.

To the extent possible, all items, both multiple-choice and open-response, were taken from existing assessments, specifically from TIMSS, NAEP, the New York Regents' Exam, and the Discovery Science Assessment. Thus, the items selected for these assessments had previously been refined through a large-scale review, field-testing and revision process. Furthermore, since the performance of a national and/or international sample of students on individual TIMSS and NAEP items is available, we were able, on selected items, to compare the performance of students participating in the STC/MS evaluation to the performance of students nationally and/or internationally. The remaining items allowed us to compare the performance of students in the treatment groups to the performance of students in the control groups but were not designed to compare results to an external group.

National Science Resources Center

The survey of student attitudes was anonymous, the same for all units, and administered by a teacher other than the science teacher. It consisted of 20 Likert-scale items designed to measure students' attitudes and perceptions about science, and was administered after the completion of the curriculum unit. The test and student survey took approximately 50 minutes to complete.

For the purpose of evaluating the STC/MS curriculum, we identified “control” students in schools that were located near, and similar in composition to, the schools that implemented the new curriculum units. All students, both treatment and control, had been exposed to “inquiry” science instruction in the earlier grades. Students in the control sites received instruction in the area being assessed but with existing curricular materials. Thus, students in the control sites were selected to be as similar as possible to students in the treatment sites. This facilitated the inference that any differences in performance between treatment and control students could be attributed to exposure to the new curriculum units.

Each new curriculum unit was implemented in four geographically distinct cities across the United States. Thus, the field test involved 16 cities. Within each city, the evaluation design aimed to sample classrooms taught by four teachers: three teachers whose students implemented the STC/MS curriculum unit, and one teacher whose students served as controls. For various reasons unrelated to the implementation of the STC/MS curriculum, certain sites returned assessments from fewer teachers than specified in the evaluation design. For each curriculum unit, this sampling design resulted in ten to twelve treatment classes (involving between 488-1078 students) and three to four control classes (involving between 74-145 students). For the purposes of the evaluation, a random subsample was drawn from the treatment and control groups for each curriculum unit containing 75 treatment and 60 control students.

Within each of the 16 cities, a designated teacher or administrator coordinated the administration of the tests to the treatment and control classes. The cities included:

1. Bozeman, MT; Clemson, SC; Fort Bend, TX; and Spotsylvania, VA (Earth in Space unit)
2. Columbia, MO; Mesa, AZ; Providence, RI; and Yakima, WA (Electrical Energy unit)

3. El Centro, CA; Minneapolis, MN; Nashville, TN; and Pittsburgh, PA (Light unit) and
4. Eugene, OR; Green Bay, WI; Huntsville, AL; and West Windsor, NJ (Organisms unit).

The evaluation design utilized a posttest only model. The assessment, along with a survey designed to gather information regarding student attitudes towards science, was administered to all students, both treatment and control, at the conclusion of the curriculum units in Spring, 2001. Since the amount of time we asked students and teachers to devote to testing for evaluation purposes was substantial (approximately 50 minutes per student), and since we also asked students and teachers who were not involved in the STC/MS Project to do the testing, a pretest/posttest design was not feasible. Teachers, especially those at the control sites, simply would not agree to give up that much time for testing.

The posttest only model relies on the key assumption that the students in the treatment and control sites were similar in all respects except for exposure to the new curriculum units. The validity of this assumption was strengthened by deliberately selecting students in the control sites who had been taught the inquiry approach to science in the earlier grades and who were receiving science instruction in the same content as students in the treatment group. That is, we selected comparison students who were as similar as possible to the treatment students in terms of their previous and current science instruction. In addition, the selection of many of the test items from TIMSS and NAEP allowed us to compare performance for both groups to other students nationally and/or internationally. We hypothesized that students in both the treatment and control sites would do at least as well as students nationally and internationally on these items.

Scoring rubrics were developed to score the open-response test items (see Appendices F-D). Scorers did not know whether tests belonged to the experimental group or to the control

group. In addition fifteen to twenty tests were double-scored per unit in order to estimate scorer reliability. The percent agreement between raters was 87% for the Earth in Space unit, 85% for the Electrical Energy unit, 88% for the Light unit, and 82% for the Organisms unit; all of these are sufficiently high to have confidence in the scoring of these items. Students' total scores on both the open response and the multiple-choice items were analyzed and reported for each unit, comparing students in the treatment and control groups. In addition, wherever possible, we compared the performance of students in each group with the performance of students nationally and/or internationally.

The following sections of this report present the results from the testing for each of the four curriculum units. First, overall results for the total scores (both the multiple-choice and short answer items) are presented. Next, the results from the multiple-choice items alone are presented. The treatment and control students will be compared for these items. Further, each group will be compared to the national and/or international performance on the corresponding items as well. Last, the performance on the open-response items will be presented. In a similar way, the performance for treatment and control students will be compared and then the performance for each of these groups in relation to the national and/or international comparisons will also be presented.

EARTH IN SPACE UNIT

All Test Items

A total of 899 students in the treatment group and 109 in the control group took the Earth in Space test. Seventy-five tests were randomly selected from the treatment group and 60 tests were randomly selected from the control group. The Earth in Space test contained 23 multiple-choice and short answer items specific to content related to astronomical concepts involving the

Earth and its relationship with the Sun and Moon. On these items, the treatment students obtained a mean of 19.4 items correct (s.d. = 5.5) and the control students obtained a mean of 16.3 items correct (s.d. = 4.2). This difference in performance of 3.1 items was statistically significant ($p < .001$). This result indicated that students who studied concepts involving Earth in Space using the STC/MS curriculum scored higher than students not using that curriculum. It should be noted that students in the control sites studied and were exposed to astronomical concepts involving Earth as part of their normal science curriculum. The p-value associated with the significance test indicated that there is only one chance in one thousand that a difference this large (3.1 items) would have occurred simply by chance alone.

Multiple-Choice Items

The multiple-choice section of the test contained 17 items. On these items, the treatment students obtained a mean of 12.5 items correct (s.d. = 3.4) and the control students obtained a mean of 10.3 items correct (s.d. = 2.5). This difference in performance of 2.2 items also was statistically significant ($p < .001$). This result indicated that students who studied concepts involving Earth in Space using the STC/MS curriculum scored higher than students not using that curriculum. The p-value associated with the significance test indicated that there is only one chance in one thousand that a difference this large (2.2 items) would have occurred simply by chance alone.

Information on the performance of a national and/or international sample of students is available for seven of the 17 multiple-choice items. On these seven items, the national/international sample of students correctly answered an average of 3.9 items. In comparison, students in the STC/MS treatment group correctly answered an average of 5.7 items,

and students in the control group correctly answered an average of 4.7 items; both of these averages are considerably higher than the national/international average. Thus, the general scientific knowledge of these students exceeded that of the average student in the national/international sample.

Short Answer Items

The Earth in Space unit test contained six short answer items. Scorers did not know whether tests belonged to the treatment or control group. In addition we double-scored a sample of twenty of each of the short answer items. The percent agreement between raters was high (87%), giving us confidence in the reliability of the results.

Items were assigned scores ranging from 0 up to, in some cases, 3 points. Total scores for individual students across all short answer items ranged from 0 to 10 points. We tested the difference in mean performance across all short answer items between the treatment and control groups for statistical significance. The treatment group outperformed the control group on the short answer items (treatment group mean = 6.85; control group mean = 6.00). This difference was statistically significant at the .05 level, i.e. the probability that a difference this size could occur by chance was less than 1 in 20. This suggests that the STC/MS curriculum was more effective in teaching the concepts assessed by these short answer items than a more traditional, albeit still an inquiry-based, approach.

Information on the performance of a national and/or international sample of students is available for four of the six short answer items. On these four items, the national/international sample of students correctly answered an average of 2.2 items. In comparison, students in the treatment group correctly answered an average of 2.8 items and students in the control group correctly answered an average of 2.6 items. Both groups scored higher than the national/international sample, with the treatment group average being considerably higher. Thus, the general scientific knowledge of students in both groups exceeded that of the students in the national/international sample.

ELECTRICAL ENERGY AND CIRCUIT DESIGN UNIT

All Test Items

A total of 635 students in the treatment group and 120 in the control group took the Electrical Energy and Circuit Design test. Seventy-five tests were randomly selected from the treatment group and 60 tests were randomly selected from the control group. The test contained 23 multiple-choice and short answer items specific to content related to concepts involving electrical energy and circuit design. On these items, the treatment students obtained a mean of 17.0 items correct (s.d. = 5.6) and the control students obtained a mean of 12.5 items correct (s.d. = 5.6). This difference in performance of 4.5 items was statistically significant ($p < .001$). This result indicated that students who studied concepts involving electrical energy and circuit design using the STC/MS curriculum scored higher than students not using that curriculum did. It should be noted that students in the control sites studied and were exposed to concepts involving electrical energy and circuit design as part of their normal science curriculum. The p-value associated with the significance test indicated that there is only one chance in one thousand that a difference this large (4.5 items) would have occurred simply by chance alone.

Multiple-Choice Items

The multiple-choice section of the test contained 16 items. On these items, the treatment students obtained a mean of 9.1 items correct (s.d. = 2.4) and the control students obtained a mean of 7.1 items correct (s.d. = 2.5). This difference in performance of 2 items was statistically significant ($p < .001$). This result indicated that students who studied concepts involving electrical energy and circuit design using the STC/MS curriculum scored higher than students not using that curriculum did. The p-value associated with the significance test indicated that there is only one chance in one thousand that a difference this large (2 items) would have occurred simply by chance alone.

Information on the performance of a national and/or international sample of students is available for four of the 16 multiple-choice items. On these four items, the national/international sample of students correctly answered an average of 1.9 items. In comparison, students in the treatment group correctly answered an average of 1.9 items and students in the control group correctly answered an average of 1.8 items; both of these averages are essentially the same as the national/international average. Thus, the general scientific knowledge of these students was the same as that of the average student in the national/international sample.

Short Answer Items

The Electrical Energy and Circuit Design unit test contained seven short answer items. Scorers did not know whether tests belonged to the treatment or control group. In addition, we double-scored a sample of twenty of each of the short answer items. The percent agreement between raters was high (85%), giving us confidence in the reliability of the results.

Items were assigned scores ranging from 0 up to, in some cases, 4 points. Total scores for individual students across all short answer items ranged from 0 to 17 points. We tested the difference in mean performance on the total short answer score between the treatment and control groups for statistical significance. The treatment group outperformed the control group on the short answer items (treatment group mean = 7.9; control group mean = 5.4). This difference was statistically significant at the .001 level, i.e. the probability that a difference this size could occur by chance was less than 1 in a thousand. This suggests that the STC/MS curriculum was more effective in teaching the concepts assessed by these short answer items than a more traditional, albeit still an inquiry-based, approach.

Information on the performance of a national sample of students is available for only one of the seven short answer items. The national sample of students correctly answered this item an average of 52.4 percent of the time. In comparison, students in the treatment group correctly answered this item an average of 62.3 percent of the time, and students in the control group correctly answered the item an average of 48.3 percent of the time. The difference for the treatment group seems large enough to be meaningful; the control group difference does not. Since this comparison is based on a single item, the difference for the treatment group should be interpreted with caution.

LIGHT UNIT

All Test Items

A total of 1078 students in the treatment group and 74 students in the control group took the Light test. Seventy-five tests were randomly selected from the treatment group and 60 tests were randomly selected from the control group. The Light test was composed of 33 multiple-choice and short answer items specific to concepts related to the physics of light. On these

items, the treatment students obtained a mean of 23.5 items correct (s.d. = 7.7) and the control students obtained a mean of 19.0 items correct (s.d. = 7.4). This difference in performance of 4.5 items was statistically significant ($p < .01$). This result indicated that students who studied concepts involving the physics of light using the STC/MS curriculum scored higher than students not using that curriculum did. It should be noted that students in the control sites studied and were exposed to concepts involving light as part of their normal science curriculum. The p-value associated with the significance test indicated that there is only one chance in a hundred that a difference this large (4.5 items) would have occurred simply by chance alone.

Multiple-Choice Items

The multiple-choice section of this test contained 26 items. On these items, the treatment students obtained a mean of 13.8 items correct (s.d. = 4.5) and the control students obtained a mean of 11.4 items correct (s.d. = 3.4). This difference in performance of 2.4 items was statistically significant ($p < .01$). This result indicated that students who studied concepts involving light using the new curriculum scored higher than students not using that curriculum did. The p-value associated with the significance test indicated that there is only one chance in a hundred that a difference this large (2.4 items) would have occurred simply by chance alone.

Information on the performance of a national and/or international sample of students is available for five of the 26 multiple-choice items. On these five items, the national/international sample of students correctly answered an average of 2.5 items. In comparison, students in the treatment group correctly answered an average of 3.2 items and students in the control group correctly answered an average of 2.9 items; both of these averages are higher than the national/international average, with the treatment group's average being considerably higher.

Thus, the general scientific knowledge of these students exceeded that of the average national/international student.

Short Answer Items

The Light unit test contained seven short answer items. Scorers did not know whether tests belonged to the treatment or control group. In addition, we double-scored a sample of fifteen of each of the short answer items. The percent agreement between raters was high (88%), giving us confidence in the reliability of the results.

Items were assigned a score ranging from 0 up to, in some cases, 3 points. Total scores for individual students across all short answer items ranged from 0 to 20. We tested the difference in mean performance on the total short answer score between the treatment and control groups for statistical significance. The treatment group outperformed the control group on the short answer items (treatment group mean = 9.7; control group mean = 7.6). This difference was statistically significant at the .05 level, i.e. the probability that a difference this size could occur by chance was less than 1 in 20. This suggests that the STC/MS curriculum was more effective in teaching the concepts assessed by these short answer items than a more traditional, albeit still an inquiry-based, approach.

Information on the performance of a national and/or international sample of students is available for four of the seven short answer items. On these four items, the national/international sample of students correctly answered an average of 1.4 items. In comparison, students in the treatment group correctly answered an average of 2.0 items and students in the control group correctly answered an average of 1.8 items. Both of these averages are higher than the national/international average. Thus, the general scientific knowledge of these students exceeded that of the average student in the national/international sample.

ORGANISMS UNIT

All Test Items

A total of 488 students in the treatment group and 145 students in the control group took the Organisms test. Seventy-five tests were randomly selected from the treatment group and 60 tests were randomly selected from the control group. The test contained 41 multiple-choice and

short answer items specific to biological concepts related to organisms. On these items, the treatment students obtained a mean of 32.0 items correct (s.d. = 7.1) and the control students obtained a mean of 29.1 items correct (s.d. = 6.8). This difference in performance of 2.9 items was statistically significant ($p < .05$). This result indicated that students who studied biological concepts regarding organisms using the STC/MS curriculum scored higher than students not using that curriculum did. It should be noted that students in the control sites studied and were exposed to concepts involving organisms as part of their normal science curriculum. The p-value associated with the significance test indicated that there is only one chance in twenty that a difference this large (2.9 items) would have occurred simply by chance alone.

Multiple-Choice Items

The multiple-choice section of this test contained 31 items. On these items, the treatment students obtained a mean of 22.3 items correct (s.d. = 5.4) and the control students obtained a mean of 20.8 items correct (s.d. = 5.0). This difference in performance of 1.5 items was not statistically significant, i.e. this difference in performance can be attributed solely to sampling fluctuation.

Information on the performance of a national and/or international sample of students is available for 20 of the 31 multiple-choice items. On these 20 items, the national/international sample of students correctly answered an average of 10.6 items. In comparison, students in the treatment group correctly answered an average of 14.7 items and students in the control group correctly answered an average of 13.9 items; both of these averages are considerably higher than the national/international average. Thus, the knowledge of these students regarding biological organisms exceeded that of the average student in the national/international sample.

Short Answer Items

The Organisms unit test contained ten short answer items. Scorers did not know whether tests belonged to the treatment or control group. In addition we double scored a sample of twenty of each of the short answer items. The percent agreement between raters was high for this type of item (82%), giving us confidence in the reliability of the results.

All items were assigned a score ranging from 0 up to, in some cases, 3 points. Total scores for individual students across all short answer items ranged from 0 to 15. We tested the difference in mean performance on the total short answer score between the treatment and control groups for statistical significance. The treatment group outperformed the control group on the short answer items (treatment group mean = 9.6; control group mean = 8.3). This difference was statistically significant at the .05 level, i.e. the probability that a difference this size could occur by chance was less than 1 in 20. This suggests that the STC/MS curriculum was more effective in teaching the concepts assessed by these short answer items than a more traditional, albeit still an inquiry-based, approach.

Information on the performance of a national and/or international sample of students is available for five of the ten short answer items. On these five items, the national/international sample of students correctly answered an average of 2.4 items. In comparison, students in the treatment group correctly answered an average of 3.1 items and students in the control group correctly answered an average of 2.6 items. The treatment group average is considerably higher than the national/international average; the difference for the control group is too small to be meaningful. Thus, the general scientific knowledge of students in the treatment group exceeded that of the average student in the national/international sample.

ANALYSIS OF STUDENT ATTITUDE SURVEY

Responses to each item on the student attitude survey (Appendix E) were coded from 1 to 4. Responses coded "1" indicated a negative attitude toward science, low self-reported performance in science, or preference for lectures or learning from textbooks while responses coded "4" indicated a positive attitude toward science, high self-reported performance in science, or an aversion to lectures or learning from textbooks. Mean responses were calculated by group (treatment and control) across all 20 items. Statistical tests were conducted to determine whether differences between the groups were statistically significant.

In two of the four curriculum units, Earth in Space and Organisms, the treatment students exhibited a significantly more positive attitude toward science when compared to the control students. Differences in attitudes were statistically significant ($p < .001$). The p-value associated with the significance test indicated that there is less than one chance in a thousand that differences this large would have occurred simply by chance alone. This result suggests that students who participated in the field test of the Earth in Space and Organisms curriculum units were more positively inclined toward science, although the design of the evaluation does not permit inferences about whether exposure to the curriculum caused this difference.

For the Electricity and Circuit Design unit, control students exhibited a significantly more positive attitude toward science. Differences in attitudes were statistically significant ($p < .05$). The p-value associated with the significance test indicated that there is less than one chance in twenty that a difference this large would have occurred simply by chance alone. Again, the design of the evaluation does not allow us to infer a causal connection between exposure to the curriculum and this difference in attitudes toward science.

With respect to the Light unit, there was no significant difference between the attitudes of treatment and control students. Appendices J-M provide the proportions of students selecting each response, broken down by curriculum unit, questionnaire item and treatment and control group.

CONCLUSION

The results of this evaluation suggest that in all four STC/MS curriculum units, (1. Earth in Space, 2. Electrical Energy and Circuit Design, 3. Light, and 4. Organisms) students exposed to the STC/MS curriculum demonstrated significantly higher performance compared to students in control groups. This difference was significant for total scores, combining both multiple-choice and short answer responses, as well as when the multiple-choice and short answer scores were analyzed separately, with the exception of the multiple-choice responses of students exposed to the Organisms curriculum. The consistency of the results favoring the STC/MS curriculum units increases our confidence in the results.

However, the design of the evaluation, as noted above, is inherently limited, as are most evaluation designs, since they are conducted in real schools under real-world constraints. Random assignment of students to treatment and control conditions, as well as random assignment of teachers to groups, is simply not feasible in schools. The design does not control for the possibility of systematic differences in student knowledge that may have existed between the treatment and control groups prior to instruction in the STC/MS curriculum. The possibility of systematic differences was reduced, but not eliminated, by selecting students for both groups who had inquiry-based science in earlier grades, identifying control classrooms that were as

similar as possible to the treatment classrooms in terms of the characteristics of students and instructional content, and sampling students from different communities across the United States.

For the same reason, it is not possible to say whether the observed differences in student attitudes towards science are attributable to exposure to the STC/MS curriculum units. Students exposed to the STC/MS curriculum appeared to have more favorable attitudes in two of the units, and a less favorable attitude in a third, compared to students in the control group. However, the differences in attitudes may have existed prior to instruction in the STC/MS curriculum.

Similarly, while students in three of the groups exposed to the STC/MS curriculum appeared to perform at a higher level compared to students in the national/international sample, it is not possible to attribute the cause to the curriculum. The performance of the students might have been higher prior to instruction in the STC/MS curriculum.

Despite these caveats, results this consistent and favorable are unusual and provide a strong indication that the STC/MS curriculum works well. Students exposed to the STC/MS curriculum performed at a higher level compared to students in the control groups and compared to the national/international sample of students. While we cannot unequivocally attribute this result to exposure to the STC/MS curriculum, this is the pattern of results we would expect to see if the curriculum was indeed more effective than the comparison instructional approaches.

APPENDIX C: LIGHT TEST

DIRECTIONS:

On the separate answer sheet provided, using a #2 pencil please **FILL-IN:**

- 1) The **NAME OF YOUR TEACHER** in the NAME section.
DO NOT put your own name.
- 2) The **IDENTIFICATION NUMBER** given to you by your teacher in the IDENTIFICATION section.

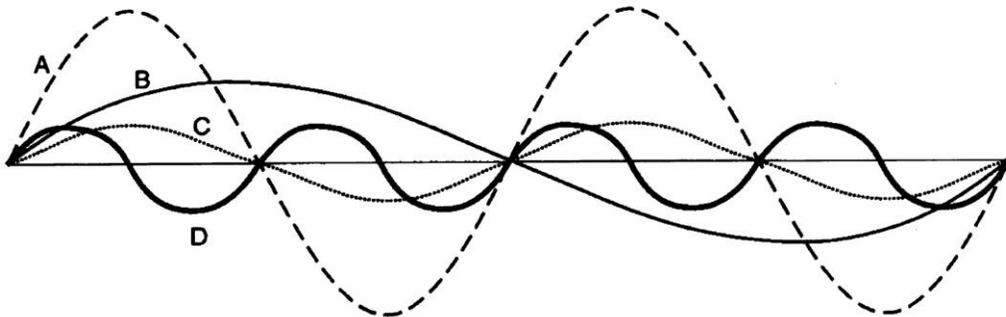
This is an assessment to measure your knowledge about the light. Do not worry if you cannot answer some of the questions; we are just trying to determine what students in your class know about these areas. Do the best you can.

THANK YOU.

SECTION A. MULTIPLE CHOICE

For the following multiple-choice questions, please **CLEARLY FILL-IN** the letter on the answer sheet corresponding to letter of your answer on the assessment.

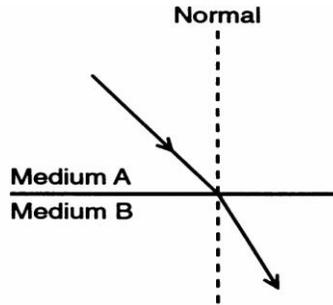
1. The diagram below represents waves A, B, C, and D traveling in the same medium.



Which two waves have the same wavelength?

- A. B and C
- B. A and C
- C. A and B
- D. D and C

2. The diagram below shows a ray of light passing through two media.



When the wave travels from medium A into medium B, its speed

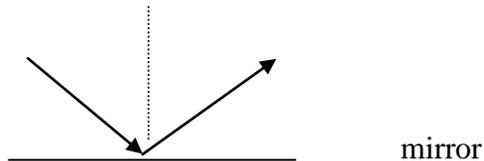
- A. decreases
- B. increases
- C. remains the same

3. A beam of light strikes a mirror as shown.

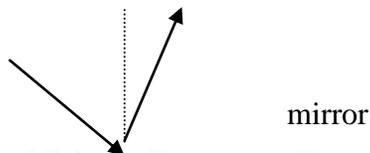


Which picture best shows what the reflected light would look like?

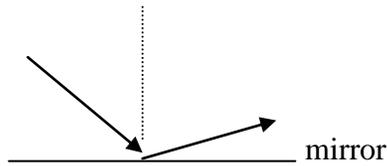
A.



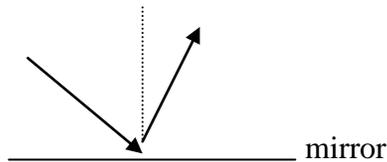
B.



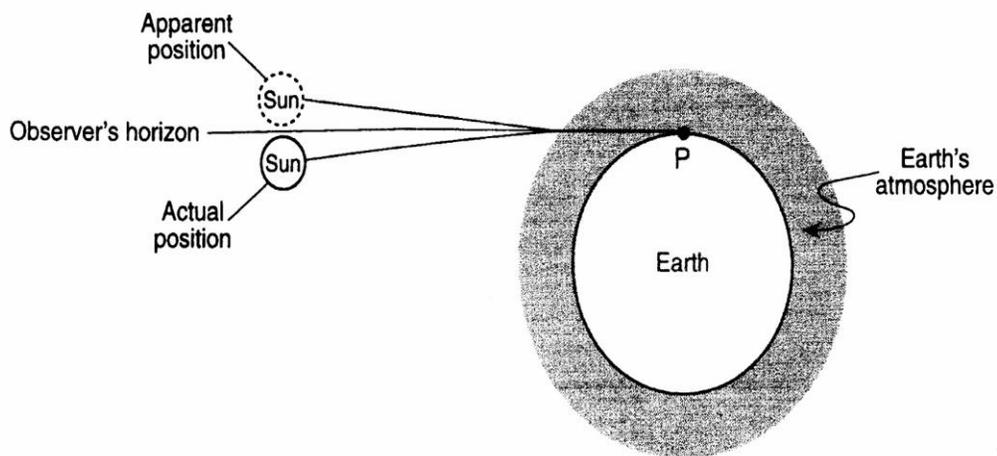
C.



D.



4. A convex lens produces a real image by causing light rays from a common point to
- A. converge and intersect at a point
 - B. disperse into component wavelengths
 - C. reflect constructively
 - D. diverge and appear to come from a point
5. Which type of images can be projected onto a screen?
- A. real images, only
 - B. virtual images, only
 - C. both real images and virtual images
 - D. neither real images nor virtual images
6. The diagram below shows how an observer located at point P on Earth can see the Sun when it is below the observer's horizon.

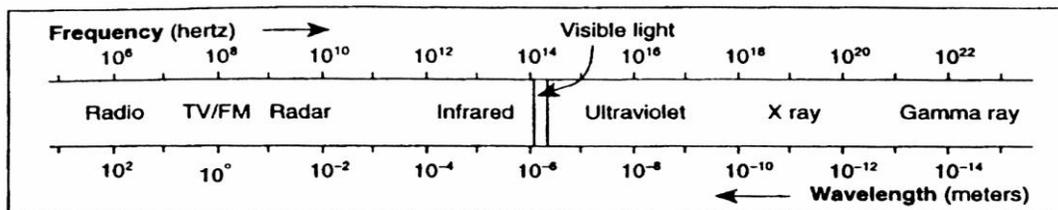


(not drawn to scale)

This observation is possible because of the ability of the Earth's atmosphere to

- A. reflect light
- B. diffract light
- C. refract light
- D. polarize light

The diagram below shows the frequency and wavelength of various types of electromagnetic energy. Please use it to answer questions 7 and 8.



7. Which type of electromagnetic wave has a wavelength of approximately 10^{-10} meters and a frequency of 10^{18} hertz?

- A. *Infrared*

Radio

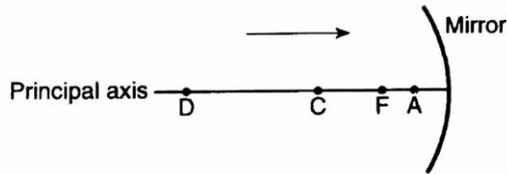
- B. X ray

Radar

8. A beam of green light may have a frequency of

- A. $5.0 \times 10^{-7} Hz$
- B. $1.5 \times 10 Hz$
- C. $3.0 \times 10^8 Hz$
- D. $6.0 \times 10^{14} Hz$

9. The diagram below shows a ray of light traveling parallel to the principal axis of a concave spherical mirror. Point F is the focal point (principal focus).

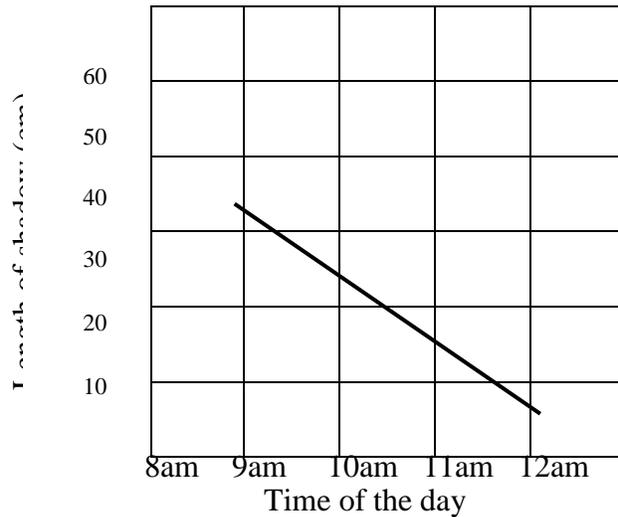


After striking the mirror, the ray of light will be reflected through which point?

- A. A
 - B. F
 - C. C
 - D. D
10. Since stars give off their own light, they are like the
- A. moon
 - B. Earth
 - C. Planets
 - D. sun
11. In which area does the technology of fiber optics have the greatest use?
- A. communications
 - B. ophthalmology
 - C. thermal engineering
 - D. textile manufacturing
12. What occurs as a ray of light passes from air into water?
- A. **The ray decreases in speed.**
 - B. **The ray increases in speed.**
 - C. **The ray decreases in frequency.**
 - D. **The ray increases in frequency.**

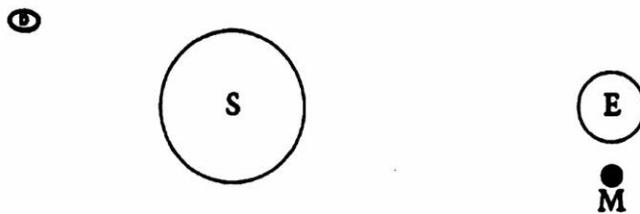
13. In the electromagnetic spectrum light is thought to travel in various packets of energy. In which part of the electromagnetic spectrum do these packets have the greatest amount of energy?
- A. red
 - B. violet
 - C. infrared
 - D. ultraviolet
14. A person is standing in front of a convex (diverging) mirror. What type of image does the mirror form of the person?
- A. erect, virtual, and smaller than the person
 - B. erect, virtual, and the same size as the person
 - C. erect, real, and smaller than the person
 - D. erect, real, and the same size as the person

15. Kim placed a stick in the ground on a sunny day. Then she measured the length of the stick's shadow at four different times. She made a graph of the measurements, which is shown below.



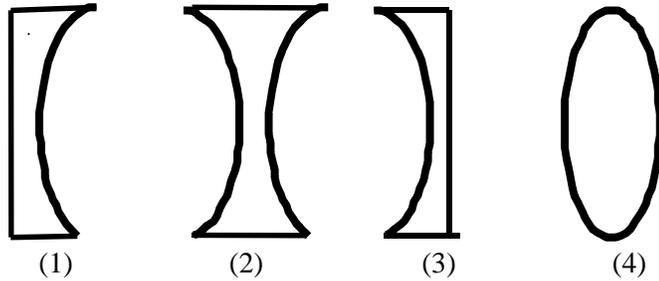
How long was the shadow of the stick at 11 a.m.?

- A. 10 cm
 - B. 20 cm
 - C. 30 cm
 - D. 40 cm
16. In which relative positions of the Sun (S), Earth (E), and Moon (M) is a lunar eclipse (a shadow on the moon) most likely to happen?



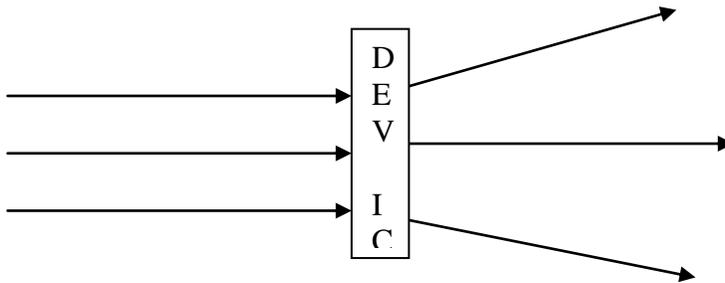
- A. A
- B. B
- C. C
- D. D

17. Which glass lens in air can produce an enlarged real image of an object?



- A. 1
- B. 2
- C. 3
- D. 4

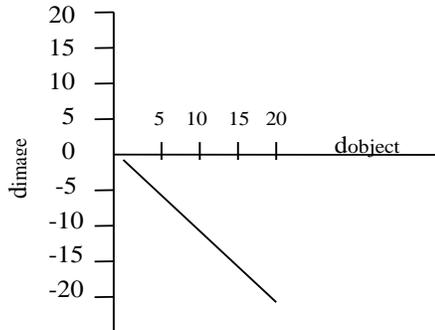
18. In the diagram below, parallel light rays in air diverge as a result of interacting with an optical device.



The device could be a

- A. convex glass lens
- B. rectangular glass block
- C. plane mirror
- D. concave glass lens

19. The graph below shows the relationship between a mirror's object distance (*d_{object}*) and its image distance (*d_{image}*)



From which type of mirror were the data collected?

- A. concave
 - B. convex
 - C. parabolic
 - D. plane
20. Compared to wavelengths of visible light, the wavelengths of ultraviolet light are
- A. shorter
 - B. longer
 - C. the same
21. Experiments performed with light indicate that light exhibits
- A. particle properties, only
 - B. wave properties, only
 - C. both particle and wave properties
 - D. neither particle nor wave properties
22. Which characteristics best describe the image produced by a plane mirror?
- A. real and inverted
 - B. real and erect
 - C. virtual and inverted
 - D. virtual and erect
23. When white light shines on Peter's shirt, the shirt looks blue. Why does the shirt look blue?
- A. It absorbs all the white light and turns most of it into blue light.
 - B. It reflects the blue part of the light and absorbs most the rest.
 - C. It absorbs only the blue part of the light.
 - D. Its gives off its own blue light.

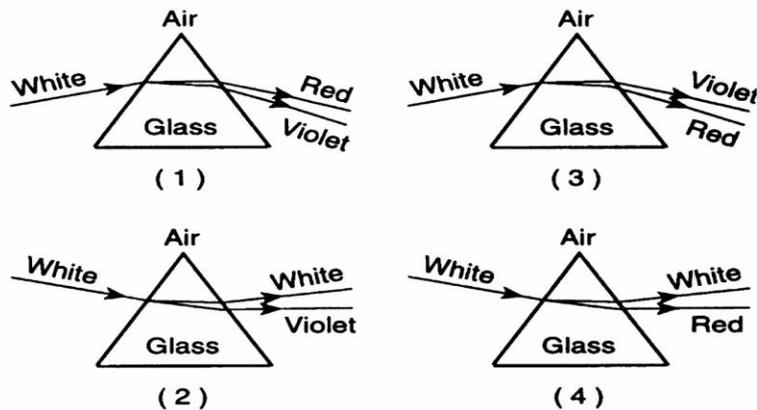
24. What is the main function of chloroplasts in a plant cell?

- A. to absorb light energy and manufacture food
- B. to remove waste materials by active transport
- C. to manufacture chemical energy from food
- D. to control the shape of the cell

25. Which form of solar radiation causes sunburn?

- A. visible
- B. ultraviolet
- C. infrared
- D. x-rays
- E. radio waves

26. Which diagram best represents the path of light passing through a glass prism?



- A. 1
- B. 2
- C. 3
- D. 4

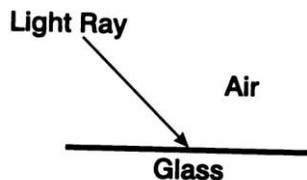
B. OPEN RESPONSE SECTION

For the following Open Response questions,

- 1) Write your **TEACHER'S NAME** and the **IDENTIFICATION NUMBER** given to you on the **UPPER RIGHT HAND CORNER** of your lined paper.
- 2) Be sure to **WRITE** each item **NUMBER** on the paper.
- 3) Read each item carefully.
- 4) Answer each item fully and to the best of your ability.

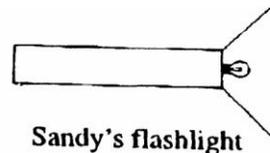
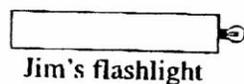
THANK YOU.

1. A light ray travels through air in a straight line until it hits the surface of a clear glass, as shown in the diagram below.



Several things could happen to the light ray. Name two things that could happen, and draw and label a diagram showing the two things you've selected.

2. Jim and Sandy each make a flashlight from identical batteries and bulbs. Sandy's flashlight contains a reflector, while Jim's does not.



Does Jim or Sandy's flashlight shine more light on a wall 5 meters away?
Explain your answer.

3. Raul's little sister, Sarah, wants to know why she can see herself in a mirror, but she can see through a window. What should Raul tell his sister to explain the differences between mirrors and windows?

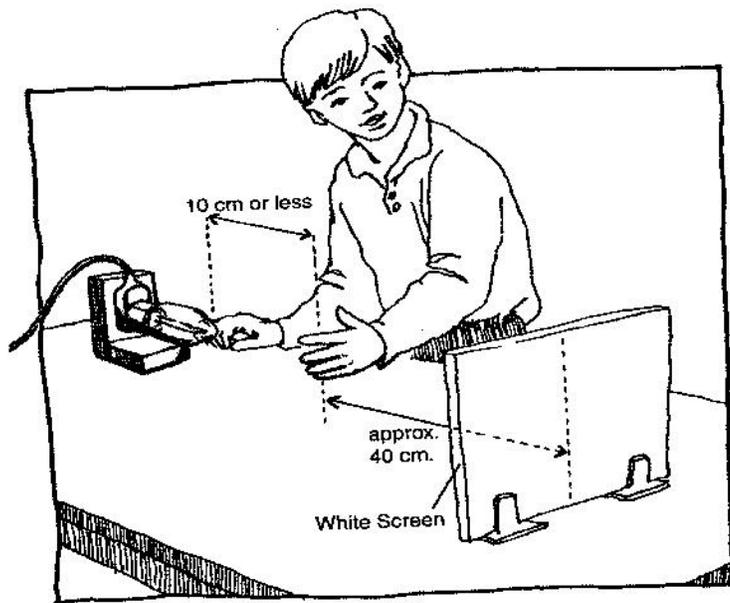
4. When operating, ordinary incandescent light bulbs produce a lot of heat in addition to light. Fluorescent light bulbs produce much less heat when operating.

A. If you wanted to conserve electricity, which type of bulb should you

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use?

- B. Explain your answer.
5. A flashlight close to a wall produces a small circle of light compared to the circle it makes when the flashlight is far from the wall.
- A. Does more light reach the wall when the flashlight is further away?
- B. Explain your answer.
6. Select the three most important components of a camera. Describe how these components make the device work.
7. Suppose you were to conduct the activity pictured below. The boy is creating a shadow on a screen by placing his hand in front of the light source.



- A. Draw a diagram showing exactly how the shadow is produced.
- B. Why is the shadow of the hand bigger than the hand?

APPENDIX D: ORGANISMS TEST

DIRECTIONS:

On the separate answer sheet provided, using a #2 **pencil** please

3) **FILL-IN** The **NAME OF YOUR TEACHER** in the NAME section.

DO NOT put your own name.

4) The **Identification NUMBER** given to you by your teacher in the IDENTIFICATION section.

This is an assessment to measure your knowledge about the life sciences. Do not worry if you cannot answer some of the questions; we are just trying to determine what students in your class know about these areas. Do the best you can.

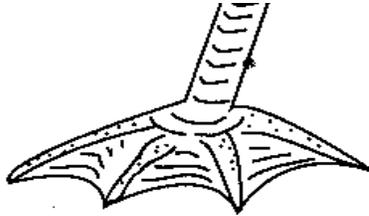
THANK YOU.

SECTION A. MULTIPLE CHOICE

For the following multiple-choice questions, please **CLEARLY FILL-IN** the letter on the answer sheet corresponding to letter of your answer on the assessment.

- 1 Which one of these refers only to living things?
- A. Clouds, fire, rivers
 - B. Fire, rivers, trees
 - C. Rivers, birds, trees
 - D. Birds, trees, worms
 - E. Trees, worms, clouds

This is a drawing of a bird's foot.

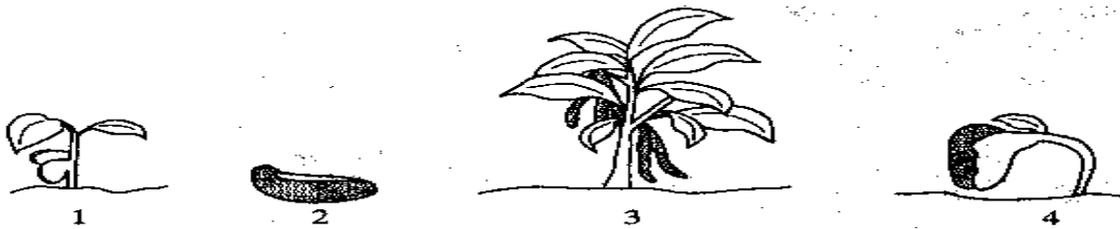


2. Where would you be MOST likely to find such a bird?
- A. A forest
 - B. A meadow
 - C. A cornfield
 - D. A desert
 - E. A lake

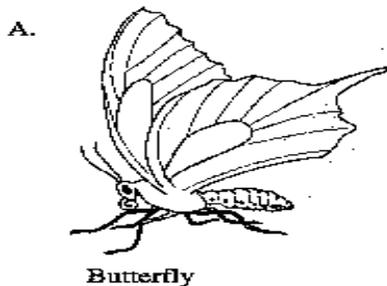
A baby chick grows inside an egg for 21 days before it hatches.

3. Where does the baby chick get its food before it hatches?
- A. It is fed by the mother hen.
 - B. It doesn't need any food.
 - C. It makes its own food.
 - D. It uses food stored in the egg.
 - E. It eats the eggshell.
4. Seeds develop within which part of a plant?
- A. Flower
 - B. Leaf
 - C. Root
 - D. Stem

The pictures below show a bean plant at different stages of growth. (The pictures are not drawn on the same scale.)



5. In what order do these stages take place?
- A. 2, 1, 3, 4
 - B. 2, 4, 1, 3
 - C. 3, 2, 1, 4
 - D. 4, 2, 3, 1
 - E. 4, 3, 2, 1
6. What is the main function of chloroplasts in a plant cell?
- A. To absorb light energy and manufacture food
 - B. To remove waste materials by active transport
 - C. To manufacture chemical energy from food
 - D. To control the shape of the cell
7. Which picture does NOT show an insect?



C.



Spider

D.



Ant

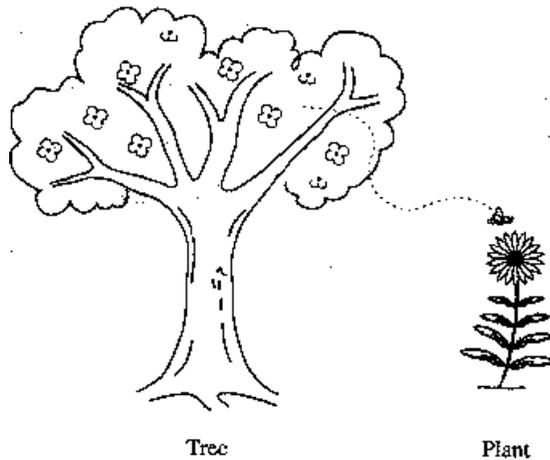
- 8 Hereditary information is found in a cell's
- A. Chloroplasts
 - B. Chromosomes
 - C. Cytoplasm
 - D. Membranes
- 9 Which part of a cell allows nutrients and other materials to enter or leave the cell?
- A. Cytoplasm
 - B. Nucleus
 - C. Chloroplast
 - D. Cell membrane
- 10 A girl found the skull of an animal. She did not know what the animal was but she was sure that it preyed on other animals for its food. What clue led to this conclusion?
- A. The eye sockets faced sideways.
 - B. The skull was much longer than it was wide.
 - C. There was a projecting ridge along the top of the skull.
 - D. Four of the teeth were long and pointed.
 - E. The jaws could move sideways as well as up and down.
- 11 A certain organism has many cells, each containing a nucleus. If the organism makes its own food, it would be classified as a(n)
- A. Bacterium
 - B. Fungus
 - C. Plant

D. Animal

12 A group of students is told to separate 30 fossils into several groups. The students find it difficult to agree on one solution. The main reason that scientists often have the same problem is that

- A. Fossils have not been studied very much
- B. They work in groups
- C. Fossils are very old
- D. There are many different ways to classify fossils

13 The picture shows how an insect can carry pollen from the flowers of a tree to the flowers of a small plant.

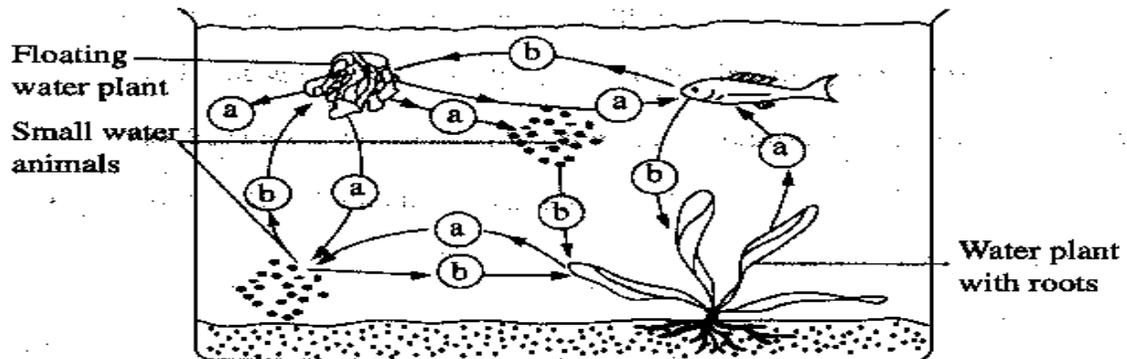


What will most likely happen?

- A. The offspring from the tree will look like the small plant.
- B. The offspring from the small plant will look like the tree.
- C. The offspring from the small plant will look like the tree and the small plant.
- D. Nothing will happen because no offspring will be produced.

- 14 What does a mitochondrion do in a cell?
- A. It controls the transport of substances into and out of the cell.
 - B. It contains the information to control the cell.
 - C. It produces a form of energy that the cell can use.
 - D. It breaks down waste products in the cell.
- 15 How do fungi obtain energy?
- A. By attaching to green plants and taking the plants' food
 - B. By combining carbon dioxide and water to make its own food
 - C. By absorbing matter from living or dead organisms to use as food
 - D. By attacking bacteria and using the bacteria as food

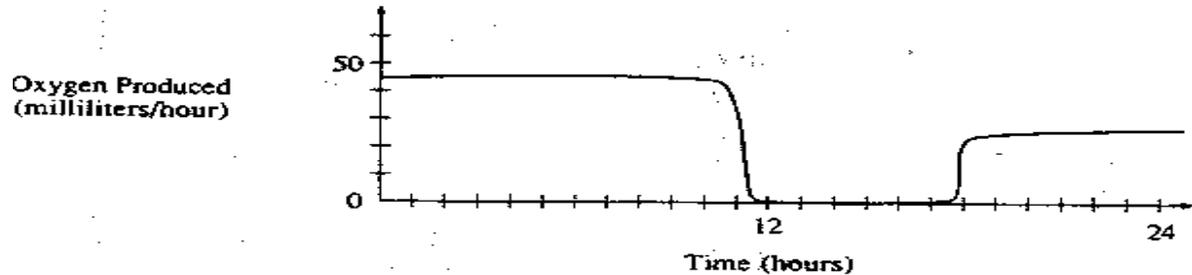
16 The diagram below shows an example of interdependence among aquatic organisms. During the day the organisms either use up or give off (a) or (b) as shown by the arrows. Choose the right answer for (a) and (b) from the alternatives given.



- A. (a) is oxygen (b) is carbon dioxide.
- B. (a) is oxygen (b) is carbohydrate.
- C. (a) is nitrogen (b) is carbon dioxide.
- D. (a) is carbon dioxide (b) is oxygen.
- E. (a) is carbon dioxide (b) is carbohydrate.

Use the following information to answer Questions 17 – 18.

The graph below shows the amount of oxygen given off by a green plant during a 24-hour period.



17 During which of the following hours was it probably dark?

- A. 0-11
- B. 11-18
- C. 11-24
- D. 18-24

18 During which hours did the plant give off the most oxygen?

- A. 0-11
- B. 11-18
- C. 11-24
- A. 18-24

Use the following information to answer Questions 19 – 20.

A plant scientist is developing a new fertilizer, HYPERGROW. She designs an experiment to test whether HYPERGROW helps plants grow faster than does SUPERGROW, a fertilizer already on the market.

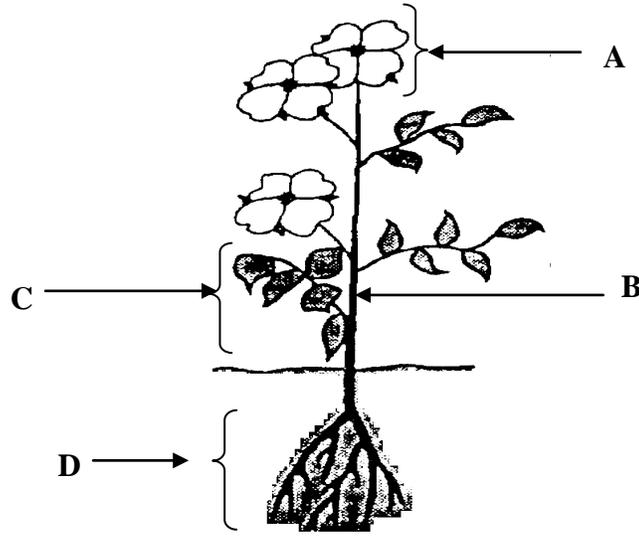
19 Which of the following should the scientist do with light during the experiment?

- A. Apply the same amount of light to all the plants.
- B. Apply only green light to all the plants.
- C. Flash the lights simulate a partly cloudy day.
- D. Keep the plants in darkness.

- 20 How should she apply fertilizer to the plants?
- A. Apply a mixture of SUPERGROW and HYPERGROW to the roots of all the plants.
 - B. Apply a mixture of SUPERGROW and HYPERGROW to the growing tips of all the plants.
 - C. Apply SUPERGROW to one-third of the plants, HYPERGROW to one-third of the plants, and nothing to the last third.
 - D. Apply SUPERGROW to the leaves on the left side of each plant and HYPERGROW to the leaves on the right side of each plant.
- 21 Of the numbers below, which would be the number of plants the scientist could use to obtain the most reliable data?
- A. 1
 - B. 2
 - C. 20
 - D. 200
- 22 Jamal has twenty silk worm larvae. Half are 2 centimeters long and half are 4 centimeters long. He knows the length of time it takes the smaller larvae to consume 100 grams of mulberry leaves. Which of the following information should he collect for the 4-centimeter larvae in order to compare the eating rates of the two sets of larvae?
- A. Weight of leaves eaten by all ten larvae in one hour
 - B. Time for each larva to eat one leaf
 - C. Time for all ten larvae to eat 100 grams of leaves
 - D. Number of leaves eaten by all ten larvae in a day

Use the picture below to answer Questions 23 and 24.

The picture shows the different parts of a plant.



23 Which plant part makes most of the plant's food?

- A. A
- B. B
- C. C
- D. D

24 The main function of part A of the plant is to

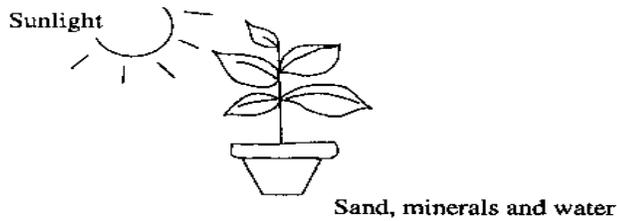
- A. Make oxygen
- B. Store oxygen and water
- C. Catch sunlight and store energy
- D. Attract insects and make seeds

25 Which statement about plant and animal cells is true?

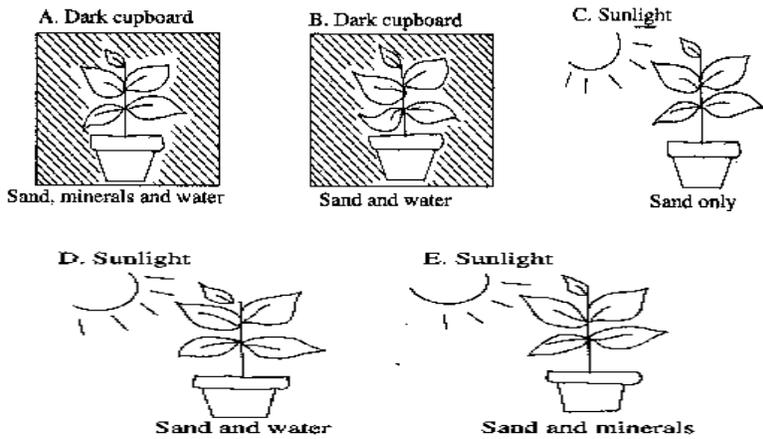
- A. Most plant cells have a nucleus and a cell wall; animal cells do not have either of these structures.
- B. Most plant cells have a cell wall and chloroplasts; animal cells do not have either of these structures.

- C. Most plant cells have a cell wall and a cell membrane; most animal cells have a cell wall but not a cell membrane.
- D. Most plant cells have chloroplasts and mitochondria; most animal cells have chloroplasts but do not have mitochondria.

26 Susan had an idea that plants needed minerals from the soil for healthy growth. She placed a plant in the Sun, as shown in the diagram below.

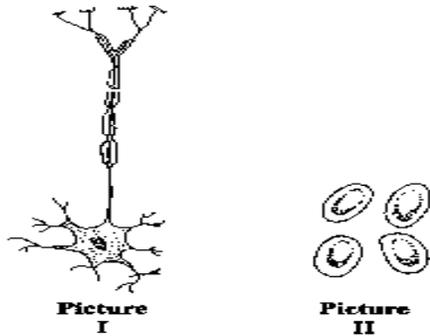


In order to check her idea, she also needed to use another plant. Which of the following should she use?



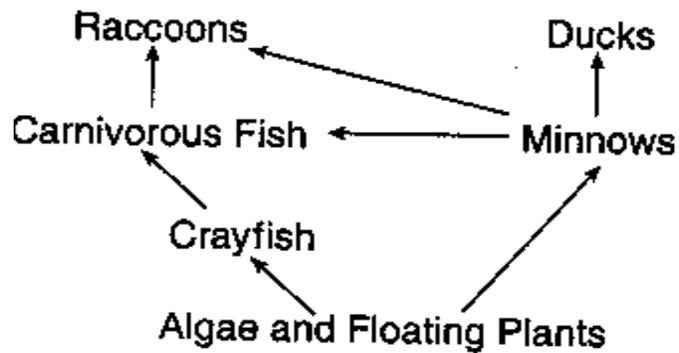
27 The pictures below are cells from the same animal.

Which statement **best** explains why the cell in Picture I looks so different from the cells in Picture II.



- A. The cells have different DNA.
- B. The cells have different functions.
- C. The cells in Picture II are very young and still growing.
- D. The cell in Picture I is diseased and damaged

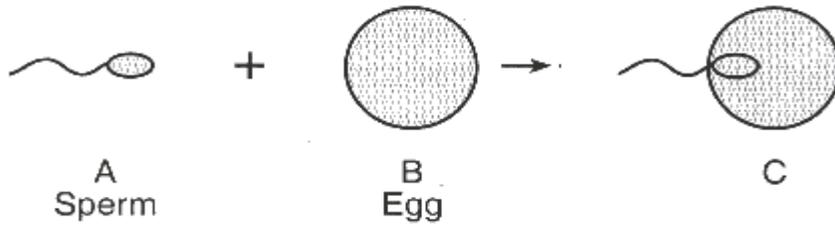
28 The diagram below illustrates the relationships between organisms in an ecosystem.



In addition to sunlight, which factor would need to be added to make this a stable ecosystem?

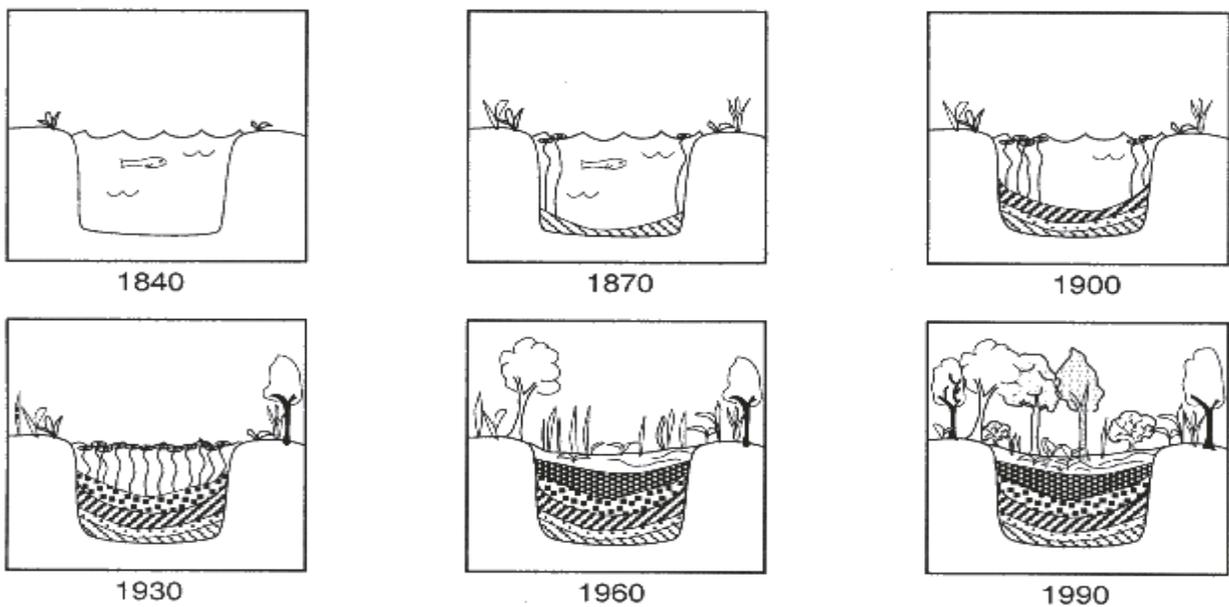
- A. Predators
- B. Prey
- C. Decomposers
- D. Herbivores

29. Which process is shown in the diagram below?



- A. Metamorphosis
- B. Regulation
- C. Fertilization
- D. Respiration

30 The sequence of diagrams below shows the process of succession.



If no human intervention or natural disaster occurs, by the year 2050 this area will most likely be a

- A. Lake
- B. Swamp
- C. Desert
- D. Forest

31 What features do all insects have?

	Number of LEGS	Number of BODY PARTS	
A.	2	4	
B.	4	2	
C.	6	3	
	D.	8	3

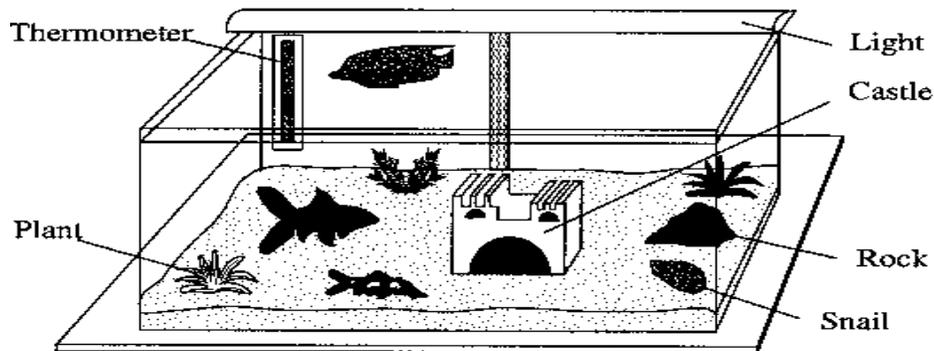
B. OPEN RESPONSE SECTION

For the following Open Response questions,

- 1) Write your TEACHER'S NAME and the ID NUMBER given to you on the UPPER RIGHT HAND CORNER of your lined paper.
- 2) Be sure to WRITE each item NUMBER on the paper.
- 3) Read each item carefully.
- 4) Answer each item fully and to the best of your ability.

THANK YOU

1. Write down one reason why animals could NOT live in a world without plants.
2. Juanita did several experiments to germinate corn. She summed up her results as follows:
 - A. Moist corn kernels germinate in the light.
 - B. Moist corn kernels germinate in the dark.What can you conclude from her results?
3. In the picture of an aquarium below, six items are labeled.

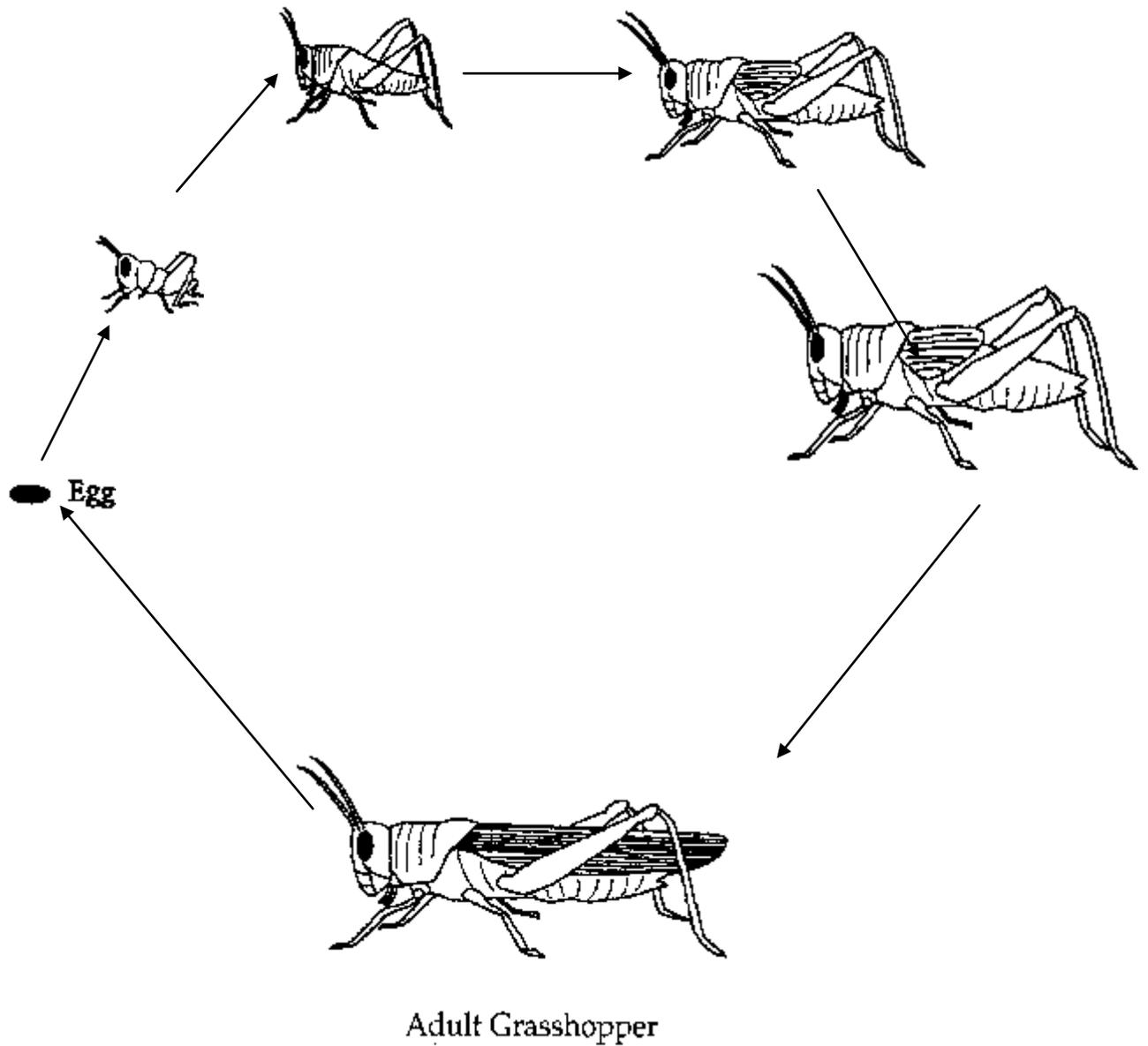


Explain why each of the following is important in maintaining the ecosystem in the aquarium.

- A. Plant
- B. Light

Use the picture below to answer Questions 4 and 5.

The picture shows the life cycle of a grasshopper.



4. Tell one way that the grasshopper's life cycle is different from the butterfly's life cycle.
5. Tell one way that the grasshopper's life cycle is the same as the butterfly's life cycle.

Use the following information to answer Questions 6 and 7.

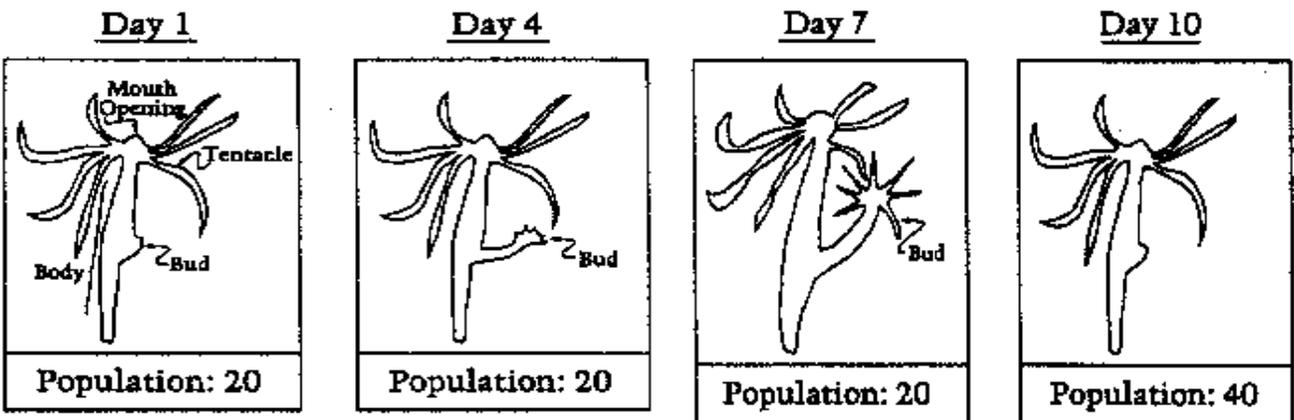
Hydras are tiny (1-centimeter long) animals that live in streams and ponds. The picture below shows an adult hydra drawn larger than actual size.



Evita and Michael used 20 hydras for a class science project. They kept the hydras in a glass dish about 5 centimeters high, fed them regularly, and bubbled air into the water to make sure the hydras had enough oxygen.

Evita and Michael observed the hydras every day for 10 days. Each day they drew the appearance of a typical hydra and recorded the total number of hydras in their lab notebook.

Their records for day 1, day 4, day 7, and day 10 are shown below.



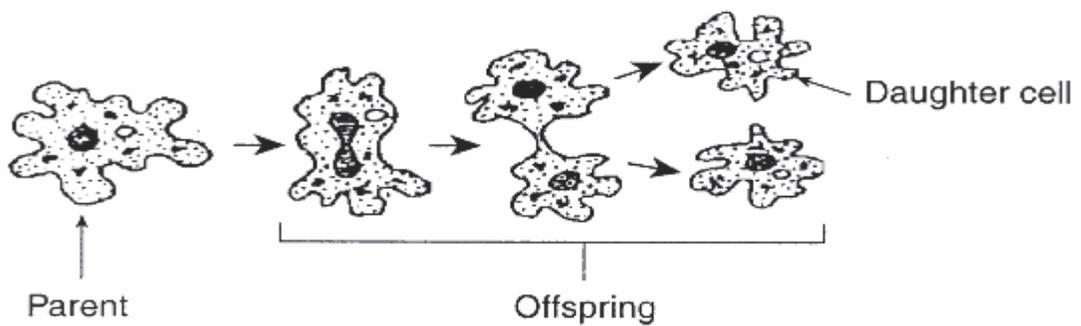
(The lab notebook drawings are not scale.)

6. Based on the information in the students' notebook, explain the changes in the appearance and number of the hydras between day 1 and day 10.

7. Evita and Michael predicted that if they fed the hydras twice as much food, the population of hydras would double their number in 5 days. Describe an experiment with appropriate controls that Evita and Michael could do to test this hypothesis.

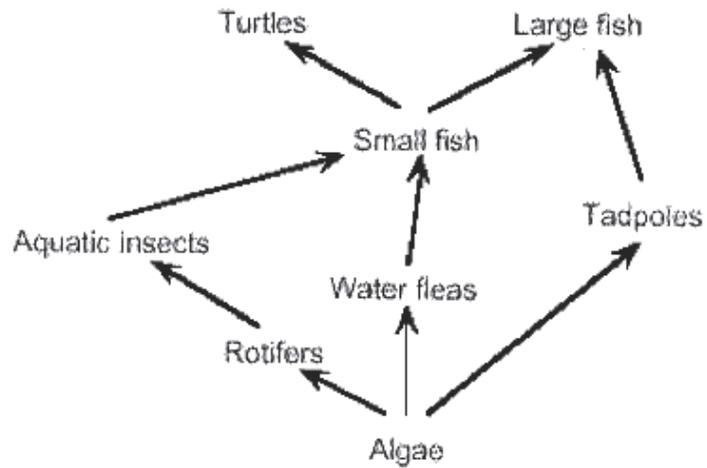
Use the information below to answer Questions 8 and 9.

The diagram below shows a form of reproduction.



8. Which type of reproduction is shown in the diagram?
9. How does the genetic material of the daughter cell compare to the genetic material of the parent cell?

10. A company wants to build a factory to produce weed killer. The new factory will be located close to the lake ecosystem with the food web in the diagram below.



What would happen if weed killer from the factory were to pollute the lake? In your response, be sure to include two ways the aquatic food chain could be affected.

APPENDIX E: Student Questionnaire on Attitudes toward Science

Directions: In this questionnaire, you will find statements about your opinions and attitudes toward science. Read each statement carefully and respond as accurately as possible. Your name will **not** be on your questionnaire, and no one will know how you responded personally.

Each question will be followed by a four choice scale where:

SA = Strongly Agree

A = Agree

D = Disagree

SD = Strongly Disagree

For each statement circle the letters corresponding to your choice. Please respond to the statements based on your experiences this year in science class.

	Strongly Agree	Agree	Disagree	Strongly Disagree
1. . It is important to do well in science	SA	A	D	SD
2. Next year I am looking forward to taking another science class	SA	A	D	SD
3. Science is boring	SA	A	D	SD
5. Science is important in everyday life.....	SA	A	D	SD
6. I look forward to coming to science class.....	SA	A	D	SD
7. Science is one of my favorite subjects.....	SA	A	D	SD
8. My parents want me to do well in science	SA	A	D	SD
9. I like to learn science by reading from textbooks ...	SA	A	D	SD
10. I understand things better when I use equipment and do experiments.....	SA	A	D	SD
11. Science class is not as interesting as my other classes	SA	A	D	SD

Continue with Item 11

<i>Agree Disagree</i>	Strongly	Agree	Disagree	Strongly
12. Science is hard for me.....SA	A	D	SD	
12. I enjoy learning about science.....SA	A	D	SD	
(1) I like working with other students in science.....SA	A	D	SD	
(2) The science I study in class is not related to anything I see outside of classSA	A	D	SD	
(3) I learn science easier when the teacher lectures and gives notesSA	A	D	SD	
(4) I have done well in my science class this year.....SA	A	D	SD	
(5) I would recommend this science class to other studentsSA	A	D	SD	
(6) Most middle school students can be successful in science.....SA	A	D	SD	
(7) I never think about science ideas outside of science classSA	A	D	SD	
(8) Discussing science ideas with lab partners and classmates helps me understand the ideas betterSA	A	D	SD	

This is the end of the questionnaire

Thank you for responding

APPENDIX F: EARTH IN SPACE OPEN RESPONSE ASSESSMENT SCORING GUIDE

EARTH IN SPACE ANSWER KEY

- 1.C
- 2.A
- 3.C
- 4.A
- 5.D
- 6.A
- 7.D
- 8.A
- 9.C
- 10.C
- 11.A
- 12.A
- 13.A
- 14.D
- 15.A
- 16.A
- 17.A

1 The sun is bigger than the Moon, but they appear to be about the same size when you look at them from the Earth. Why is this? (If you wish, you make a diagram on your lined paper as part of your explanation.)

Complete response MUST include BOTH of the following components:

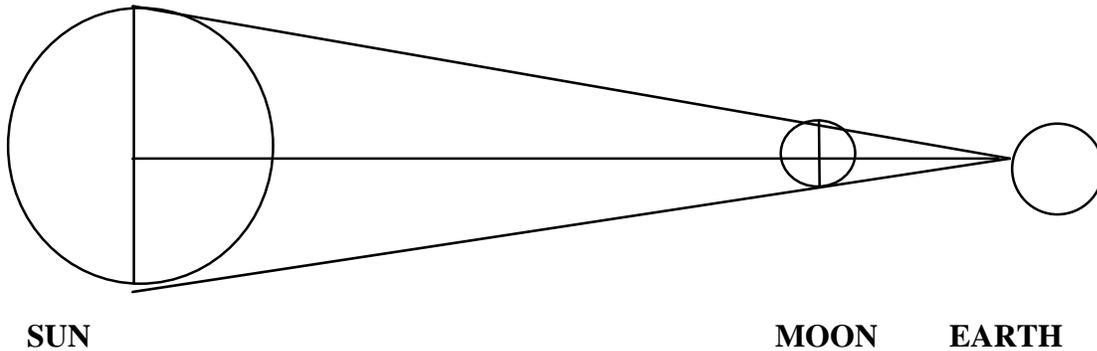
- a. Relative distance of objects affects perceived size.
- b. Actual difference in size between the Sun and Moon cannot be perceived by observers on Earth due to the difference their in relative distance from the Earth.

EX 1. While the Sun is 400x bigger than the Moon, the Sun is also 400x farther away from Earth than the Moon.

EX 2. The difference in size between the Sun and the Moon is cancelled out by the difference in their relative distances from the Earth.

EX3. The Sun is much bigger but it is also farther away so it looks the same size as the Moon.

Student response may include a diagram similar to the one below as part of the explanation.



- 3 = Complete** - Response meets both criteria.
- 2 = Essential** - Response meets only one criterion BUT student provides a detailed diagram like the one above.
- 1 = Partial** - Response meets only one criterion without a diagram
- Response includes a detailed diagram without an explanation OR with wrong explanation OR with an explanation that shows understanding BUT also includes one wrong concept.
- 0 = Incorrect/Unsatisfactory**
- Student provides NO component of the acceptable response, OR
 - Student provides an INCORRECT diagram without further explanation, OR
 - Student crosses out/erases response and no further writing is shown, OR
 - Student's response is illegible or impossible to interpret.

B = Non-response – Student does not respond to item by leaving the answer space blank.

2. Below is a diagram of our Sun and Earth.... Where will the Moon be during a solar eclipse as seen from the Earth? Draw the Moon in the dotted line in that position on your paper.

Correct response:

The student response shows a Moon that is within 20 degrees of the 9 o'clock position of the dotted line representing the Moon's orbit.

1 = Correct – Student provides the correct response.

0 = Incorrect/Unsatisfactory

- Student places the Moon more than 20 degrees of 9 o'clock position, OR
- Student crosses out/erases response and no further writing is shown, OR
- Student's response is illegible or impossible to interpret.

B = Non-response – Student does not respond to item; the answer space is left blank.

3. Jane and Mario were discussing what it might be like to live on other planets. Their science teacher gave them data about Earth and an imaginary planet, Athena.... Write down one important reason why it would be difficult for humans to live on Athena if it existed.

a. Acceptable response includes at least one of the following reasons:

- Greenhouse effect – There is too much carbon dioxide in Athena.
- Oxygen – There is too little oxygen in Athena.
- Ozone layer – There is no ozone layer in Athena.
- Bound rotation – The periods of revolution around the Sun and rotation on Athena's own axis are the same, such that one side of the planet is always facing the Sun and the other side is always dark and cold.

Unacceptable response: Athena is too close to a star, without further explanation.

2= Correct – Response meets criterion **a**.

1=Partial – Response meets criterion **a** BUT also includes unacceptable reasons.

0 = Incorrect/Unsatisfactory

- Response does NOT meet criterion **a**, OR
- Student crosses out/erases response and no further writing is shown, OR
- Student's response is illegible or impossible to interpret.

B = Non-response – Student does not respond to item; the answer space is left blank.

4. State two ways in which this simple model is different from the real Solar System.

Acceptable responses include references to:

- a. Scale – the sun and the planets are too close together in model.
- b. Outer planets missing in model.
- c. Satellites/asteroids missing in model.
- d. Circular orbits – the orbits in model should be elliptical not circular.

- e. Orbital plane – the orbits of the planets of the model should not be all in the same plane; three dimensions rather than two should be considered.
- f. Shape of the planets – the planets in the model should not be perfectly spherical.
- g. Positions of planets – the planets in the model should not be lined up perfectly.
- h. Planet/Sun Rotation – the rotation of planets and the Sun is not shown in model.
- i. Tilt – the tilt of each planet is not shown in model.
- j. The Sun is too small relative to the planets.
- k. The Sun and planets are too small.

2 = Complete – Student states TWO ways that are considered acceptable responses, in which the simple model is different from the real Solar System.

1 = Partial – Student states ONE way that is considered an acceptable response AND one that is NOT considered an acceptable response.

0 = Incorrect/Unsatisfactory

- Student provides unacceptable responses, OR
- Student crosses out/erases response and no further writing is shown, OR
- Student’s response is illegible or impossible to interpret.

B = Non-response – Student does not respond to item; the answer space is left blank.

5. John stuck a meter stick in the ground at 8:00 in the morning. How will the stick's shadow at 2:00 in the afternoon compare to its shadow at 8:00 in the morning? WRITE THE LETTER OF YOUR ANSWER ON YOUR LINED PAPER (A, B, C, or D).

Correct response: D.

2 = Correct – Student provides the correct response.

1 = Partial – Student provides correct response BUT includes an incorrect explanation.

0 = Incorrect/Unsatisfactory

– Student chooses A, B, or C, OR

– Student crosses out/erases response and no further writing is shown, OR

– Student's response is illegible or impossible to interpret.

B = Non-response – Student does not respond to item; the answer space is left blank.

6. Explain the relationship between shadow length and the Sun's position in the sky.

Complete response MUST contain ALL of the following components:

a. The shadow length decreases as the Sun rises during the morning hours.

b. The shadow length is at its shortest when the Sun has reached its apex (at high noon).

c. The shadow length increases as the Sun sets during the afternoon hours.

3 = Complete – Student provides ALL THREE components in the response.

2 = Essential – Student provides only TWO of the three components in the response AND either no further explanation is found OR an explanation not found as components of an acceptable response is given.

1 = Partial – Student provides only ONE of the three components in the response AND either no further explanation is found OR explanations not found as components of an acceptable response is given.

0 = Incorrect/Unsatisfactory

– Student provides NO component of the complete response, OR

– Student crosses out/erases response and no further writing is shown, OR

13. Student's response is illegible or impossible to interpret.

B = Non-response – Student does not respond to item; the answer space is left blank.

MULTIPLE CHOICE ITEMS ANSWER KEY

- 1) E
- 2) C
- 3) C
- 4) D
- 5) C
- 6) D
- 7) D
- 8) B
- 9) B
- 10) D
- 11) D
- 12) B
- 13) A
- 14) D
- 15) A
- 16) A

OPEN RESPONSE ITEMS

Question 1

Criteria for complete response:

- a) Student draws a parallel circuit containing two light bulbs.
- b) Schematic includes a source (battery)
- c) Student uses the appropriate schematic symbols.

Symbols:

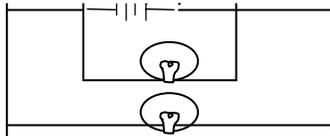
Source



Switch



Light bulb



Correct response:

3 pts Response meets all criteria.

Partial response:

2 pts Response meets criteria **a** and **b**.

1 pt Response only meets criterion **a**.

Incorrect response:

0 pts Response does not meet any of the required criteria

OR

Student draws a series circuit.

ii Crossed out, erased, blank, illegible or impossible to interpret.

Question 2

Criteria for complete response:

- a) Student selects fluorescent light bulbs.
- b) Student explains that heat energy results from the transformation of electrical energy to light and that fluorescent bulbs produce less heat and more light for any given amount of electricity produced.

OR

The less heat produced the less electricity you consume for a given amount of light (a link between heat and energy consumption must be made).

Correct response:

2 pts Response meets criteria a and b

OR

Any other logical link between heat and energy consumption.

Example: The filament in an incandescent bulb must get red hot before it glows. A lot of heat is produced before you get any light. A fluorescent bulb does not require this amount of heat be produced since the chemicals inside the bulb make it glow.

Partial response:

1 pt Response meets criteria a only. OR

Meets **a** and **b** partially. Example: because it produces less heat.

OR

Student does not identify EITHER type of lamp BUT gives a plausible explanation.

Example: I would choose the lamp that produces less heat because it would use less electrical energy.

Incorrect response:

0 pts Student selects incandescent bulb with or without explanation.

ii Crossed out, erased, blank, illegible or impossible to interpret.

Question 3

Part A

Criteria for complete response:

- a) Student states that the chemical energy in the coal is transformed into heat energy that heats up water to produce steam. The steam turns the turbines of a generator that transforms mechanical energy into electrical energy.

Chemical energy → Heat energy → Mechanical energy → Electrical energy

Correct response:

2 pts Response meets criterion a.

Partial response:

1 pt Student identifies three energy transformations.

Incorrect response:

0 pts Student identifies less than 3 energy transformations.

OR

Student identifies incorrect energy transformations.

OR

Response does not meet criterion.

ii Crossed out, erased, blank, illegible or impossible to interpret.

Part B

Criteria for complete response:

- a) The student states that the amount of energy used by the light bulb is much smaller than that received by the house,
b) The amount of energy used by the home is much less than the amount produced by the power plant.
c) The student states that as the electrical energy moves from the power plant to the house and then to the plant some energy is lost due to heat dissipation.

Example:

The power plant produces electricity to service many homes and the electricity received by the home powers many other appliances besides the light bulb. As the energy moves from the power plant to the house, some energy is lost because of heat.

Complete response:

3 pts Response meets all criteria.

Partial response:

2 pts Response meets any 2 criteria.

1 pt Response meets only 1 criteria.

Incorrect response:

0 pts Response does not meet any criteria.

OR

Student states that the amount of energy is the same but in different form.

ii Crossed out, erased, blank, illegible or impossible to interpret.

Question 4

Criterion for correct response:

- a) Student paraphrases the question stem: "Do durable batteries outlast any other kind of battery. Must

address **outlast** or run longer.

Complete response:

1 pt Response meets criterion a.

Incorrect response:

0 pts Response does not meet either criterion or is too vague. Example: Which battery works better or how long batteries last.

ii Crossed out, erased, blank, illegible or impossible to interpret.

Question 5

Criteria for correct response:

Student states that:

(9) S(he) will get different kinds of batteries.

(10) S(he) will put them in the same type of toy or device.

(11) S(he) will see which one lasts longer.

(12) The procedure will be repeated multiple times to see if results hold.

Complete response:

4 pts Response meets all 4 criteria

Partial response:

3 pts Response meets any 3 criteria.

2 pts Response meets any 2 criteria.

1 pt Response meets only 1 criterion.

Incorrect response:

0 pts Response does not meet any criteria

ii Crossed out, erased, blank, illegible or impossible to interpret.

Question 6

Criterion for correct response:

- a) The number of hours each battery lasts.
- b) Record operation time.

Example:

I would record the amount of time the batteries last by using a stop watch.

Complete response:

4 pt Response meets all criteria.

Partial response:

3 pts Response meets any 3 criteria.

2 pts Response meets any 2 criteria.

1 pt Response meets only one criterion.

Incorrect response:

0 pts Response meets none of the criteria

ii Crossed out, erased, blank, illegible or impossible to interpret.

Question 7

Criteria for correct response:

- a) Student lists three variables that should be kept the same.

Examples: size, shape, age, expiration date, voltage of the batteries in the sample and the same starting time; toy or device on which the batteries will be tested; environmental conditions (e.g., room temperature and humidity) and operational conditions (e.g., surface, incline obstacles, etc.).

Complete response:

2 pts Response meets criterion.

Partial response:

1 pt Response includes 2 correct possibilities.

Incorrect response:

0 pts Response does not meet criterion

ii Crossed out, erased, blank, illegible or impossible to interpret.

APPENDIX H: LIGHT ASSESSMENT SCORING GUIDE

MULTIPLE CHOICE ITEMS ANSWER KEY

- 1) B
- 2) A
- 3) A
- 4) A
- 5) A
- 6) C
- 7) C
- 8) D
- 9) B
- 10) D
- 11) A
- 12) A
- 13) D
- 14) A
- 15) B
- 16) A
- 17) D
- 18) D
- 19) D
- 20) A
- 21) C
- 22) D
- 23) B
- 24) A
- 25) B
- 26) A

OPEN RESPONSE ITEMS

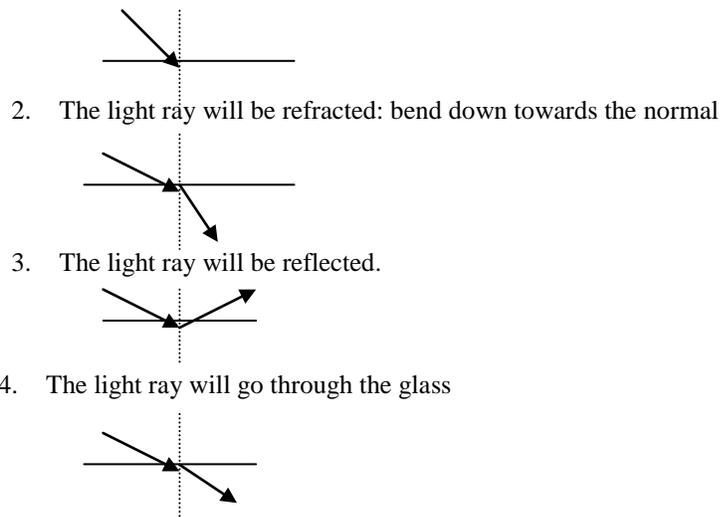
Question 1

Possible correct responses:

(13) Student names two correct outcomes.

Possible outcomes:

1. The light ray will be absorbed.



(14) Student accurately draws the possible outcome.

(15) Student labels the diagram to show the light ray, the glass and the air.

Criteria for correct response:

3 pts Response meets all 3 criteria.

Criteria for partial response:

2 pts Response meets criterion **a** and at least one other criterion

OR

Response includes only one outcome BUT meets criteria **b** and **c** for that outcome.

1 pt Response meets criterion **a**

OR

Response includes only 1 outcome AND meets criterion **b**.

Incorrect responses:

0 pts Response only includes 1 outcome and does not meet any other criterion

OR

Response does not meet any criteria

ii Crossed out, erased, blank, illegible or impossible to interpret.

Question 2

Criteria for correct response:

a) Student identifies Sandy's flashlight as the one that will reflect the most light and offers a plausible explanation.

Examples of correct responses:

1. Sandy's. The reflector reflects all the light towards the wall.
2. Sandy's. In Jim's flashlight the light shines in all directions.
3. Any combination of 1 and 2.

Complete response:

2 pts Response meets criterion **a**.

Partial response:

- 1 pt** Response identifies Sandy's flashlight but offers no explanation OR an incomplete explanation. Example:
Sandy's because of the reflector.
Sandy's because it reflects more light.

Incorrect responses:

- 0 pts** Jim's. There is no reflector.
Jim's with explanation belonging to Sandy's.
Jim's with any other explanation.
Jim's or Sandy's with no explanation.
Sandy's with Jim's explanation.
- ii** Crossed out, erased, blank, illegible or impossible to interpret.

Question 3

Criteria for correct response:

- a) Student refers to the physical properties of mirrors and glass (reflective or opaque vs. transparent material).
- b) Student refers to how light interacts with each of these materials (reflects with mirrors and goes through glass).
- c) Student refers to the characteristics of the reflective backing in mirrors and its relationship to reflective properties.

Complete response:

- 3 pts** Response meets all 3 criteria.

Partial response:

- 2 pts** Response meets any two possible criteria.

- 1 pt** Response meets only one possible criterion.

OR

Any other partial response. Example: mirrors reflect more light.

Incorrect responses:

- 0 pts** Student repeats stem of the question and offers no explanation for differences
OR

Any other incorrect response.

- ii** Crossed out, erased, blank, illegible or impossible to interpret.

Question 4

Criteria for correct response:

- c) Student selects fluorescent lightbulbs.

- d) Student explains that heat energy results from the transformation of electrical energy to light and that fluorescent bulbs produce less heat and more light for any given amount of electricity produced.

OR

The less heat produced the less electricity you consume for a given amount of light (a link between heat and energy consumption must be made).

Correct response:

2 pts Response meets criteria **a** and **b**

OR

Any other logical link between heat and energy consumption.

Example: The filament in an incandescent bulb must get red hot before it glows. A lot of heat is produced before you get any light. A fluorescent bulb does not require this amount of heat be produced since the chemicals inside the bulb make it glow.

Partial response:

1 pt Response meets criterion **a** only.

OR

Response meets **a** and **b** partially: fluorescent because it produces less heat.

OR

Student selects **a** but gives incorrect explanation.

Incorrect response:

0 pts Student selects incandescent bulb with or without explanation.

ii Crossed out, erased, blank, illegible or impossible to interpret.

Question 5

Criteria for correct response:

1. Student correctly states that more light does not reach the wall when the flashlight is further away. The same amount of light and less light are both acceptable responses.
2. Student gives a plausible explanation as to why that is. For example: the same light reaches the wall but it is more spread out;
OR
When the flashlight is closer to the wall the light is less spread out
OR
Less light reaches the wall because of light absorption by the air.
OR
The light rays expand (spread out) as they move away from the source.

Complete response:

2 pts Response meets both criteria a and b.

Partial response:

1 pt Meets criterion **a** only.

Incorrect response:

- 0 pts** Student states that more light reaches the wall with or without an explanation.
OR
Selects criteria a but gives wrong explanation (e.g., there's less light at a greater distance or vice-versa).
- ii** Crossed out, erased, blank, illegible or impossible to interpret.

Question 6

Criteria for complete response:

- a) Student selects any three of the following components of a camera:
1. The film;
 2. Any component used to focus the light on the film (e.g., the lens, focusing mechanism, or the aperture);
 3. Any part of the camera used to protect the film from light (e.g., the shutter, the black box, or the diaphragm).
- b) Student explains how these components make the camera work.
- Examples:
1. The film makes the camera work by recording the image that is captured by the lens.
 2. The lens makes the camera work by capturing, focusing and directing the light towards the film. The focusing mechanism also positions the lenses to focus the light so as to create a clear image. The aperture is a small opening that allows light to enter the camera to imprint an image on the film.
 3. The shutter is a mechanism that covers the lens after the picture has been taken to protect the film from light . The black box serves the same purpose-- it protects the film from light. The diaphragm also protects the film by controlling the opening of the aperture

Correct response:

4 pts Response meets criteria **a** and **b**.

Partial response:

- 3 pts** Student selects and explains two components from the list
OR
Student selects three components from the list but only explains two.
- 2 pts** Student selects 2 or 3 components from the list BUT only explains one
OR
Response meets criterion **a** only.
- 1 pt** Student selects 2 or 3 components from the list but explains none
OR
Student selects and explains one component from the list.

Incorrect response:

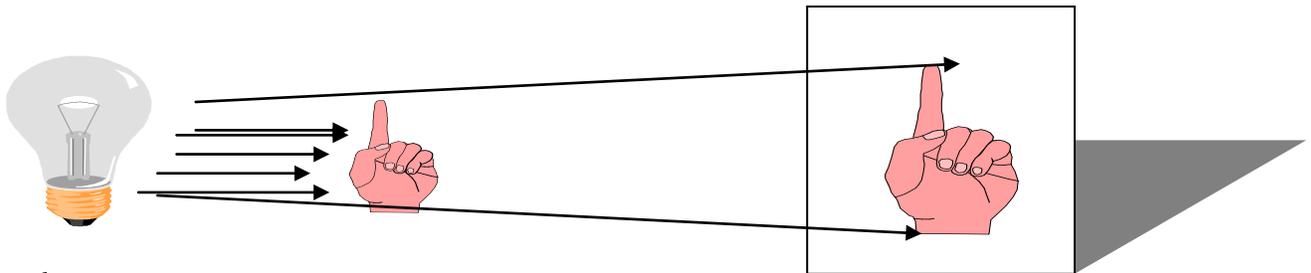
- 0 pts** Student selects one component from the list without explanation
OR
Student selects components that are not on the list with or without explanation.
- ii** Crossed out, erased, blank, illegible or impossible to interpret.

Question 7

Part A

Criteria for correct response:

14. The diagram includes the light source, the hand, the screen, and the shadow of the hand.
15. The shadow **MUST** be bigger than the hand.
16. The diagram shows what happens to the light rays between the source and the screen (the light rays spread out because the only rays that hit the screen are those that are at an angle).



Complete response:

3 pts The diagram meets all three criteria.

Partial response:

2 pts The diagram meets at least two criteria
OR

The diagram includes all three criteria **BUT** one of the criteria is incomplete (e.g., the labels are missing).

1 pt The diagram meets only one criterion
OR

Two or more criteria are incomplete

Incorrect response:

0 pts The diagram meets none of the criteria
OR

Any other incorrect response.

ii Crossed out, erased, blank, illegible or impossible to interpret.

Part B

Criteria for correct response:

- a) Student states that light travels in a straight line.
- b) Student explains that the shadow is formed because the hand is an opaque object and it blocks the light.
- c) Student explains that the shadow is bigger than the hand because light rays are emitted in all directions and that the hand blocks the rays that go straight. The rays that hit the screen go at an angle, therefore, the shadow is bigger than the hand.

OR

The rays spread out as they travel away from the source. As they spread out, the area blocked by the hand increases and the shadow becomes larger than the object.

Complete response:

4 pts Response meets all three criteria.

Partial response:

3pts Response fully meets two criteria and partially meets a third.

Example: The hand blocks the light and forms a shadow. The further the light is, the more light is blocked so the shadow is larger.

2 pts Response meets any 2 criteria.

OR

Response partially meets two criteria.

Example: The hand blocks the light and the shadow gets bigger because the light spreads out.

1 pt Response meets only one criterion.

Example 1: The hand blocks the light rays

Example 2: The light spreads out.

Example 3: The light goes around the hand.

Example 4: Because the light expands (spreads out) from the source.

Example 5: Because the light source is further away.

Example 6: Because the hand is closer to the light.

Incorrect responses:

0 pts Response meets none of the criteria

OR

Student describes setup or repeats the question stem without an explanation.

Any other incorrect response (e.g., the light source is small and the screen is large).

ii Crossed out, erased, blank, illegible or impossible to interpret.

APPENDIX I: ORGANISMS ASSESSMENT SCORING GUIDE

ORGANISMS FROM MACRO TO MICRO ANSWER KEY

1.D

2.E

3.D

4.A

5.B

6.A

7.C

8.B

9.D

10.D

11.C

12.D

13.D

14.C

15.C

16.A

17.B

18.A

19.A

20.C

21.D

22.C

23.C

24.D

25.B

26.D

27.B

28.C

29.C

30.D

31.C

1. Write down one reason why animals could NOT live in a world without plants.

Acceptable responses include references to:

- a. The food chain or food web in which animals are dependent on plants directly AND indirectly for food.
- b. Photosynthesis in which animals use oxygen given off by plants AND in which plants absorb the carbon dioxide given off by animals.
- c. Protection in which animals use plants for shelter AND for camouflage.

Unacceptable responses include:

- a. References to the aesthetics of plants for animals.
- b. The mere repetition of the stem.

2 = Complete – Student gives one reason why animals could not live in a world without plants *in full detail*. (Ex. Some animals eat plants, and some animals eat other animals that eat plants.)

1 = Partial – Student gives a response *with incomplete detail or no detail*. (Ex. Animals use oxygen.) [Student response does not detail further that plants also absorb carbon dioxide given off by animals.]

0 = Incorrect/Unsatisfactory

- Student does not give correctly one reason why animals could not live without plants, OR
- Student crosses out/erases response and no further writing is shown, OR
- Student's response is illegible or impossible to interpret.

B = Non-response - Student does not respond to item by leaving the answer space blank.

2. Juanita did several experiments to germinate corn. She summed up her results as follows:

- 1. Moist corn kernels germinate in the light.**

2. Moist corn kernels germinate in the dark.

What can you conclude from her results?

Acceptable response variations include:

- a. Light is not required for germination of moist corn kernels.
- b. Moist corn kernels can germinate in both light and dark.
- c. Moisture is needed for germination but not light.

Unacceptable responses include:

- c. Light is required for germination.
- d. Darkness is required for germination.

1 = Correct – Student provides one of the correct response variations for corn germination requirement.

0 = Incorrect/Unsatisfactory

- Student provides an incorrect response.
- Student crosses out/erases response and no further writing is shown, OR
- Student's response is illegible or impossible to interpret.

B = Non-response - Student does not respond to item by leaving the answer space blank.

3. In the picture of the aquarium below, six items are labeled. Explain why each of the following is important in maintaining the ecosystem in the aquarium.

Part A. Plants

Acceptable responses for **Part A.** include references to:

- a. Photosynthesis in which plants absorb carbon dioxide from the fish and snail
AND/OR that plants release oxygen for the fish and snail.

- b. Provision of food for aquarium organisms.
- c. Provision of protection or shelter for fish eggs.
- d. Cleaning of aquarium water through absorption of nitrogenous waste from fish and snail.

Unacceptable responses include references to:

- a. Aesthetics of the plant in aquarium.
- b. The creations of a more natural surrounding for aquarium organisms.

1 = Correct – Student provides one of the correct responses for the importance of plants in the aquarium ecosystem.

0 = Incorrect/Unsatisfactory

- Student provides an unacceptable response, OR
- Student crosses out/erases response and no further writing is shown, OR
- Student's response is illegible or impossible to interpret.

B = Non-response - Student does not respond to item by leaving the answer space blank.

3. In the picture of the aquarium below, six items are labeled. Explain why each of the following is important in maintaining the ecosystem in the aquarium.

Part B. Light

Acceptable response variations for **Part B.** include references to:

- a. A necessary component for photosynthesis in plants to occur.
- b. The plants' survival.

Unacceptable responses include references to:

- a. Aesthetics (so that the interior of the aquarium can be seen).

- b. Ability for the fish to see clearly.
- c. Provision of warmth for the aquarium.
- d. Observers being able to see the aquatic organisms more clearly.

1 = Correct – Student provides one of the correct responses for the importance of light in the aquarium ecosystem.

0 = Incorrect/Unsatisfactory

- Student provides an unacceptable response, OR
- Student crosses out/erases response and no further writing is shown, OR
- Student's response is illegible or impossible to interpret.
-

B = Non-response - Student does not respond to item by leaving the answer space blank.

4. Tell one way that the grasshopper's life cycle is different from the butterfly's life cycle.

Acceptable responses include:

- a. A grasshopper goes through an INCOMPLETE metamorphosis, where its form does not change, while a butterfly goes through a COMPLETE metamorphosis and change form from the caterpillar stage to the adult butterfly stage.
- b. A grasshopper eats similar food throughout its lifespan, while a butterfly has different nutritional needs at each of its 4 life stages.
- c. A grasshopper does not go through a cocoon/pupa stage, while a butterfly does go through such a stage.

1 = Correct – Student provides one of the correct responses that tells one difference between the grasshopper life cycle and the butterfly life cycle.

0 = Incorrect/Unsatisfactory

- Student does not provide an acceptable response, OR
- Student crosses out/erases response and no further writing is shown, OR

- Student's response is illegible or impossible to interpret.

B = Non-response - Student does not respond to item by leaving the answer space blank.

5. Tell one way that the grasshopper's life cycle is the same as the butterfly's life cycle.

Acceptable responses include:

- Both are insects.
- Both hatch from eggs.
- Both undergo size increase.
- Both develop into adults.
- Neither insect is born with wings.

1 = Correct – Student provides one of the correct responses that tells one similarity between the grasshopper life cycle and the butterfly life cycle.

0 = Incorrect/Unsatisfactory

- Student does not provide an acceptable response, OR
- Student crosses out/erases response and no further writing is shown, OR
- Student's response is illegible or impossible to interpret.

B = Non-response - Student does not respond to item by leaving the answer space blank.

6. Based on the information in the students' notebook, explain the changes in the appearance and number of the hydras between day 1 and day 10.

Complete response includes ALL of the following components:

- Bud formation begins from Day 1 to Day 4 with bud maturation at Day 7.
- The hydra buds separate from the parent hydras at Day 10, leading to the doubling of the hydra population.

2 = Complete – Student provides both components of a complete response.

1 = Partial – Student gives only ONE component in her/his response.

0 = Incorrect/Unsatisfactory

- Student does not correctly give any component in her/his response, OR

- Student crosses out/erases response and no further writing is shown, OR
- Student's response is illegible or impossible to interpret.

B = Non-response - Student does not respond to item by leaving the answer space blank.

7. Evita and Michael predicted that if they fed the hydras twice as much food, the population of the hydras would double their number in 5 days. Describe an(d) experiment with appropriate controls that Evita and Michael could do to test this hypothesis.

Complete response includes ALL of the following components:

- a. The hydras are separated into two groups, an experimental group and a control group.
- b. More than 1 hydra is used for each of the two groups.
- c. All conditions are the same for both groups except for the amount of food fed between the two groups.

2 = Complete – Student gives ALL THREE components of a complete response.

1 = Partial – Student gives only ONE or TWO of the three components of a complete response.

0 = Incorrect/Unsatisfactory

- Student does not correctly give any component in her/his response, OR
- Student crosses out/erases response and no further writing is shown OR
- Student's response is illegible or impossible to interpret.

B = Non-response - Student does not respond to item by leaving the answer space blank.

8. Which type of reproduction is shown in the diagram?

Acceptable responses include:

- a. Asexual reproduction
- b. Cell division
- c. Mitosis AND Cell division

d. (Binary) fission

1 = Correct – Student provides one of the correct responses that identifies the type of reproduction.

0 = Incorrect/Unsatisfactory

- Student provides an incorrect response, OR
- Student crosses out/erases response and no further writing is shown, OR
- Student's response is illegible or impossible to interpret.

B = Non-response - Student does not respond to item by leaving the answer space blank.

9. How does the genetic material of the daughter cell compare to the genetic material of the parent cell?

The correct response is: The genetic materials between the daughter cell and the parent cell provide the same information.

1 = Correct – Student provides the correct response.

0 = Incorrect/Unsatisfactory

- Student provides an incorrect response, OR
- Student crosses out/erases response and no further writing is shown, OR
- Student's response is illegible or impossible to interpret.

B = Non-response - Student does not respond to item by leaving the answer space blank.

10. A company wants to build a factory to produce weed killer. The new factory will be located close to the lake ecosystem with the food web in the diagram below. What would happen if weed killer from the factory were to pollute the lake? In your response, be sure to include two ways the aquatic food chain could be affected.

Complete responses may include:

- a. The collapse of the lake ecosystem due to the killing of algae by the weed killer, which causes other organisms within the ecosystem to die off due to a lack of food.
- b. The killing of organisms at all levels of the food chain within the lake ecosystem due to the weed killer's general toxicity.
- c. The heavy concentration of the weed killer in the organisms at the top of the food chain within the lake ecosystem (due to biological magnification).

Unacceptable responses include:

- a. The lake ecosystem will not be affected.
- b. The lake will dilute the weed killer.
- c. The eventual formation of weed-killer-resistant organisms within the lake ecosystem from those surviving that had a natural tolerance for the weed killer.
- d. Mutations can be found in organisms within the lake ecosystem.

2 = Complete – Student gives TWO acceptable responses or ways the aquatic food chain could be affected.

1 = Partial – Student gives only ONE acceptable response and either provides no other acceptable response OR provides an unacceptable response.

0 = Incorrect/Unsatisfactory

- Student gives an unacceptable response. OR
- Student crosses out/erases response and no further writing is shown, OR
- Student's response is illegible or impossible to interpret.

B = Non-response - Student does not respond to item by leaving the answer space blank.

APPENDIX J: STUDENT ATTITUDES TOWARD SCIENCE

EARTH IN SPACE UNIT

ITEM	FIELD GROUP				CONTROL GROUP			
	SA	A	D	SD	SA	A	D	SD
1	0.54	0.46	0.00	0.00	0.32	0.63	0.04	0.00
2	0.25	0.49	0.22	0.03	0.14	0.42	0.35	0.09
3	0.06	0.14	0.53	0.25	0.16	0.11	0.53	0.18
4	0.28	0.57	0.15	0.00	0.23	0.60	0.11	0.02
5	0.17	0.58	0.24	0.01	0.07	0.42	0.39	0.09
6	0.19	0.29	0.36	0.15	0.09	0.28	0.42	0.19
7	0.51	0.44	0.04	0.00	0.42	0.49	0.07	0.00
8	0.00	0.24	0.38	0.39	0.02	0.07	0.33	0.56
9	0.65	0.31	0.03	0.00	0.56	0.37	0.04	0.02
10	0.08	0.21	0.49	0.22	0.11	0.25	0.47	0.14
11	0.01	0.21	0.47	0.32	0.05	0.21	0.44	0.23
12	0.25	0.56	0.19	0.08	0.07	0.54	0.21	0.11
13	0.35	0.58	0.03	0.03	0.40	0.47	0.02	0.02
14	0.01	0.10	0.60	0.38	0.04	0.07	0.60	0.23
15	0.06	0.14	0.39	0.39	0.04	0.21	0.19	0.47
16	0.40	0.49	0.04	0.04	0.25	0.53	0.11	0.02
17	0.22	0.57	0.17	0.04	0.18	0.49	0.14	0.09
18	0.28	0.68	0.03	0.01	0.19	0.65	0.05	0.02
19	0.03	0.29	0.43	0.25	0.09	0.19	0.56	0.07
20	0.49	0.33	0.15	0.03	0.44	0.44	0.04	0.02

APPENDIX K: STUDENT ATTITUDES TOWARD SCIENCE

ELECTRICITY AND CIRCUIT DESIGN UNIT

ITEM	FIELD GROUP				CONTROL GROUP			
	SA	A	D	SD	SA	A	D	SD
1	0.49	0.43	0.07	0.00	0.39	0.53	0.04	0.05
2	0.21	0.54	0.15	0.09	0.23	0.44	0.19	0.11
3	0.09	0.16	0.45	0.30	0.23	0.35	0.35	0.30
4	0.28	0.55	0.16	0.00	0.23	0.58	0.11	0.07
5	0.22	0.49	0.22	0.06	0.14	0.53	0.19	0.14
6	0.16	0.30	0.34	0.19	0.21	0.19	0.37	0.21
7	0.55	0.33	0.09	0.03	0.44	0.53	0.02	0.02
8	0.04	0.09	0.46	0.39	0.02	0.09	0.37	0.47
9	0.61	0.33	0.04	0.01	0.49	0.47	0.00	0.04
10	0.07	0.21	0.42	0.27	0.14	0.23	0.37	0.25
11	0.09	0.19	0.45	0.21	0.05	0.30	0.42	0.18
12	0.24	0.49	0.16	0.07	0.47	0.40	0.23	0.05
13	0.40	0.49	0.06	0.01	0.28	0.56	0.05	0.02
14	0.07	0.15	0.45	0.28	0.04	0.21	0.49	0.21
15	0.16	0.28	0.18	0.34	0.09	0.14	0.44	0.28
16	0.25	0.45	0.15	0.10	0.30	0.30	0.18	0.18
17	0.33	0.48	0.09	0.07	0.25	0.42	0.21	0.05
18	0.34	0.43	0.13	0.01	0.19	0.65	0.09	0.02
19	0.18	0.21	0.34	0.22	0.11	0.30	0.39	0.14
20	0.57	0.28	0.07	0.03	0.37	0.35	0.16	0.04

APPENDIX L: STUDENT ATTITUDES TOWARD SCIENCE

LIGHT UNIT

ITEM	FIELD GROUP				CONTROL GROUP			
	SA	A	D	SD	SA	A	D	SD
1	0.36	0.64	0.03	0.00	0.30	0.67	0.05	0.00
2	0.25	0.40	0.29	0.07	0.17	0.58	0.18	0.08
3	0.09	0.29	0.36	0.25	0.15	0.18	0.47	0.20
4	0.28	0.45	0.25	0.04	0.25	0.52	0.23	0.02
5	0.12	0.47	0.29	0.13	0.15	0.53	0.20	0.10
6	0.16	0.28	0.37	0.21	0.15	0.42	0.27	0.17
7	0.44	0.49	0.08	0.01	0.37	0.58	0.03	0.00
8	0.00	0.07	0.44	0.52	0.05	0.20	0.50	0.27
9	0.63	0.32	0.05	0.01	0.68	0.28	0.05	0.00
10	0.13	0.19	0.55	0.15	0.22	0.10	0.52	0.18
11	0.01	0.29	0.49	0.20	0.05	0.13	0.52	0.27
12	0.13	0.51	0.29	0.07	0.23	0.45	0.18	0.08
13	0.41	0.51	0.07	0.01	0.38	0.50	0.07	0.00
14	0.07	0.16	0.53	0.23	0.08	0.03	0.55	0.22
15	0.05	0.21	0.28	0.44	0.10	0.32	0.32	0.25
16	0.27	0.52	0.16	0.05	0.28	0.57	0.07	0.05
17	0.21	0.47	0.21	0.07	0.25	0.47	0.20	0.08
18	0.23	0.67	0.11	0.00	0.25	0.60	0.08	0.02
19	0.12	0.31	0.39	0.17	0.17	0.18	0.53	0.10
20	0.37	0.51	0.07	0.05	0.52	0.35	0.08	0.02

APPENDIX M: STUDENT ATTITUDES TOWARD SCIENCE

ORGANISMS UNIT

ITEM	FIELD GROUP				CONTROL GROUP			
	SA	A	D	SD	SA	A	D	SD
1	0.41	0.55	0.04	0.00	0.38	0.56	0.05	0.00
2	0.20	0.43	0.23	0.15	0.15	0.53	0.29	0.04
3	0.13	0.21	0.41	0.24	0.05	0.24	0.56	0.13
4	0.20	0.60	0.15	0.07	0.33	0.47	0.20	0.00
5	0.15	0.45	0.29	0.12	0.09	0.58	0.33	0.02
6	0.17	0.27	0.35	0.21	0.16	0.35	0.29	0.18
7	0.51	0.44	0.03	0.03	0.47	0.44	0.07	0.00
8	0.07	0.11	0.37	0.45	0.00	0.22	0.40	0.42
9	0.60	0.32	0.04	0.03	0.60	0.33	0.07	0.00
10	0.08	0.21	0.47	0.17	0.11	0.25	0.47	0.16
11	0.08	0.29	0.47	0.17	0.04	0.29	0.51	0.16
12	0.19	0.51	0.24	0.07	0.15	0.62	0.18	0.05
13	0.45	0.43	0.07	0.04	0.42	0.55	0.04	0.00
14	0.09	0.15	0.51	0.25	0.04	0.18	0.62	0.15
15	0.07	0.15	0.35	0.44	0.07	0.20	0.25	0.47
16	0.27	0.43	0.23	0.07	0.22	0.60	0.13	0.04
17	0.31	0.47	0.16	0.07	0.22	0.58	0.16	0.04
18	0.24	0.56	0.19	0.01	0.22	0.58	0.18	0.02
19	0.12	0.27	0.41	0.19	0.11	0.35	0.44	0.11
20	0.48	0.35	0.12	0.05	0.38	0.53	0.09	0.02