R E P O R T   R E S U M E S

ED 020 152   24   SE 004 830

MATERIALS USED IN TEACHING AND EVALUATING THE CONCEPTS RELATED TO THE BIOLOGICAL CELL IN GRADES 2-6, PRACTICAL PAPER NO. 2.

BY- STAUSS, NYLES G.
WISCONSIN UNIV., MADISON

REPORT NUMBER BR-5-0216   PUB DATE   JAN 68
CONTRACT OEC-5-10-154
EDRS PRICE   MF-$0.25   HC-$1.80   43P.

DESCRIPTORS- *BIOLOGY, *CONCEPT FORMATION, *COGNITIVE PROCESSES, *ELEMENTARY SCHOOL SCIENCE, *LEARNING, *SCIENTIFIC CONCEPTS, AUDIOVISUAL AIDS, CYTOLOGY, INSTRUCTIONAL MATERIALS, MULTIPLE CHOICE TESTS, OBJECTIVE TESTS, TESTS,

INCLUDED ARE MATERIALS FOR USE IN TEACHING AND EVALUATING 11 SELECTED CONCEPTS RELATED TO THE BIOLOGICAL CELL IN GRADES 2 TO 6. THE CONCEPTS WERE SELECTED AND THEIR ORDER DETERMINED THROUGH AN ANALYSIS OF ELEMENTARY TEXTBOOK SERIES, HIGH SCHOOL AND COLLEGE BIOLOGY TEXTS, CYTOLOGY TEXTS, AND INFORMATION GATHERED THROUGH A PILOT STUDY. THE MATERIALS HAVE BEEN EXPERIMENTALLY EVALUATED AND A BRIEF RESUME OF THE DATA IS PROVIDED. PART 1 DESCRIBES 11 LESSONS, ONE LESSON FOR EACH CONCEPT SOUGHT. THE LESSONS ARE DEVELOPED FOR ORAL PRESENTATION IN ASSOCIATION WITH APPROPRIATE VISUAL MATERIALS SUCH AS PHOTOMICROGRAPHS, ROCK SECTIONS, DIAGRAMATIC DRAWINGS, FILMLOOPS, AND OTHERS. PART 2 PROVIDES MULTIPLE-CHOICE TYPE TESTS FOR TESTING STUDENT KNOWLEDGE, COMPREHENSION, AND APPLICATION OF EACH OF THE 11 CONCEPTS. EACH TEST INCLUDES 36 ITEMS DIVIDED EQUALLY BETWEEN THE THREE LEVELS OF UNDERSTANDING. TEST RELIABILITIES ARE GIVEN. THE STUDY FOR WHICH THESE MATERIALS WERE DEVELOPED IS REPORTED IN FULL IN TECHNICAL REPORT NO. 40 OF THE CENTER FOR COGNITIVE LEARNING AT THE UNIVERSITY OF WISCONSIN. (DS)

BR-5-0216
PA-24

PRACTICAL PAPER NO. 2

MATERIALS USED IN TEACHING AND EVALUATING THE CONCEPTS RELATED TO THE BIOLOGICAL CELL IN GRADES 2—6

REPORT FROM THE SCIENCE CONCEPT LEARNING PROJECT

WISCONSIN RESEARCH AND DEVELOPMENT
CENTER FOR
COGNITIVE LEARNING

Practical Paper No. 2

MATERIALS USED IN TEACHING AND EVALUATING THE CONCEPTS RELATED TO THE BIOLOGICAL CELL IN GRADES 2-6

By Nyles G. Stauss

Report from the Science Concept Learning Project

Milton O. Pella and George T. O'Hearn, Principal Investigators

Wisconsin Research and Development
Center for Cognitive Learning
The University of Wisconsin
Madison, Wisconsin

January 1968

The research and development reported herein was performed pursuant to a contract with the United States Office of Education, Department of Health, Education, and Welfare, under the provisions of the Cooperative Research Program.

Center No. C-03 / Contract OE 5-10-154

PREFACE

Contributing to an understanding of cognitive learning by children and youth—and improving related educational practices—is the goal of the Wisconsin R & D Center. Activities of the Center stem from three major research and development programs, one—Processes and Programs of Instruction—is directed toward the development of instructional programs based on research in teaching and learning and on the evaluation of concepts in subject fields. The staff of the science project, initiated in the first year of the Center, has developed and tested instructional programs dealing with major conceptual schemes in science to determine the level of understanding children of varying experience and ability can attain.

For an investigation into children's learning of concepts related to the biological cell, the lessons and tests described in the Practical Paper were developed. The Introduction briefly describes the study and results which are reported in full in Technical Report No. 40 of the Center.

Herbert J. Klausmeier
Director

CONTENTS

	page
Introduction	vii
Lessons	1
Introductory Lesson	1
1. Cells are parts of living things and living things only.	2
2. Cells have a basic structure.	3
3. The parts of cells have specific functions.	4
4. Plant cells differ in structure depending upon their function.	6
5. Animal cells differ in structure depending upon their function.	7
6. The activities associated with life are carried on in the cell.	9
7. Organisms differ in size depending upon the number of cells possessed, not the cell size.	11
8. Cells come from previously existing cells as a result of the process of division.	12
9. DNA is the important molecule concerned with regulation of cell activities.	15
10. DNA replicates itself and also serves as a template for RNA formation involved in regulation of cell activities.	17
11. Cells cannot grow to indefinite size.	18
Test Directions	21
Tests	22
Lesson 1	22
Lesson 2	23
Lesson 3	24
Lesson 4	25
Lesson 5	26
Lesson 6	28
Lesson 7	29
Lesson 8	30
Lesson 9	32
Lesson 10	33
Lesson 11	34

INTRODUCTION

The value to pupils of developing concepts rather than memorizing facts has been recognized for many years. The use of science concepts and conceptual schemes has recently become the focus for science curriculum development and teaching.

The emphasis on concept learning in elementary science necessitates a selection of concepts fundamental in science and appropriate for specific grade levels. The focus of this study was the identification of the concepts included within the conceptual scheme—the biological cell—most appropriate for study by children in Grades 2-6.

Subproblems were: (1) to determine the relative levels of understanding as indicated by objective test scores, (2) to determine whether significant differences exist between pupils at different grade levels in terms of their level of understanding of each concept, and (3) to determine the relationships within grades of the level of understanding of each concept as indicated by test scores, to IQ and age.

Through the analyses of elementary textbook series, high school and college biology texts, and cytology texts, as well as information gathered through a pilot study, the following concepts were selected and their order decided upon.

1. Cells are parts of living things and living things only.
2. Cells have a basic structure.
3. The parts of cells have specific functions.
4. Plant cells differ in structure depending upon their function.
5. Animal cells differ in structure depending upon their function.
6. The activities associated with life are carried on in the cell.
7. Organisms differ in size depending upon the number of cells possessed, not the cell size.
8. Cells come from previously existing cells as a result of the process of division.
9. DNA is the important molecule concerned with regulation of cell activities.
10. DNA replicates itself and also serves as a template for RNA formation involved in regulation of cell activities.
11. Cells cannot grow to indefinite size.

The instruction for each of the selected concepts consisted of an oral presentation accompanied by appropriate visual materials in the form of photomicrographs of plant and animal tissues, rock sections, and metallic alloys; diagrammatic drawings; pictures; and new or scientific terms. All of these were presented on 2 x 2 slides prepared by the University of Wisconsin Photolab from materials photographed in the laboratory of the Zoology Department or developed at the Research and Development Center. In addition, two film loops were utilized. These were Cytoplasmic Streaming in Plant Cells (R. & M. Allen, Princeton, N.Y.) and Mitosis—Animal and Plant (Technicolor Corp., New York).

Instruction on each concept was presented to one class each at Grades 2-6. The instructional time for a given concept was constant from grade to grade. The length of time devoted to instruction depended upon the concept taught and averaged approximately 20 minutes for each class.

Achievement was measured utilizing multiple response, multiple choice type questions. Questions were of three types, knowledge, comprehension, and application, based on ***Bloom's Taxonomy*** and grouped into separate parts of the test. Equal numbers of each of the three types of questions were used on each of the concept tests. All tests included 36 separate responses to be considered; 12 of each type for each concept.

Because of reading difficulties in several of the lower grade classes, all tests were orally as well as visually presented to the pupils; pupils were encouraged to read along on their individual test copies as the teacher read to the class. Repetitions of reading individual items were carried out without concern for time; however, once a section of the test was completed, return to that portion was not permitted. This was necessary because of the use of materials as clues, described in earlier parts of the test, on later parts.

Testing time for a given concept was constant from grade to grade. The length of time devoted to testing depended upon the concept. Average time per test was approximately 15 minutes. Test reliabilities are as follows:

Test Reliabilities

Test	Levels of Understanding			Total
	Knowledge*	Comprehension*	Application*	
1	.88	.91	.69	.83
2	.40	.43	.70	.51
3	.73	.84	.80	.71
4	.79	.85	.80	.81
5	.73	.85	.86	.82
6	.49	.70	.68	.59
7	.84	.89	.83	.85
8	.71	.55	.71	.66
9	.71	.67	.76	.68
10	.43	.73	-.47	.44
11	.70	.53	.36	.51

*Reliabilities adjusted by Spearman-Brown formula so number of items on subsets is equal to that on total test.

The criterion for the inclusion of a score earned by a pupil as a part of the data analyzed was the attendance of the pupil during all instructional and testing periods. The minimum number of pupils meeting this criterion in any class was 20. When the number of pupils completing the entire instructional and testing sequence exceeded 20 in a given class, the number of pupils was reduced by random exclusion methods.

In order for achievement, with regard to a concept, to be considered satisfactory at a particular grade level, two criteria had to be satisfied. (1) The mean scores on the concept tests had to be significantly higher than a postulated guessing score. (2) A minimum of 50 percent of the class had to score 65 percent or higher of the maximum attainable score. The analysis of variance technique and the Newman-Keuls post-hoc tests were employed to determine whether significant differences in performance existed among the classes. Correlation coefficients between concept test scores and age within a grade and between concept test scores and IQ were calculated and tested for significance.

The grades in which satisfactory mastery of specific concepts was attained at the three levels of understanding were:

Concept 1. Knowledge, comprehension, and application. Grades 2-6.

Concept 2. Knowledge. Grades 2-6. Comprehension. None. Application. Grades 4 and 6.

Concept 3. Knowledge and comprehension. Grades 2-6. Application. Grades 4-6.

Concept 4. Knowledge. Grades 2-6. Comprehension and application. Grades 3-6.

Concept 5. Knowledge. Grades 2-6. Comprehension. Grades 3-6. Application. Grades 4-6.

Concept 6. Knowledge, comprehension, and application. Grades 2-6.

Concept 7. Knowledge. Grades 2-6. Comprehension and application. Grades 4-6.

Concept 8. Knowledge. Grades 3-6. Comprehension and application. Grades 4-6.

Concept 9. Knowledge and comprehension. Grades 2-6. Application. Grades 3-6.

Concept 10. Knowledge. Grades 3-6. Comprehension. Grades 4-6. Application. Grade 6.

Concept 11. Knowledge. Grades 4-6. Comprehension. Grades 5 and 6. Application. None.

LESSONS

INTRODUCTORY LESSON

Visuals	Instructional Procedure
CELL (word)	During the next week or so, we will try to see what we can learn about something called a CELL.
	To help us understand what cells are, and where we find them, we will first look at some other things with which we are familiar.
OBJECT (word) Object = a thing (words)	First, let us consider some *objects*. What do we mean by this word? Well, to put it as simply as possible, we might say that an *object* is a *thing*. Let's look at some examples of objects, or things, to help us understand it better.
Chair (picture)	This is a chair; it is an *object*.
Pencil (picture)	This is a pencil; *it* is an object.
Blue (plain blue slide)	Now, let's look at this. This is blue. Is *blue* an object?
Clear light slide	Here is something else. This is light. Is it an object?
	We can see now that blue, light, hot, cold, and so forth are different from such things or objects as a chair or a pencil.
OBJECTS ARE MADE OF PARTS (words)	Next we want to consider the idea that "Objects are made of parts."
PARTS (word)	Let's look again at the objects we have seen before and see what we mean by "parts" and also what the parts are that our object is made of.
Chair and parts of chair (picture)	Here is the chair again, and these are the parts which make up this chair.
Pencil and parts of pencil (picture)	This is the pencil and these are the parts from which it is made.
Blue—1/2 of slide	But now, let's look at something again which we said was not an object. Blue. It isn't made of parts like the other *objects* were!
	So, we can see that "objects are made of parts." Or, looking at it from the other way around, "parts make up objects."
Parts can make up objects in different ways (words)	Let's consider another important idea. "Parts can make up objects in different ways."
Slides of chair and its parts.	Suppose we look again at the chair and its parts.

Slide of chair parts rearranged to form new object	Let's take these same parts and rearrange them to form a different object. Notice that we have used the same parts, put them together differently and changed the appearance of the object.

We have seen, then, what we mean by an *object*; that objects are made of parts; and, that parts can make up objects in different ways. We will use these ideas in our next study—the cell.

LESSON 1

CELLS ARE PARTS OF LIVING THINGS AND LIVING THINGS ONLY.

Visuals	Instructional Procedure
	We have seen that objects are made of parts. Plants and animals are objects, and it is reasonable to wonder if they are also made of parts.
Plant, showing roots, stems, leaves	Let's look at this plant. We can see that it is made of certain parts. It has leaves; it has a stem; it has roots. It may even have a blossom.
Dog	If we look at a dog, we can see that it, too, has parts. The dog has legs; it has a body; it has a head; it has a tail. All these are parts of the dog.
	But, let's look at the plant and animal again. Could we perhaps see even tinier parts if we looked more closely?
Tradescantia epidermis	If we take a leaf from a plant and place it under a microscope, we will see something like this.
Cells (word)	You are looking at the surface of a leaf and you see all these parts which look like bricks in a wall. The whole leaf is made up of these parts. We call these *cells*.
Sedum epidermis	Here is another slide from a different plant leaf. Notice, again, all the cells. They are shaped differently in this plant leaf, looking much like pieces of a jigsaw puzzle.
	So, we can see that plant leaves are made of these tiny parts called cells. Is this true of other parts of the plant?
Stem x-s (Ranunculus stem x-s)	Well, let's look at a piece from a stem. This stem is cut crosswise like this (illustrate) and a very thin slice is placed on the slide. Looking at it under the microscope, we see this. Again, we see all the little parts we called cells.
Root x-s (Smilax root x-s)	Next, look at this section cut from a root. Notice again, that it, too, is made of cells. Thus, we see that the entire plant is made of these tiny parts we call cells.
Frog epithelium	What about animals? Let's look at a slide showing the skin of the frog. Notice all the little parts again? It would seem that our frog, too, is made of cells.
Human epithelium	Is it possible, then, that we might be made of cells too? If we scrape the inside of our cheek with a toothpick and place the material on a slide, adding a little coloring, we see something like this. Notice, again, all the little cells!
	Later on we're going to be looking at more slides from different parts of plants and animals and we shall see more evidence that *all* plants and animals are made of these tiny parts called cells.

Slide of chair parts rearranged to form new object	Let's take these same parts and rearrange them to form a different object. Notice that we have used the same parts, put them together differently and changed the appearance of the object.
	We have seen, then, what we mean by an *object*; that objects are made of parts; and, that parts can make up objects in different ways. We will use these ideas in our next study—the cell.

LESSON 1

CELLS ARE PARTS OF LIVING THINGS AND LIVING THINGS ONLY.

Visuals	Instructional Procedure
	We have seen that objects are made of parts. Plants and animals are objects, and it is reasonable to wonder if they are also made of parts.
Plant, showing roots, stems, leaves	Let's look at this plant. We can see that it is made of certain parts. It has leaves; it has a stem; it has roots. It may even have a blossom.
Dog	If we look at a dog, we can see that it, too, has parts. The dog has legs; it has a body; it has a head; it has a tail. All these are parts of the dog.
	But, let's look at the plant and animal again. Could we perhaps see even tinier parts if we looked more closely?
Tradescantia epidermis	If we take a leaf from a plant and place it under a microscope, we will see something like this.
Cells (word)	You are looking at the surface of a leaf and you see all these parts which look like bricks in a wall. The whole leaf is made up of these parts. We call these *cells*.
Sedum epidermis	Here is another slide from a different plant leaf. Notice, again, all the cells. They are shaped differently in this plant leaf, looking much like pieces of a jigsaw puzzle.
	So, we can see that plant leaves are made of these tiny parts called cells. Is this true of other parts of the plant?
Stem x-s (Ranunculus stem x-s)	Well, let's look at a piece from a stem. This stem is cut crosswise like this (illustrate) and a very thin slice is placed on the slide. Looking at it under the microscope, we see this. Again, we see all the little parts we called cells.
Root x-s (Smilax root x-s)	Next, look at this section cut from a root. Notice again, that it, too, is made of cells. Thus, we see that the entire plant is made of these tiny parts we call cells.
Frog epithelium	What about animals? Let's look at a slide showing the skin of the frog. Notice all the little parts again? It would seem that our frog, too, is made of cells.
Human epithelium	Is it possible, then, that we might be made of cells too? If we scrape the inside of our cheek with a toothpick and place the material on a slide, adding a little coloring, we see something like this. Notice, again, all the little cells!
	Later on we're going to be looking at more slides from different parts of plants and animals and we shall see more evidence that *all* plants and animals are made of these tiny parts called cells.

Are these cells, then, characteristic of living things, or are objects which are not, and never were, living also made of cells? To answer that question, we must look at some non-living objects.

Metal surface magnified

First, we'll look at a piece of metal under magnification. If we look at it closely, we fail to see these little parts called cells. They just aren't there.

Rock section magnified

Probably no other object is a better example of something which is not alive than a rock. Here we see a thin section cut from a rock and enlarged in the same manner as our other objects were. We do not see any evidence of cells.

Thinking back now, over all the examples we have shown, we find that: *Cells are parts of living things and living things only.*

LESSON 2

CELLS HAVE A BASIC STRUCTURE.

Visuals	Instructional Procedure
	We have seen, in the previous lesson, that living things are made of tiny parts which we call cells. What are these cells like, and of what importance are they in the plant or animal? In this lesson, we will consider the first part of the question to try and see what a cell is like.
Frog epithelium	Let's begin by looking again at the skin cells from the frog.
	Looking carefully, we see these very fine boundary lines surrounding the cells. This is a *very* thin structure that surrounds the entire cell. Only where one cell touches another can we really see it. The structure is given the name CELL MEMBRANE. The diagram on this next slide will show this more clearly.
Cell diagram with only the cell membrane labeled	This *cell membrane* is found in all living cells of plants and animals.
Frog epithelium	Returning to the frog skin slide, notice the dark, somewhat round body. This is the NUCLEUS, and is found in various positions in the cells of almost all plants and animals. Most cells have only one nucleus. In animals, some muscle cells have many.
Diagram of frog cell— cell membrane and nucleus labeled	Returning to the diagram, let's put in the nucleus. So far, then, we have seen two important parts of a cell, the CELL MEMBRANE around the outside, and the NUCLEUS somewhere in the inside.
Frog epithelium	What is all the material found around the nucleus? It is a very important mixture of many substances. We give the name CYTOPLASM to this area.
Diagram of frog cell with cell membrane, nucleus and cytoplasm labeled	Let's locate this on the diagram, too. We now see three important parts of a cell; the *cell membrane*, *nucleus*, and *cytoplasm*. These three parts are usually found in all living cells, both plant cells and animal cells.
	The cells we have looked at, up to now, came from the frog, which is an animal. Let's look now at some cells from a plant and find these same parts, and perhaps some additional ones.
Elodea (word) Elodea leaf cells	The plant we are using is a water plant called Elodea, and we are looking at some cells in a leaf. One of the first things we notice is an extremely broad boundary surrounding the cells here, compared to the frog cells seen before. This is due to the fact that besides having a cell membrane around the cell, plant cells also have another

Visuals	Instructional Procedure
Diagram of a plant cell with cytoplasm, nucleus and a cell wall (wall labeled)	structure around the outside of the cell membrane. This is a CELL WALL. The thickness of the wall varies from cell to cell. In some it is quite thin; in others rather thick. Here is a diagram of a plant cell. It shows the nucleus, cytoplasm, and the *cell wall.*
Elodea leaf cell	Returning to the elodea leaf cell, looking at the cytoplasm we find quite a number of roundish light green bodies in it. These are called CHLOROPLASTS. These chloroplasts are not found in all plant cells, only in those which make food.
Diagram of a plant cell with cytoplasm, nucleus, cell wall, and chloroplasts (chloroplasts labeled)	Let's return to the diagram and locate the chloroplasts.
Film loop of cytoplasmic streaming	For another view of the parts of a plant cell, we'll look at a short film of the living elodea leaf cells. Notice how the cytoplasm moves. Notice also the other parts of the cell again, the cell wall, the nucleus and the chloroplasts.
Diagram of a plant cell with cytoplasm, nucleus, cell wall, chloroplasts, and vacuole (vacuole labeled)	The cytoplasm appears to be moving around the edge of the cells. This is because the center of a living plant cell often has a large storage place called a VACUOLE. In animal cells we do not find such a large vacuole, but rather, many small ones.
Unplasmolyzed onion cells Plasmolyzed onion cells	While we have mentioned the cell membrane as a part found in both animal and plant cells, we have actually noticed its presence only in the animal cell. The reason we cannot readily notice it in the plant cell is that it lies right up against the cell wall and, as thin as it is, we can't visibly separate the two. If we add a salt solution to our material, however, it will cause water to leave the cytoplasm. The result is that the contents of the cell shrink away from the cell wall, which is rigid and can't shrink inward. Looking at a slide of this cell, we can now see where the cell membrane is.
Diagram of plant and animal cells with parts labeled	Our next slide will show a diagram of the animal and plant cells, and their parts which we have shown to you. (Point out the parts of each.) All living cells of plants and animals have these three main parts: cell membrane, cytoplasm, and nucleus. In addition, plant cells have a cell wall. Plant cells which make food also have chloroplasts.
	Cells have other parts besides those shown so far. However, most of these cannot be seen with our microscope, and so we have not mentioned them.

LESSON 3

THE PARTS OF CELLS HAVE SPECIFIC FUNCTIONS.

Visuals	Instructional Procedure
Diagram of a plant and an animal cell with parts labeled	In the last lesson, we learned that plant and animal cells have certain parts. You saw that all living cells have a cell membrane, cytoplasm, and a nucleus. In addition to this you found that plant cells have a cell wall, may have chloroplasts—if they are food-making cells—and usually have a rather large vacuole compared to smaller ones in an animal cell.

Function (word)

Diagram of a plant and an animal cell with parts labeled (keep on screen for balance of lesson)

We are now going to see what the function of each of these parts is. By *function*, we mean the *job* they do for the cell.

Let's begin with the parts that both plants and animals have. The first part we pointed to was the ***cell membrane***. It surrounds the cytoplasm and separates the cells from each other and their surroundings. It also serves another very important function by allowing certain materials needed by the cell, such as food and oxygen, to pass through it into the cytoplasm, and also lets waste material leave the cell. In fact, to a certain extent, the cell membrane controls what can pass in or out and what cannot do so.

The second part we saw was the ***nucleus***. It is extremely important. It is the control center for all the activities of the cell. A cell may continue to live for a certain length of time without a nucleus, but before long it dies. If a cell does not have a nucleus it cannot divide to form new cells when needed, nor can it repair itself or carry on its work for very long. Not only does the nucleus control all the activities of the cell, but it also determines what the cell is or is to become, that is, what type of cell it will grow up to be and what work it will do for the whole plant or animal.

The third part of a cell we discussed was the ***cytoplasm***. Earlier, I called it a mixture of many substances which was found in the area surrounding the nucleus between the cell membrane and the nucleus. As yet scientists do not understand everything that goes on in the cytoplasm. Nor are we familiar, as yet, with all the parts which make up cytoplasm. We do know, however, that it is in the cytoplasm where the activities of the cell occur, such as forming new materials, using oxygen to get energy for the cell from food materials, and so forth. In other words, ***the activities needed to keep the cell alive and working take place in the cytoplasm.***

Another structure which both plant and animal cells have is one or more ***vacuoles***. These are mainly storage places. Here the cell may store food materials for future use, or also, in other vacuoles, waste materials which have not been removed from the cell.

These are the parts found in both animal and plant cells. Let's look now at the function of the parts which are added in plant cells. In plants, we saw that the parts we talked about before are surrounded by a ***cell wall***. This cell wall is laid down around the outside of the cell and has as its main function the job of giving support to the cell and the entire plant. Plants have no skeleton like higher animals, or any other means of support, so the cell wall has to serve this purpose.

The last structures we discussed were the ***chloroplasts***. These are the oval, greenish bodies which are found in the cytoplasm. In the last lesson you were told that the chloroplasts were found only in those plant cells which made food for the plant. The reason is that it is the ***chloroplasts*** which make the food. This is their job. Any cell which does not have chloroplasts cannot make food. There are many cells in plants which don't have chloroplasts and don't make food. Such cells have other jobs to perform. But, those parts of plants which are green have chloroplasts in the cells and these are the food-making cells. They are found mainly in the leaves, although some parts of stems may be green also; and here, too, food can be made.

We have now seen that ***cells are made of certain parts*** and that ***these parts have a definite job to do in the cell.***

LESSON 4

PLANT CELLS DIFFER IN STRUCTURE DEPENDING UPON THEIR FUNCTION.

Visuals	Instructional Procedure
	Up to now we have only looked at frog skin cells and elodea leaf surface cells. Not all cells in plants and animals look like this. In this lesson we are going to look at many kinds of plant cells to show you that *plant cells differ in structure depending upon the work they do*.
Tradescantia epidermis (surface view)	I'm going to start by showing to you again the slide of the surface cells of some leaves. You have seen this once before. Notice how tightly all these cells fit together. These cells have the job of protecting what is underneath, and therefore they *have* to fit together tightly. They protect the cells beneath from drying out. They help to keep disease germs out. To some extent they also help hold together all the cells of the leaf. These surface cells often have a waxy layer on them for added protection.
Tradescantia epidermis (same as previous slide)	As we look around on this slide, we see that certain cells look different from the ones we pointed out before. Notice that they occur in pairs, with a small hole between them. The hole allows air to enter the leaf. Plants need oxygen just as we do. They also need carbon dioxide for making food. However, even though these holes are necessary to allow gases to enter and leave, they also cause considerable loss of water, especially on hot days. These two cells are shaped so they can open and close the hole by getting bigger or smaller. So, these cells are shaped differently than the other surface cells because of their work.
Leaf (w.m.) showing veins Lilac leaf x-s at midrib	Let's look at some other cells. Notice the veins in a leaf. Some of their cells have the job of supporting the leaf; holding it open and flat rather than drooping. If we cut through the leaf and look at the cut edge using a microscope we see that the cells have very thick cell walls. Notice then how these cells also are constructed differently to suit their function.
Lilac leaf (xylem area) Xylem elements in leaf (sketch)	As we look at other cells in the vein, we find that they are hollow. Viewing them from another angle, we see that they are stacked one on top of the other to form a tube. They actually form a sort of pipeline which runs all the way from the roots, up through the stem, and into the leaves. Through these cells, water can thus be carried to all parts of a plant. These cells are no longer living. They have died and all the other parts of the cell have been removed, leaving only the cell walls on the sides. But carrying water is their job. They are formed in these places and then die, leaving only the cell walls behind. Thus, they can serve the water-carrying function for the plant.
Lilac leaf x-s (not thru mid-rib; with chloroplasts)	Next, I'm going to show you another section through the blade of a leaf. Again, we are looking at the cut edge. Here we can see the types of cells which are found in a leaf all the way from the upper surface, through the leaf, down to the bottom surface. This will help us to get a better idea of how these cells differ according to the work they do. Notice the cells on the top and bottom. These are the surface cells we looked at before. Here again you can see how tightly they fit together and in this way they give good protection to the cells

inside. Next, let's look at these long cells under the upper surface. These have chloroplasts in them as you can see. As we learned earlier, only those cells with chloroplasts can make food. So, we see that these cells are specially made for the work they do.

Below them we have some loosely packed cells. They too have chloroplasts and therefore are also adapted for making food. You can see also that these cells have many spaces between them. This allows air coming in through these holes (pointing) to circulate among the cells. Remember that earlier we said cells need oxygen and, also, these food-making cells need the gas carbon dioxide to make sugar.

Here we see some veins. Again you see the hollow cells through which water is carried. You also see here again the cells with very thick walls which help support the leaf.

Ranunculus root x-s (l.p. section)

We have shown that the cells in a leaf differ in structure according to the work they do. Is this also true in the root and stem? This slide is a section through a root. Do you see the water-carrying cells here? (Point) Here (point) we have many large cells with purplish material inside. This material is stored food, stained here so we can see it better. These cells are made for storing food material. Around the outside, we can see cells which protect. Notice how nice and tightly they fit together? Protection, storage, water-carrying; *different jobs, different shape and structure.*

Corn stem x-s (l.p. section)

Is this true in the stem, too? As we look at a section from a stem, we can again see different kinds of cells. They don't all look alike, do they? Some, way around the outside, are tightly packed to protect; some of the cells are big and hollow like this, to carry water; some store materials, and so forth.

Tissue (word)

We have a special name that we give to cells which look alike and do the same work. We give them the name "*tissue.*" So, we have those cells which protect—they make up one tissue; we have those cells which carry water—they make up another tissue; those which store food make up another tissue, and so forth.

By looking at the parts of a plant, we can see that not all plant cells are alike. *Plant cells differ in structure depending upon the work they do.*

LESSON 5

ANIMAL CELLS DIFFER IN STRUCTURE DEPENDING UPON THEIR FUNCTION.

Visuals	Instructional Procedure
Frog epithelium	In the last lesson we looked at a number of cells from different parts of a plant and discovered that plant cells aren't all alike. They differ in structure depending upon the work they do. Is this true also for animal cells? Let's return to the slide of the frog skin cells. These cells are for protection. This is their job. They, too, fit together to form a complete covering. If these cells had a lot of spaces in between them, they couldn't protect very well, could they?
Muscle cells	We'll look at some other animal cells now and see how their structure differs depending upon the work they do. Here are some muscle cells. They are very long, compared to most other cells. These cells have the power to contract, or shorten them-

Diagram of arm and muscle (2 positions)

selves, and when they do they produce movement. In this diagram we can see what happens when the muscle cells in an arm muscle contract or shorten. Notice how this will pull up the forearm. In this muscle of the arm thousands of cells are woven together so they can work together. When these cells contract, the arm is drawn up; when they relax and go back to their original shape, the arm will no longer be held up.

Nerve cells

Diagram—nerve cell; spinal cord to finger

In this next slide we have another kind of animal cell. This is a nerve cell. This cell has many fibers, like wires, to carry messages to the cell and also from the cell to other parts of the body. Some of the fibers are quite long. For example, this cell might be right next to your spinal cord in your back and one of the fibers would run all the way down to your fingertip. Now if it were not for these long fibers, it would be impossible for this cell to perform its function of carrying messages from one part of the body to another. This cell, while it has a cell membrane, cytoplasm, and a nucleus just like the frog skin cells, is still somewhat different because of these fibers. This difference is a good example to show us that ***animal cells***, too, ***are different depending upon the work they do.***

Adipose tissue

The cells you see on this slide are fat cells. That is, they are built to store food material and these specifically, store fat. Here is the cell membrane (pointing), and here you can see the small amount of cytoplasm which remains. The rest of this area, which is now empty because the fat was removed when the slide was made, normally is filled with stored fat. Notice then, that these fat cells are especially designed for storage. They have these large areas in which the material can be stored.

Human blood cells

What you will see in this next example is somewhat different. These cells are normally floating in a liquid. The cells you see are human blood cells. These smaller ones are the red blood cells; the slightly larger ones with the blue objects inside are white blood cells. The shape of the red blood cell allows it to move easily through the blood vessels, even through the tiniest of vessels. Imagine the difficulty they would have if they had long fibers like the nerve cells!

The human red blood cells are unusual in another way. They don't have a nucleus when found in the blood stream. Originally they have one, but it is lost before the cells get into the blood stream. Some believe that this lack of a nucleus enables them to carry more oxygen.

Sketch of a white blood cell engulfing germs

The white cells *do* have a nucleus. You can see it here. Remember, however, all these slides have been treated with stains to make certain parts more visible. These are not the natural colors of the cells. Some white cells have an unusual ability, too. They can change their shape, often moving out of the blood vessels and moving in between other cells. As they meet bacteria, and so forth, they surround them, take them in, and destroy them.

All the examples we have given show that the cells, while generally having the same parts, ***differ depending upon the work they do.*** A cell shaped like a red blood cell wouldn't be very capable of carrying messages over a great distance, nor would it be good for causing movement such as muscle cells do. ***Cells are different depending upon the work they do.***

LESSON 6

THE ACTIVITIES ASSOCIATED WITH LIFE ARE CARRIED ON IN THE CELL.

Visuals | Instructional Procedure

CELL
Unit of structure
(words)

In several earlier lessons the cell was discussed as the *unit of structure* of all living things. That is, all living things are made of cells. While these cells are, in turn, made of many small parts, none of the parts can exist as a structure by itself, at least not for any length of time. None can separately carry on the activities associated with life.

CELL
Unit of function
(words)

The cell, as a unit, can, however, carry on all these activities. It is the smallest part of an organism which can do so. Therefore the cell is not only the unit of structure of all living things, but also the *unit of function*. Thus it is possible to have organisms like the paramecium and amoeba which have only one cell.

While, in the larger plants and animals, cells may differ in their activities as far as the whole organism is concerned, each cell must still carry on certain activities of its own in order to remain a living cell. All these activities require energy, and this energy is supplied by chemical changes within the cell. Different parts of the cell perform different jobs. Yet, all parts must also work together. It is difficult, at times, to determine exactly what is done at a given time by a given part of the cell. We will discuss some of the important activities which take place in a cell. However, they are actually so complicated that we will only be able to tell you a little about them here.

Nutrition—obtaining food (words)

Nutrition—all living cells need food. It is the source of energy which is required to carry on all activities of the cell. In a previous lesson we learned that plant cells which have chloroplasts can make their own food. Other plant cells which do not have chloroplasts must obtain their food from the cells which make it. Animal cells do not have chloroplasts and so all animal cells must take in food from their environment.

Absorption—taking something in (into the cell) (words)

Absorption—by absorption we mean taking something in. As we use the word here, it means taking materials into the cell. In an earlier lesson we learned that the cell membrane played an important part in allowing substances to pass into the cell. In fact, it appears to control this to a considerable extent. Many substances are needed by the cell and must pass into it through the cell membrane. Among the important materials that come in are water, food material and minerals, as well as other chemical substances. All cells must carry on this process of absorption to obtain needed materials.

Digestion—to break food into smaller particles and make it usable (words)

Digestion—In order for food materials to be used by the cell for energy, they must be broken down into rather simple particles. To be taken through the cell membrane, a considerable amount of digestion may have to be done outside of the cell. Many-celled animals have solved this problem by developing special organs for this. The food is broken up into simpler and smaller particles and also made soluble in water. This last step is necessary because water is the carrier or transportation system in living things. Even after the food material is in the cell it may need to undergo changes before it can be used as building material or as a source of energy.

Synthesis—putting together; building (words)

Synthesis—this process involves the building up of the various materials needed in the cell for growth, repair, and so forth. These activities are controlled by the material in the nucleus (DNA). Digestion breaks down complex food molecules into simpler molecules and through the process of *synthesis* these simple molecules are used as building blocks to form the different materials needed by the cell for growth and regulation of its activities.

Respiration—energy release (words)

Respiration—this is the process by which energy is released in the cell when certain molecules from the cell's food supply are split. In most cases this process requires oxygen and finally results in the release of energy and the formation of water and a gas, carbon dioxide. In single-celled plants and animals or very simple ones with more than one cell, the oxygen needed can come into the cell through the cell membrane without great difficulty. The carbon dioxide gas and excess water can leave the same way. In larger animals, like ourselves for example, most of the cells are too far from the surface to get oxygen from the air, and to have the carbon dioxide pass out of the cell and into the air. For this reason we have lungs to help exchange these gases with the outside air, and have blood to carry them to all cells in the body. The energy which is released from the food enables the cell to carry on its life processes.

Excretion—waste removed (words)

Excretion—the general activities of the cell result in the production of certain materials which cannot be used by the cell. Some may even be poisonous if allowed to remain in the cell. These substances must pass out of the cell. Where cells are in close contact with the environment, the substances can be removed without too much difficulty. In larger organisms, special structures help in removing these from the general vicinity of the cell and move them to special areas for elimination.

Secretion—substance made by a cell (words)

Secretion—certain cells produce substances which influence the activities of other cells. These substances are produced by certain cells in a many-celled organism for the purpose of regulating or otherwise influencing the activities of other cells of the organism. Vitamins, hormones, and enzymes of various types are examples of such substances. Even within cells, substances may be produced influencing that particular cell.

Movement—(word)

Movement—This is another characteristic of all cells. Several types of movement may occur. We learned earlier that muscle cells have the ability to contract, or shorten themselves. This is movement. Whole cells may move from place to place under their own power. For example, single-celled organisms can move about. Even in our bodies, certain cells, like some of our white blood cells, can move about. There is also movement within cells. You saw a short film not long ago showing the cytoplasm moving within cells. This type of activity is constantly going on as a means by which materials are moved throughout a cell.

Response—reaction to something (words)

Response—This is an ability to react to various stimuli (outside conditions) which influence the cell; for example, heat, light, touch and many others. It is not as easy for us to see how the cell reacts to some of these things as it is to see the reaction of a whole organism. You have all probably touched something hot, and jumped, or suddenly had a bright light shone in your eyes which caused you to squint. The individual cell, however, also reacts to outside influences. Actually, all of our reactions as an organism are a product of the reactions of individual cells.

Reproduction—produce more of (words)

Reproduction—This is the ability of cells to produce more like themselves. Cells have the ability to divide into two, which when followed by growth, results in two cells just like the one from which they came. This is a very important process upon which organisms depend for growth, repair of injured areas, as well as reproduction of the entire organisms. Most cells which have not become overly specialized for certain jobs can reproduce themselves. Others, like our nerve cells, can no longer do so. Because this is such a very important activity of cells and must be carried out just so, in order to have the new cells like the old, we will study the process in greater detail in another lesson.

Activities
Nutrition, Absorption, Digestion, Synthesis, Respiration, Excretion, Secretion, Movement, Response, Reproduction (in words)

These, then, are some basic activities carried on by cells. (Read through list.) Only living things can carry on these activities. They are characteristics of life.

LESSON 7

ORGANISMS DIFFER IN SIZE DEPENDING UPON THE NUMBER OF CELLS POSSESSED, NOT THE CELL SIZE.

Visuals

Instructional Procedure

We have studied the idea that all living things are made of cells. We have seen that these cells have certain parts, but, at the same time the cells differ somewhat depending upon the work they do. Perhaps you have wondered about the differences between big plants and little plants; big animals and small animals. If all are made up of cells, then, are some plants and animals bigger than others because their cells are *larger*, or because they have *more* cells?

It would be impossible for us to count all the cells in a plant or animal in order to see whether some have more cells than others. So, let's look at some cells of different organisms and see if the larger organisms *have bigger* cells or not. If they do, then we might be safe in saying that the size of a plant or animal depends on the size of its cells. But, if we cannot see a noticeable difference in size, then we may assume that the size of the organism depends on the *number* of cells it has.

Roots, corn and buttercup (cross-sections)

The first slide we have is that of a corn root. Look only at the size of the cells. Now compare the size with that of the buttercup root cells shown here. Both samples are enlarged the same amount by our microscope, so that we can compare them. Are the cells of one much larger than the other? The buttercup plant grows to a height of about 12 to 15 inches, and corn usually grows to be 8 to 10 feet tall. Yet, there is no real difference in the size of their cells. Each has some large cells; each has some smaller ones.

Zea stem, Tilia, 2 yr. old (cross-sections)

Let's compare cells from a corn stem with cells from a basswood tree stem. We know that the basswood tree is taller than a corn plant. Do you see any great difference in cell size here? Many of the corn cells are larger than those of the basswood tree. We see, then, that the size of a large plant must be due to the fact that it has many *more* cells, rather than larger cells.

Visuals	Instructional Procedure
Frog blood Human blood	What about animal cells? Are you bigger than a frog because your cells are larger or because you have more cells than a frog? Here are some frog blood cells and here are some blood cells from a human being. Which are larger? Since the cells of the frog in this case are larger than ours, it might be that we are bigger because we have *more* cells. Now *all* frog cells aren't bigger than all human cells. Some of ours are about the same size as those of the frog; some of ours are larger. But, if we compared cells from different parts of our body to cells of the same kind in a frog, we would find that over-all there is no real difference in size. We are bigger because we have more cells in our body than a frog has.
Elephant epithelium Human epithelium Mouse epithelium	In spite of what we have seen so far, if I asked you whether an elephant's cells were bigger than ours, or those of a mouse, you'd probably still say "yes." After all, an elephant is a *very* large animal, and it would be very hard to believe that his cells were no bigger than ours, or those of a mouse! The following slides show cells taken from the mouth of an elephant, a human, and a mouse. Can you tell which is larger? Surprising as it is, the size of the elephant is *not* due to larger cells. He just has so *many more* cells than we have, or than a mouse has.
Paramecium; amoeba (w.m.) Hydra (w.m.)	Thus we see that living things differ as to the number of cells they have. Some, like these two examples (paramecium and amoeba), have only one cell. Others, while still quite small like this one (hydra), have many cells.
	The bigger the living thing, the more cells it has. *Size of living things*, then, *depends on the number of cells they have*. Large size *does not* mean that cells are larger.

LESSON 8

CELLS COME FROM PREVIOUSLY EXISTING CELLS AS A RESULT OF THE PROCESS OF DIVISION.

Visuals	Instructional Procedure
	We have seen that the bigger a living thing is, the more cells it has. Where do all the cells come from as a baby elephant grows up? Where do all the cells come from that *you* are adding to *your* body as you grow? About a hundred and thirty years ago a number of scientists decided, after careful investigation, that all new cells arose by having cells already there, divide themselves into two. In other words, no cell can be formed in any way except by having another cell divide itself in two.
Onion root tip mitosis	Let's look at how the cell can give rise to another cell by this method. A good place to look for new cells being formed is in a young root tip, because it is growing. The slide we will see now is of a root which has been split lengthwise. This particular one happens to be the tip of an onion root. As we look at the cells in this slide, we see, first of all, some ordinary cells with the cell wall, cytoplasm, and nucleus visible. We do, however, also notice some cells in which the nucleus looks different. Something is going on! Let's follow this nucleus for a while, going from a cell in which the nucleus looks like it did in cells we have seen before, step by step through a series of changes.

In the ordinary cell, all we can see in the nucleus is a grainy material. Remember again, that all these slides are stained with special coloring material, so that we are better able to see certain structures. With the ordinary microscope we cannot see what this grainy material really is like. As we follow a nucleus, however, as our cell goes through the step by step division process, something happens which enables us to see this grainy material more clearly. It looks as though fine threads are formed from this material. Scientists, who have looked at the nucleus with an electron microscope which can enlarge things much more than our light microscopes can, have found that these thread-like structures exist all the time. They only look like grainy material because we can't enlarge them enough to see them with our ordinary microscopes. The reason that we are able to see these thread-like structures when the cell is dividing, is that the threads have coiled up tightly. Look at this diagram. On the left is a thin line which, let's say, is a thread, or piece of wire. Let's coil it up to make a structure such as this, on the right. Now if these were much smaller than they are on the screen, we might have a lot of trouble seeing the piece of wire on the left, but we could still see this coil on the right.

Wire strand and spring

Wire strand and spring (distant view)

Onion root mitosis

So it is with these thread-like parts in the nucleus. Usually, they are uncoiled, and therefore hard to see. But, when the cell gets ready for division, these thread-like parts coil up tightly, and, when they do so, we *can* see them with our microscope.

Why are we so interested in these tiny structures? Do you remember when we studied the parts of a cell and what they did? At that time we said the function of the nucleus was to control all the activities of the cell. We also learned that the nucleus determines what the cell is, or is to become. That is, what type of cell it will grow up to be and what work it will do for the whole plant or animal. It is really the material in these little thread-like structures, called CHROMOSOMES, that controls these things.

Chromosomes (word)

Because these chromosomes are so important, every time a cell divides into two it must make sure that each of the two cells formed gets exactly the same number of these chromosomes. Not only the same number, but the same *kinds*. This is important because the chromosomes are not all alike; they don't all control the same activities.

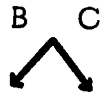
Diagram—group of 8 chromosomes, segregated into two groups of 4, then 2, etc.

How can this be done? We couldn't just split the chromosomes of one cell into two equal groups every time the cell divided, because very soon we'd run out of chromosomes. Besides, if the cells of a certain animal need, let's say, 8 chromosomes to control all the activities, and this cell divided and thus gave each new cell 4, these cells would be missing half the needed number and there wouldn't be anything there to control those activities. This means that each new cell must receive ***exactly*** the same ***number*** of chromosomes and the same ***kinds*** of chromosomes as the cell from which it came.

Diagram—fruit fly chromosomes

How can this happen? Let's use, as an example, a cell from a tiny fly which we often find around ripe bananas and other fruit. We call the little fly a fruit fly because of this. The fruit fly has only eight chromosomes in a cell, as compared with 46 chromosomes in each of ours. Because it has only eight, they can be studied more easily. Scientists have found that the chromosomes always exist in pairs, that is, two are always very alike in their appearance and in the activities of the cell they control. So, in the fruit fly, while there are 8 chromosomes in a cell, there are 4 pairs, since two are always alike.

Diagram (1st division)
A B C D (black)
A B C D (red)



ABCD ABCD

What happens when the cell divides into two? Let's name tne four kinds of chromosomes with the black letters A, B, C, and D, and their partners with red letters A, B, C, and D. We might think that we could divide up the chromosomes between the two new cells as is shown here in this diagram. Each new cell would still have one of each kind of chromosome; but only one of each, instead of two. What would happen the next time the cells divided? If each new cell would get one half of the chromosomes, we could divide them something like is shown in this next diagram.

Diagram (2nd division)
<u>A B C D</u>

AB and CD
or
AC and BD
or
AD and BC

But, notice now that each new cell would no longer have every kind of chromosome. What would control those activities in a cell with only B and C chromosomes that had always been controlled by the A and D chromosomes? We can see that this type of cell division wouldn't be very satisfactory!

Then what *does* happen in the cell so that we don't have these problems? Before the cell begins to divide; even before we can *see* any sign of anything happening in the nucleus, each and every chromosome in the cell is duplicated. By *duplicated*, we mean that the living material in the nucleus constructs new chromosomes just exactly like those the cell already has. Let's look at the next diagram now and see what this means.

Diagram of cell with 2n, then 4n chromosome number: —— > 2n (using letters A-D)

Notice that by duplicating every chromosome before the cell divides, the cell will be able to pass on to the two new cells the same number and kinds of chromosomes that the parent cell had to begin with. This means that each new cell formed will be like the cell from which it came.

Onion mitosis

Now let's go back to the slide of the onion root and follow the chromosomes as the cell divides. Notice in these cells how the chromosomes become more visible. Notice, too, that the nucleus is no longer present as a roundish body. In fact, all that we can see of it are these chromosomes. The nucleus had been surrounded by a membrane much like the cell membrane we studied earlier. This membrane has disappeared and the material formerly in the nucleus is now out in the general cytoplasm.

Eventually the chromosomes move toward the central area of the cell and as we can see in this next stage, they line up in this central area. You may also be able to see some very thin fibers running from one end of the cell to the other. They play a part, too, in the chromosomes' movement.

Diagram: repeat of 2n, 4n, 2n slide

The next step in division is very important. The chromosomes separate into two groups—one for each future new cell. But, they do *not* separate in just any old way! Earlier in this lesson we pointed out some problems if this occurred. Since all the chromosomes had been duplicated earlier, they were able to line up at the central area of the cell in such a way that two of each kind can go to each new cell. This can again be seen in our diagram.

Telophase stage in mitosis with cell plate information
Diagram: Plant cell with new cell wall
Photomicrograph of cell plate formation

With the chromosomes properly separated into two groups, a membrane forms around them, forming a nucleus. The plant cell now forms a new wall through the middle. We can see this better on this diagram, and also on this next photograph where the separation is beginning. When this is completed, we then have two new cells.

Whitefish mitosis

We have looked at the onion root tip. Is the process of cell division similar in animals? Let's look at some animal cells in the process of dividing. These are cells from whi.efish eggs in the process of growing into young fish. Notice that we have the same steps involved here as in the onion. There are a few differences between cell division in plants and division in animals, but the process is basically the same.

One main difference, of course, is in the final step in which the cytoplasm is divided into two. We said that in plant cells a new wall is built through the middle resulting in two cells. Now we know that animal cells don't have a cell wall. Therefore, none can be formed to create two cells. When we watch this last step in animals, we see that the cell sort of pinches itself in two. It can do this *because* it has no rigid cell wall.

Mitosis film-loop

Let's look at this short film to see how a cell divides. With our slides we could not follow a single cell as we can here. Notice that the cell division goes on smoothly from beginning to end. Notice too how the animal cell which is used in this film is able to pinch itself in two after the chromosomes have been properly divided up for the new nucleus for each cell.

In this lesson we have seen that: *All cells come from previously existing cells by a process of division.*

LESSON 9

DNA IS THE IMPORTANT MOLECULE CONCERNED WITH REGULATION OF CELL ACTIVITIES.

Visuals	Instructional Procedure
	In the last lesson, we showed how cells go about the process of reproducing themselves. It was seen that all cells come from previously existing cells by a very exact process of cell division. We also learned about the importance of the chromosomes in this process in that they contain the material which controls the activities of the cells, and therefore when a cell divides, it will have to provide each new cell with a set of chromosomes like those of its own.
Protein Nucleic acid (words)	Perhaps you may wonder what these chromosomes are made of and how they can control the activities of the cell. It had been known for some time that the chromosomes were made of two kinds of chemical substances called protein and nucleic acid. Since it was known that the chromosomes controlled the activities of the cell, the question was asked, "Does the protein part of the chromosome control the cell activity, or does the nucleic acid do this?" Studies carried on during World War II showed that it was the nucleic acid which controlled the activities of the cell. What is this strange material which has such great influence? Until recently, only the chemical composition (make-up) of nucleic acid was known, but not how the atoms of these chemicals are arranged.
Deoxyribonucleic acid, or DNA (words)	In 1953 two scientists succeeded in working out the physical structure of the nucleic acid called deoxyribonucleic acid, or DNA for short. That is, they were able to determine how the atoms of the chemicals in this substance are arranged. This was extremely important, since it was found that differences in the arrangement of

sections of the DNA molecule affect the activities of the cell. In other words, it is the DNA which apparently controls the cell's activities.

Let's consider this DNA molecule and see how scientists believe it to be constructed. Actually, at the present time we have no direct method by which we can see this molecule and what we know about its structure, or believe to be its structure, is based upon indirect observations.

Diagram: twisted ladder model of DNA

Scientists constructed a model of what they thought the DNA molecule looks like. This diagram shows some characteristics of a part of this molecule as visualized by the scientists. It is built something like a ladder which is then twisted, or coiled, as is shown in this next picture.

Diagram: twisted ladder model of DNA with types of molecules represented

Though we speak about the DNA *molecule*, it is actually composed of many smaller molecules. Surprisingly, there are only six basic kinds of these molecules in DNA. In the siderails, we have molecules of phosphates alternating with molecules of a special sugar, called deoxyribose sugar. We have represented these with the letter P, for the phosphate molecule, and the letter S, for the sugar molecule. This arrangement is the same for all DNA molecules. Therefore, there must be something else about the molecules of DNA which makes them differ enough so different parts of DNA molecules control different activities of the cell.

Adenine - A
Guanine - G
Thymine - T
Cytosine - C (words)

Diagram: twisted ladder model of DNA with types of molecules represented

If we look at the rungs of the ladder, we find that only four kinds of molecules appear, with only two per rung. The molecules involved are named, ***adenine***, ***guanine***, ***thymine***, and ***cytosine***. We represent them here by the letters A, G, T and C. You will notice that in this molecule A and T are always together, and C and G—never other combinations. The difference between DNA molecules is then apparently due only to which rung, A-T or C-G, is found at a given location, and the overall frequency of particular rungs in a certain area of the molecule. You will notice that the rungs are always attached to the sugar molecule in the siderails, not to the phosphate. So, we do not have any variation here. Parts of this DNA molecule control certain activities of the cell. We are not positive of the exact method, but experimentation has shown that if certain sections of the chromosome, and thus of the DNA molecule, are removed, certain activities of the cell are affected.

We see then, that the DNA is involved in control, and, we also believe that it is the arrangement of the rungs of this twisted ladder-like molecule which not only determines what activities will be controlled, but also how. That is, the arrangement directs these activities.

Atomistic model of DNA

This ladder model of DNA does not give us a very good idea of how complex DNA really is, since it only shows the areas occupied by the six smaller molecules of which it is composed. This next picture shows a more detailed model of a portion of the DNA molecule with different colored balls representing the ***atoms*** of the various elements which make up the six kinds of molecules found in DNA. Remember this model is only of a part of a DNA molecule, and that the entire molecule is actually so small that we cannot see it with our microscope.

What is even more amazing is that when a cell divides, and we say the chromosomes duplicate themselves, every one of these complex DNA molecules must duplicate itself. In the next lesson we will try to see how scientists believe this duplication is accomplished.

LESSON 10

DNA REPLICATES ITSELF AND ALSO SERVES AS A TEMPLATE FOR RNA FORMATION INVOLVED IN REGULATION OF CELL ACTIVITIES.

Visuals	Instructional Procedure
Replicate (word)	In the last lesson we discussed the scientists' ideas concerning the chemical make-up of the chromosome, especially the structure of the important nucleic acid, DNA. Since it has been shown that this DNA is responsible for controlling the activities of the cell, we want to examine the current theory of how these molecules duplicate, or, as the scientists refer to it, *replicate* themselves, when cell division takes place.
Diagram: ladder model of DNA with symbols representing molecules	Let's look, again, at a diagram representing a portion of the DNA molecule. This diagram looks a little different from the ladder we showed yesterday. Here we have different-shaped symbols for the six basic molecules of which DNA is composed. The shaded circles represent the phosphates and the pentagons, or five-sided figures, represent the sugar molecules. Since A and T always go together in a rung of the ladder, they are represented by symbols which fit together in such a way that neither G nor C could be attached. The same is true for the G-C combination.
	Remember now, this is only a diagram. The symbols we use only stand for these molecules. The molecules do *not* look like the symbols any more than a stick-man really looks like you. The diagram, however, does help us to sort of form a picture in our mind which is useful in understanding what we think takes place.
Diagram showing "splitting" of DNA molecule Nucleotide (word) Diagram showing nucleotides attaching Diagram: DNA model after replication	All these molecules of which DNA is composed are manufactured in the cell, as needed. When the time arrives for the DNA molecule to replicate itself, the chemical bonds holding A to T and C to G break, and so the ladder begins to come apart down the middle. As this occurs, new molecules which had been made in the cell now attach themselves to these free ends. Usually these new molecules are not found singly in the cell, but rather in small groups called *nucleotides*, made of either an A, G, C, or T—that is, one of these attached to a sugar molecule and a phosphate group. One after the other attaches itself to the free ends of the old DNA molecule until two complete molecules have been formed. The DNA molecule has thus succeeded in making an exact copy of itself.
	It should be mentioned again that we have not been able to observe this directly and the diagrams and the model of DNA molecule only represent what we *think* is happening. Unless or until we find some situation or problem which cannot be answered with this model, it will remain very useful in helping us to understand the cell's ability to duplicate the material of its chromosomes and thus provide a complete set for the new cells formed in the process of division.
	It has been said before that the DNA and its replication are important because the DNA appears to control the cell's activities. How does it do this? In a certain way the method by which DNA sends messages, so to speak, to the proper places in the cytoplasm on how to make certain substances, is somewhat similar to the way it duplicates itself.
	The manner in which the directions of DNA are carried into the cytoplasm and followed, involves another chemical substance which

Ribose (word) Uracil (U) (word)	is very closely related to DNA. It is also a nucleic acid and is very much like DNA. Actually, it differs only in two ways. The sugar molecule is slightly different (has one more atom of oxygen), and is called *ribose* rather than deoxyribose, and instead of containing the material thymine or T, it contains a slightly different material called *uracil* or U. Mainly because of the difference in the sugar part, we call this nucleic acid, *ribonucleic acid*, or RNA, for short.
Sketch of animal type cell with parts labeled Ribosomes (word) Diagrams of messenger RNA template formation	When certain materials are to be made in the cell, a message must be sent from the DNA in the nucleus to the manufacturing areas in the cytoplasm. These areas are tiny granules in the cytoplasm called *ribosomes*. The message is sent by having that part of the DNA molecule which controls this particular activity make a pattern of itself out of RNA material. This piece of RNA then leaves the nucleus and moves to the manufacturing areas, the ribosomes, in the cytoplasm. Because it carries the message from the DNA to this area it is referred to as "*Messenger RNA*." The Messenger RNA attaches itself to the ribosome where it serves as a template, or pattern. Other RNA in the cytoplasm (Transfer RNA) bring the building blocks of which proteins are made to the RNA on the ribosome, and there, then, the proteins are put together.
Enzymes (word)	Since most proteins in the cell are enzymes, and the enzymes are substances which direct all cellular activities, we can see the manner in which DNA controls the cell's activities.
Sketch to summarize DNA, RNA, protein synthesis relationship	Going over the steps briefly again, we find that certain parts of the DNA molecule control certain cell activities. They transfer their directions to the places in the cytoplasm where the activities are carried out by having a pattern made of RNA. This RNA leaves the nucleus and goes to the ribosomes in the cytoplasm where it serves as a pattern for enzyme building. These enzymes direct the cell's activities.

LESSON 11

CELLS CANNOT GROW TO INDEFINITE SIZE.

Visuals	Instructional Procedure
	In the last few lessons we have examined the process by which cells divide to form new cells. We have also studied the material called DNA in the chromosomes of the nucleus and have seen how this material replicates itself, as well as how it is able to direct the activities of the cell.
Paramecium (word) Paramecium fission	An important question which we will now consider is: "Why do cells divide?" We can see several advantages for having cell division. Take a look at this slide of the one-celled animal, *Paramecium*, which we saw in an earlier lesson. Notice that when the single cell, of which this animal is composed, divides, we end up with two animals instead of one. As far as single-celled living things are concerned then, cell division results in increasing the number of organisms, or, reproduction.
Hydra (word) Hydra (w.m.)	The next slide is of a larger animal, the hydra. It is made of many cells. In this animal little buds may grow out of the side and these develop into a whole new individual. When mature enough, it breaks away from the parent and we now have two animals. Where

did the cells in the young animal come from? By cell division, of course. Again, cell division may give rise to more animals.

But, we can see another result of cell division in this animal and that is the formation of a larger animal than the one-celled paramecium. By having cells divide and remain together, rather than separating as in the paramecium, larger animals like this hydra can develop, or still larger animals, like ourselves. We are made of a very large number of cells.

Couldn't just as large an organism be formed by simply having one cell grow extremely large? After all, the paramecium is a whole animal which can eat and swim, and so forth, *even* though it has only one cell. Perhaps there are reasons why the cell cannot keep on growing. Let's look at some theories that have been advanced as to why a cell needs to divide, rather than being able to continue its growth indefinitely.

Diagram: animal type-cell with parts labeled

One theory as to why cells cannot increase in size beyond a certain point concerns the volume-surface area relationship. All the material necessary to keep the cell alive must pass into the cell through the cell membrane. Likewise, all waste material produced in the cell must pass out through the cell membrane. As a cell increases in size, the amount of cytoplasm increases. Thus the cell requires more and more materials and produces more and more waste. All of this must pass through the cell membrane.

Diagram of blocks illustrating area and volume calculations

You might think that as the cell grows larger, so does the surface area of the cell membrane. This is true, but the surface area does not increase at the same rate as the volume. It increases much more slowly. Let's look at this diagram and use a little arithmetic to see this. Let's assume that the length of a side of the small block is *one* unit. The volume of the block is then 1 x 1 x 1 = 1 cubic unit. If we stack 8 of these small blocks to make a large one as shown here, the volume will be 8 cubic units (each small one was 1 cubic unit and we stacked 8 of them). Thus, the volume has increased 8 times in going from the small block to the large one.

Now, let's look at the surface area. The area of each side of the small block is 1 x 1 = 1 sq. unit. The block has 6 such sides for a total surface area of 6 sq. units. How many square units of surface area does the large block have? Let's count all the small squares exposed to the outside. There are 4 on each side of the big block, for a total of 24 on the entire block, or, 24 sq. units of surface area. The small one had 6 sq. units, so the large block has 4 times as much.

You will see now that the volume increased 8 times, and the surface area only 4 times. So, we can see that each unit of surface area must now serve two units of volume. If we were to increase the size of the block still more, each unit of surface would have to serve an even greater volume. The same is true in the case of the cell membrane and the volume of cytoplasm it serves. Eventually not enough material could pass through the cell membrane to meet the needs of the cytoplasm, and the cell would die.

Diffusion (word)
Sketch—illustrating diffusion

Another theory concerning the reason why cells cannot be successful if they are overly large concerns the distribution of materials inside the cytoplasm. Materials spread throughout the cytoplasm by a process called *diffusion*. By this process, molecules of substances tend to spread themselves evenly throughout another substance. It takes material longer to spread throughout a larger volume of cytoplasm than throughout a small volume. All these materials, as mentioned before, come in through the cell membrane. If the cell would become extremely large, it would take too long for the materials to reach the central areas of the cell.

Related to this is another factor which has been noticed in connection with cell size. Animals whose cells have a rather high rate of cell activity, such as mosquitoes, bees, hummingbirds, etc., generally have smaller cells than animals in which the rate of cell activity is slower. This is to be expected, since cells with a high rate of activity need more materials brought into the cell in a shorter period of time, than do cells with a slow rate of activity. And, as we have seen before, smaller cells have greater surface area per unit of volume through which to accomplish this, and also, have shorter distances through which to diffuse materials. Thus, in animals of this type, there is a limit to how large the cell can get, depending upon the rate of cell activity.

Diagram of an animal-type cell with parts labeled

Another theory involves the role of the nucleus in the cell. We learned earlier that the nucleus controls the activities of the cell. Many of these activities are carried out in the cytoplasm. Perhaps then, the nucleus can only efficiently exercise control over a certain amount of cytoplasm. If the cytoplasm becomes too large, that is, if it occupies too great an area, the nucleus may not be able to exercise its control efficiently. This may, in part, be associated again with the problem of diffusion of materials such as Messenger RNA. Therefore, the cell may need to maintain a certain ratio between amount of nucleus and amount of cytoplasm.

Another fact which must be remembered, is that the nucleus is also surrounded by a membrane. If the size or amount of cytoplasm increases, more materials must be exchanged through this membrane surrounding the nucleus. Even if the nucleus becomes larger, this problem will not be solved, since just as in the case of the cell membrane, the membrane around the nucleus does not undergo an increase in surface area at the same rate as the volume of the nucleus would increase.

Amoeba (w.m.)

To see if cell size might really be a factor in cell division, scientists have taken an amoeba, such as one of these, and cut away a part of the cytoplasm each time it approached normal size. The amoeba did not divide. In one experiment an amoeba had a piece cut off daily for four months and did not divide. During the same time another amoeba, allowed to grow freely, underwent 65 divisions!

Size alone does not, however, *cause* a cell to divide. Many cells do not divide upon reaching full growth. Apparently the nucleus gives the signal for division to take place. How and why it reaches a decision to give the signal is not known as yet.

TEST DIRECTIONS

The tests that you will be given on each lesson are a combination of multiple-choice and yes-no questions. Every main question will have a number of responses listed. As you read each one you will have to decide whether it is correct or not. If it is correct, ***draw a circle*** around the word "yes"; if it is ***not*** correct ***draw a circle*** around the word "no."*

Let's try the following question together for practice:

A chair

<u>Yes</u> No	1.	is an object.
Yes <u>No</u>	2.	is not made of parts.
<u>Yes</u> No	3.	is a thing.
Yes <u>No</u>	4.	is a part of an object.

Like a multiple-choice question, this particular question had *four* possible answers. However, instead of only one choice being correct, there were two "yes" answers. So, throughout our tests you will have to think about every possible choice. In some questions they might all be "no"; in others, all "yes"; or, some "yes" and some "no." Therefore, please think carefully about every one.

*In this paper, correct answers are underlined.

Let's try one more example to help us get used to this type of question. I will alwa_s be reading the questions out loud to you and you can then follow along on your question sheet.

A boy looks out of the window and sees that it is raining. If he goes outside

<u>Yes</u> No	1.	he will probably get wet.
Yes <u>No</u>	2.	he should wear a hat to provide shade from the sun.
<u>Yes</u> No	3.	he should wear a raincoat.
Yes <u>No</u>	4.	it will stop raining.
Yes <u>No</u>	5.	the flowers will now grow better.

Notice again that there is more than one correct choice. Notice, too, that while each question must be considered separately, we must always go back to the little story and to the first part of the sentence we are trying to complete.

Be sure that you always write your name at the top of your paper. Also be sure that you always answer ***every*** question.

TESTS

LESSON 1

Part I:

It has been found that plants

<u>Yes</u> No 1. may have parts such as stems and leaves.
<u>Yes</u> No 2. may have parts called cells.
Yes <u>No</u> 3. have cells only in leaves.
<u>Yes</u> No 4. have cells in all parts of the plant.
Yes <u>No</u> 5. need not be made of cells.

Our study of animals showed that

<u>Yes</u> No 6. cells are found in frogs.
Yes <u>No</u> 7. no cells are found in humans.
<u>Yes</u> No 8. all animals are made of cells.

In comparing living things with nonliving things, it is known that

<u>Yes</u> No 9. all living things are made of cells.
Yes <u>No</u> 10. only some living things are made of cells.
Yes <u>No</u> 11. nonliving things are also made of cells.
Yes <u>No</u> 12. a piece of rock may be made of cells.

Part II:

If we looked at a tomato plant, we would find that

Yes <u>No</u> 1. it did not have any cells.
Yes <u>No</u> 2. it had cells in its leaves only.
<u>Yes</u> No 3. the entire tomato plant is made of cells.
Yes <u>No</u> 4. it would have a few cells scattered throughout its body.

Examination of a mouse would show that

Yes <u>No</u> 5. it did not have any cells.
<u>Yes</u> No 6. it had cells in its tail.
Yes <u>No</u> 7. only certain parts had cells.
<u>Yes</u> No 8. its whole body is made of cells.

A piece of granite rock

Yes <u>No</u> 9. would have some cells in it.
Yes <u>No</u> 10. would have cells like living things do.
<u>Yes</u> No 11. would not have any cells.
Yes <u>No</u> 12. would have cells much larger than those in living things.

Part III:

You are given an object and must decide whether it is living or nonliving. If it were living,

Yes <u>No</u> 1. it would not be made of parts.
Yes <u>No</u> 2. it might have cells but need not.
Yes <u>No</u> 3. it would have parts, but these would not be cells.
<u>Yes</u> No 4. cells could be seen with a microscope.

You are given an object and must decide whether it is living or nonliving. If it were nonliving,

Yes <u>No</u> 5. it would not be made of parts.
<u>Yes</u> No 6. it might be made of parts, but not cells.
Yes <u>No</u> 7. cells could be seen with a microscope.

GPO 807-736-4

A number of slides will be shown on the screen. Look at them carefully and decide whether what you see came from a living object or a non-living object.

Yes No 8. Is this from a living object? [Granite slide]

Yes No 9. Is this from a living object? [Corn leaf x-s]

Yes No 10. Is this from a living object? [Metal]

Yes No 11. Is this from a living object? [Hydra x-s]

Yes No 12. Is this from a living object? [Blood smear]

TEST
LESSON 2

Part I:

Looking at cells under a microscope, we see that

Yes No 1. the cell membrane is located around the cytoplasm.

Yes No 2. the nucleus is surrounded by cytoplasm.

Yes No 3. animal cells have cell walls.

Yes No 4. plant cells have a cell membrane.

Plant cells differ from animal cells in that plant cells

Yes No 5. do not have vacuoles.

Yes No 6. have chloroplasts in all of their cells.

Yes No 7. have a cell wall.

Yes No 8. do not have the parts found in the animal cells.

Animal and plant cells

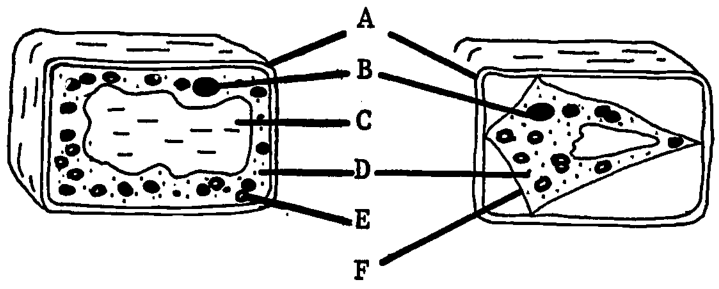
Yes No 9. have a nucleus, cytoplasm and cell membrane.

Yes No 10. usually have vacuoles of about the same size.

Yes No 11. do not have any of the same parts.

Yes No 12. are exactly alike in structure.

Part II:



The drawings above represent cells, in which

Yes No 1. the letter C points to the cytoplasm.

Yes No 2. the letter E points to a nucleus.

Yes No 3. the letter B points to a nucleus.

Yes No 4. drawing number one represents an animal cell.

Yes No 5. the letter F points to the nucleus of a plant cell.

Yes No 6. drawing #2 shows the cytoplasm pulled away from the cell wall.

In an animal such as a mouse, the cell

Yes No 7. would have a large vacuole.

Yes No 8. would not have a cell wall.

Yes No 9. would have a cell membrane, but no cell wall.

If you were looking at cells from a tomato plant,

Yes No 10. all the cells would have chloroplasts.

Yes No 11. some cells would not have a cell membrane.

Yes No 12. all the cells would have a cell wall.

Part III:

You are looking at a cell under the microscope and you see a nucleus, chloroplasts, and cytoplasm. This cell *could* be from

Yes No 1. a cat.

Yes No 2. a carrot leaf.

Yes No 3. any kind of green plant.

Yes No 4. a very large tree.

Yes No 5. any kind of animal.

Yes No 6. either a plant or an animal.

A boy is looking at a number of different kinds of cells. He is asked to put all animal cells into one group and all plant cells into another.

Yes <u>No</u> 7. All cells with a cell membrane should go into the animal group.

Yes <u>No</u> 8. If he sees a nucleus and a vacuole he can decide into which group to place the cell.

Yes <u>No</u> 9. A cell can go into the animal group if it has only a few chloroplasts in the cytoplasm.

<u>Yes</u> No 10. He might not be able to decide into which group to place the cell unless he saw a cell wall.

Yes <u>No</u> 11. If he sees cytoplasm he can decide into which group to place the cell.

Yes <u>No</u> 12. It would be impossible to separate any of them.

TEST
LESSON 3

Part I:

In the living cell

<u>Yes</u> No 1. the cell membrane controls what materials may pass into or out of the cell.

Yes <u>No</u> 2. the nucleus stores waste materials which have not been removed from the cell.

<u>Yes</u> No 3. the vacuoles are mainly storage places.

<u>Yes</u> No 4. many of the activities needed to keep the cell alive take place in the cytoplasm.

In plant cells

<u>Yes</u> No 5. the chloroplasts make the food.

<u>Yes</u> No 6. the cell wall surrounds the entire cell and gives support to the plant.

<u>Yes</u> No 7. the nucleus determines what type of work the cell will do for the whole plant.

Yes <u>No</u> 8. the cell membrane does nothing.

In animal cells

<u>Yes</u> No 9. the cell membrane separates the cells from each other.

<u>Yes</u> No 10. the cells cannot divide if they don't have a nucleus.

<u>Yes</u> No 11. the vacuoles store materials.

Yes <u>No</u> 12. the cell membrane does not allow waste materials to leave the cell.

Part II:

You have learned that the cell wall gives support to the cell. A large tree would most likely

Yes <u>No</u> 1. have a skeleton to hold it up.

Yes <u>No</u> 2. have many cells with no cell wall.

<u>Yes</u> No 3. have many cells with thick cell walls.

Yes <u>No</u> 4. have no need for cell walls for support.

Cells need chloroplasts to make food. Certain food materials are stored in the vacuoles. The sugar cane plant contains much sugar.

<u>Yes</u> No 5. Some of its cells must contain chloroplasts.

Yes <u>No</u> 6. The soil in which it grows must contain sugar.

<u>Yes</u> No 7. It is likely that many cells in the plant have large vacuoles.

Yes <u>No</u> 8. There is no connection between the presence of sugar in the plant cells and the chloroplasts.

The cytoplasm of the cell is surrounded by a cell membrane which somewhat controls what materials pass into and out of the cell. You would expect that

<u>Yes</u> No 9. animal cells need a cell membrane.

Yes <u>No</u> 10. plant cells do not need a cell membrane because they have a cell wall.

<u>Yes</u> No 11. all living cells need a cell membrane.

Yes <u>No</u> 12. only cells without a nucleus need a cell membrane.

Part III:

A thin piece of a plant stem is looked at by means of a microscope, and it is found to be made up of cells that have no chloroplasts in them. Because of this, you can decide that

Yes **No** 1. the cell could not have been able to get rid of wastes.

Yes No 2. the cell could not have made any food.

Yes **No** 3. chloroplasts aren't necessary in cells for making food.

Yes **No** 4. some other part of the cell also makes food.

An amoeba, a single-celled animal, has had its nucleus removed by means of surgery. It would be reasonable to expect that

Yes **No** 5. the amoeba would divide, forming two.

Yes No 6. the amoeba could live for a while as the cytoplasm continues its activity.

Yes No 7. the amoeba will die before long because nothing remains to control its activities.

Yes **No** 8. the amoeba would continue to grow and carry on all its activities.

In all living cells, the cytoplasm is surrounded by a cell membrane. A value of this may be that

Yes No 9. certain materials can be kept out of the cytoplasm.

Yes No 10. it holds the cytoplasm together.

Yes **No** 11. it keeps the material of the nucleus separated from the cytoplasm.

Yes No 12. it controls the movement of needed materials into the cytoplasm.

TEST LESSON 4

Part I:

The surface cells of a leaf

Yes No 1. protect the cells beneath from drying out.

Yes **No** 2. are the chief food making parts of the leaf.

Yes No 3. fit together tightly for better protection.

The cells which give most support to the plant

Yes **No** 4. have many chloroplasts.

Yes No 5. have thick cell walls.

Yes **No** 6. have no special characteristics.

Cells which carry water in the plant

Yes **No** 7. have a nucleus, cytoplasm and chloroplasts.

Yes No 8. form hollow tubes through which the water passes.

Yes No 9. are dead.

Plant cells

Yes No 10. differ in structure depending upon the work they do.

Yes **No** 11. do not differ in the work they do.

Yes **No** 12. are all alike in structure.

Part II:

Plant cells differ in structure depending upon the work they do. Water-carrying cells in a bean plant

Yes No 1. would be hollow and tube-like.

Yes No 2. would probably look different than storage cells.

Yes **No** 3. might also have chloroplasts and make food.

Yes No 4. have no living parts left in them.

Those cells which look alike and do the same work are called a tissue. Do the following types of cells belong to the same kind of tissue?

<u>Yes</u> No 5. Surface cells from the leaf of a bean plant and surface cells from the stem of the bean plant.

Yes <u>No</u> 6. Water-carrying cells in the leaf and food making cells in the leaf.

<u>Yes</u> No 7. Water-carrying cells in the leaf and water-carrying cells in the root.

<u>Yes</u> No 8. Food storage cells in a stem and food storage cells in a root.

Cells of different structure do different kinds of work in a plant. In a carrot plant,

Yes <u>No</u> 9. cells with many chloroplasts do the same work as cells without chloroplasts.

<u>Yes</u> No 10. the hollow tube-like water-carrying cells do not do the same work as cells with large vacuoles.

Yes <u>No</u> 11. the thick-walled support-giving cells also make food.

Yes <u>No</u> 12. all of the cells do the same work even if built differently.

Part III:

You are looking at a slide showing a section through a plant stem. You notice that some cells have rather thick walls and no longer contain the living parts of a cell.

<u>Yes</u> No 1. These cells probably help to support the plant.

Yes <u>No</u> 2. These cells are useless.

<u>Yes</u> No 3. These cells may carry water in the plant.

Yes <u>No</u> 4. These cells may serve as a storage place for food materials.

Some plant cells have been looked at by means of a microscope, and found to contain a large number of chloroplasts in the cytoplasm. These cells probably

Yes <u>No</u> 5. are most often used for storage.

<u>Yes</u> No 6. make food.

Yes <u>No</u> 7. protect the water-carrying cells.

Yes <u>No</u> 8. give support to the leaf.

A section of a bean plant root is being looked at by means of a microscope. We are to find some cells adapted for the job of carrying water. We would look for

Yes <u>No</u> 9. cells with thin walls and large vacuoles.

Yes <u>No</u> 10. cells with many chloroplasts in the cytoplasm.

<u>Yes</u> No 11. hollow cells with thick walls.

Yes <u>No</u> 12. thick walled cells containing cytoplasm.

TEST
LESSON 5

Part I:

The muscle cells of animals

<u>Yes</u> No 1. are long when compared to skin cells.

<u>Yes</u> No 2. have the ability to shorten themselves.

<u>Yes</u> No 3. are able to produce movement.

Nerve cells

Yes <u>No</u> 4. do not have a cell membrane, nucleus and cytoplasm.

Yes <u>No</u> 5. have large storage vacuoles.

<u>Yes</u> No 6. have long fibers.

White blood cells

Yes <u>No</u> 7. have long fibers.

<u>Yes</u> No 8. have a nucleus, cell membrane and cytoplasm.

<u>Yes</u> No 9. have a shape which enables them to flow easily through vessels.

Animal cells

Yes <u>No</u> 10. are all alike.

Yes <u>No</u> 11. all do the same work.

<u>Yes</u> No 12. differ in structure depending upon the work they do.

Part II:

Animal cells differ in structure depending upon the work they do. You would expect the muscle cells of a mouse

Yes No 1. to have a structure much like muscle cells in a frog.
Yes No 2. to be quite different in structure than the blood cells of a mouse.
Yes **No** 3. to have long fibers like the nerve cells of the mouse.
Yes **No** 4. to be no different in structure than any other cells of a mouse.

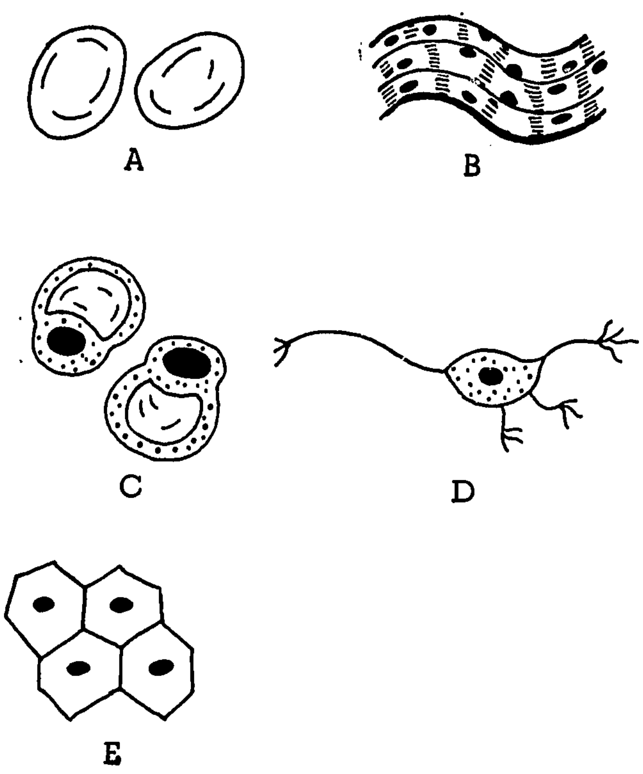
Cells which have the same structure and do the same work are called a tissue. Do the following types of cells belong to the same kind of tissue?

Yes **No** 5. Blood cells in a mouse and nerve cells in a mouse.
Yes No 6. Nerve cells in a mouse and nerve cells in a dog.
Yes No 7. Muscle cells in a mouse tail and muscle cells in a mouse leg.
Yes **No** 8. All of the cells in a cat.

Animal cells with different structures do different kinds of work. If we studied a rabbit,

Yes **No** 9. its muscle cells would have large vacuoles for food storage.
Yes **No** 10. its nerve cells would be mainly concerned with destroying germs.
Yes **No** 11. it would have different kinds of cells doing the same work.
Yes **No** 12. all of its cells would be alike.

Part III:



The drawings above represent animal cells.

Yes **No** 1. A and B show cells from the same kind of tissue.
Yes **No** 2. The cells shown in C and E would do the same kind of work.
Yes **No** 3. Cells in D and E are for covering and protecting.
Yes **No** 4. All the cells pictured have the same function.

You are given a slide with different kinds of animal cells and you are asked to find cells with a structure that would be best suited for the function of producing movement. You would look for cells which

Yes **No** 5. are ball-shaped.
Yes **No** 6. could be any shape, but have a food storage area.
Yes No 7. are rather long and narrow with the ability to shorten themselves.
Yes **No** 8. have long thin fibers.

As you are looking at different kinds of animal cells, you come across some which are tightly packed together. They look like a group of flat, many-sided stones side by side with no space between them. The function of these cells might be to

Yes **No** 9. carry messages.
Yes **No** 10. produce movement.
Yes No 11. cover and protect.
Yes **No** 12. make food.

TEST
LESSON 6

Part I:

In many-celled living things,

Yes No 1. the cells have special jobs to do for the whole organism.
Yes No 2. the cells carry on certain activities of their own.
Yes No 3. the cells require energy to carry on activities.
Yes No 4. the parts of cells carry on the activities of the cell.

Individual cells

Yes **No** 5. can always make their own food.
Yes **No** 6. do not need oxygen.
Yes No 7. build up complex materials from simpler materials.
Yes No 8. produce some materials which cannot be used by the cell.

The activity of the cell

Yes No 9. involving a reaction to outside influences is called a ***response.***
Yes No 10. by which energy is released from food molecules is called ***respiration.***
Yes **No** 11. in which large food molecules are broken down into smaller ones is called ***synthesis.***
Yes **No** 12. which results in production of materials that influence other cells is called ***absorption.***

Part II:

The cell has been found to be the unit of function of living things.

Yes No 1. None of the parts of a cell can, by itself, remain alive.
Yes **No** 2. None of the parts of a cell perform any function.
Yes No 3. All activities needed for life are carried on by a cell.
Yes No 4. In organisms made up of many cells, the cell still functions as a unit.

The amoeba is a one-celled animal. It is reasonable to expect that:

Yes No 5. it must have food as a source of energy.
Yes **No** 6. there is no movement in its cytoplasm.
Yes No 7. it would be able to react to stimuli, such as heat or light.
Yes No 8. it carries on all of the normal cell activities.

If a cell of a tomato plant is to remain alive,

Yes No 9. it must take in oxygen for respiration.
Yes **No** 10. it must reproduce itself.
Yes No 11. it must remove waste materials which are formed.
Yes No 12. it will need food from which to get energy.

Part III:

How are the living cells of a tree and those of a bear alike?

Yes No 1. Both must carry on synthesis to form materials needed for growth and regulation.
Yes **No** 2. Neither needs an outside source of food.
Yes No 3. Both produce carbon dioxide as a product of respiration.
Yes **No** 4. Neither performs the activity of excretion.

In comparing a cell from your little toe with a one-celled animal, we would find that

Yes No 5. both take materials in through their cell membrane.

Yes **No** 6. only within the one-celled animal would any movement take place.

Yes No 7. both are able to respond to stimuli.

Yes **No** 8. the cell from your toe cannot reproduce itself.

The chloroplasts in plant cells are the centers of food manufacture. With the aid of energy from the sun they make the food upon which all plants and animals depend.

Yes **No** 9. Chloroplasts can exist outside of the cell.

Yes **No** 10. Chloroplasts can be considered as a unit of function like the cell.

Yes No 11. Chloroplasts cannot carry on all the activities associated with life.

Yes No 12. Chloroplasts must work together with other parts of the cell.

TEST LESSON 7

Part I:

When cells from a corn stem are compared with cells from a basswood tree stem, it is found that

Yes No 1. some cells in the corn stem are larger than some in the basswood tree stem.

Yes No 2. some cells in the basswood tree stem are larger than some in the corn stem.

Yes **No** 3. the basswood tree stem cells are always larger than those of the corn stem.

Yes No 4. the corn stem has some cells smaller than those of the tree and some that are larger.

In comparing cells from the frog with those from the human,

Yes **No** 5. human blood cells are found to be larger than frog blood cells.

Yes **No** 6. all frog cells are found to be bigger than human cells.

Yes No 7. it may be concluded that humans are larger than frogs because humans have more cells making up their bodies.

When the cells from the mouth of an elephant, a human, and a mouse were compared, you saw that

Yes **No** 8. the mouse cells are smallest.

Yes **No** 9. the elephant cells are largest.

Yes No 10. there is no real difference in size between the cells of the three.

The size of a large plant is due to

Yes **No** 11. large cells,

Yes No 12. a large number of cells.

Part II:

A man bought two tomato plants. One is six inches taller than the other. If the size of a tomato plant is determined by the number of cells that make it up, then:

Yes **No** 1. the taller plant has longer cells.

Yes No 2. the taller plant has more cells.

Yes **No** 3. it is impossible to tell which has more cells.

Yes No 4. both may have the same sized cells.

Two full grown bean plants grow in a garden. One plant is twice as large as the other. If the size of a plant's cells does not determine the size of the plant, it would be reasonable to expect that:

Yes **No** 5. the cells of the small bean plant are half as large as those of the larger plant.

Yes No 6. the cells of the large plant are the same size as the cells of the small plant.

Yes No 7. the cells of both plants may vary in size.

Yes No 8. the smaller bean plant has fewer cells than the larger plant.

Yes **No** 9. the size of the cells of bean plants determines the size of the plant.

When we say that organisms differ in size depending upon the number of cells they have, we mean that

Yes No 10. the smaller the animal, the fewer cells it probably has.

Yes **No** 11. large animals have bigger cells.

Yes No 12. larger animals probably have more cells in their bodies than do small animals.

Part III:

If some cells from a St. Bernard dog were examined by means of a microscope and compared with those of one of her puppies, one would expect that

Yes **No** 1. the cells of the puppy would be the smaller of the two.

Yes No 2. the full grown dog would have more cells than the puppy.

Yes No 3. there would be no difference in the size of the cells from the two dogs.

Yes No 4. some kinds of cells in the puppy would be larger than some kinds of cells in the mother.

In comparing cells from the neck of a giraffe with those from the neck of a squirrel, one would expect that

Yes **No** 5. most of the cells from the neck of the giraffe would be much larger than those from the neck of the squirrel.

Yes No 6. some cells from the neck of the squirrel could be as large as some from the neck of the giraffe.

Yes No 7. not all of the cells from the neck of one animal would be bigger or smaller than those from the neck of the other animal.

Yes **No** 8. some cells from the neck of the giraffe would be longer and narrower than those from the neck of a squirrel.

If cells from a large organism are compared with those from a small organism,

Yes No 9. each may be found to have some large and some small cells.

Yes **No** 10. the cells of the larger organism are found to be generally larger than those of the smaller organism.

Yes No 11. it would generally be found that the difference in size of the organism is due to a difference in number of cells.

Yes **No** 12. the large organism would generally not have any more cells than the smaller organism.

TEST LESSON 8

Part I:

In looking for cells beginning the process of division, the part of the cell to observe is the

Yes **No** 1. cell wall.

Yes **No** 2. cytoplasm.

Yes No 3. nucleus.

Chromosomes are more easily seen during the process of cell division because

Yes **No** 4. when the cell is not dividing there are no chromosomes.

Yes No 5. they coil up tightly.

Yes **No** 6. they become fewer in number.

A function of chromosomes is:

Yes No 7. to control the cell's activities.

Yes No 8. to determine the kind of work the cell will do for the whole plant or animal.

Yes **No** 9. to carry on respiration for the cell.

The number of chromosomes per cell

Yes **No** 10. is the same in the fruit fly and in man.

Yes No 11. is the same in all cells of a given animal.

Yes No 12. must double before the cell divides.

GPO 807-736-3

Part II:

When scientists say that all cells come from previously existing cells, they mean that

Yes No 1. a new cell can only be formed if an existing cell divides.

Yes No 2. as an animal adds new cells, some of the old ones must be dividing.

Yes No 3. dead cells can become alive again.

Since new cells need the same number and kinds of chromosomes as the cells from which they are formed,

Yes No 4. half of the chromosomes from the original cell go to each new cell.

Yes No 5. each chromosome in the original cell splits into two chromosomes.

Yes No 6. each chromosome duplicates itself before the new cells are formed.

Chromosomes exist in pairs in all living things. Which of the following chromosome numbers would be possible in an organism,

Yes No 7. ten?

Yes No 8. forty-three?

Yes No 9. fifty-two?

The membrane which surrounds the nucleus disappears during the process of cell division. Also during this process,

Yes No 10. the chromosomes are found in the cytoplasm.

Yes No 11. the nucleus, as a structure, is not present.

Yes No 12. it is possible for a nucleus to be formed again.

Part III:

A cell with eight chromosomes

Yes No 1. would have four pairs of chromosomes.

Yes No 2. could have 16 chromosomes before division.

Yes No 3. has eight different kinds of chromosomes.

Yes No 4. may divide into two cells each having four different kinds of chromosomes.

Yes No 5. may divide into two cells each having four pairs of chromosomes.

Suppose you had cut your finger on a sharp object while playing, and a nurse put some salve and a bandage on your finger. Several days later you notice that the cut is healing. Where are the new cells coming from?

Yes No 6. They are being formed from the salve placed on the cut.

Yes No 7. They are being formed by the division of old cells in the area.

Yes No 8. No new cells are present.

Suppose we had a container in which all the materials needed by one-celled plants and animals were present, but no living things were present in the container. If we looked into the container again after one month and found that there were quite a few one-celled animals of a certain kind present, we could suppose that

Yes No 9. cells can be formed from the materials in the container.

Yes No 10. at least one one-celled animal must have gotten into the container from the outside.

Yes No 11. the one or more one-celled animals that entered the container divided.

Yes No 12. all the animals in the container must have gotten in from the outside.

TEST
LESSON 9

Part I:

The chemical substance in the chromosomes believed to control the cell's activities

Yes <u>No</u> 1. is a protein.
<u>Yes</u> No 2. is a nucleic acid.
Yes <u>No</u> 3. has not yet been discovered.

The DNA molecule

<u>Yes</u> No 4. is made of many smaller molecules.
<u>Yes</u> No 5. is made of only six basic kinds of molecules.
<u>Yes</u> No 6. is believed to be built something like a twisted ladder.

The way in which the activities of the cell are carried on is affected by

Yes <u>No</u> 7. the type of sugar in the DNA molecule.
<u>Yes</u> No 8. differences in the arrangement of sections of the DNA molecule.
<u>Yes</u> No 9. the frequency of appearance of certain combinations of parts in a given area of the DNA molecule.

The DNA molecule is believed to be made up of a number of parts.

<u>Yes</u> No 10. The sugar and phosphate are found in the siderails of the DNA molecule.
<u>Yes</u> No 11. The A and T molecules always go together in a rung.
Yes <u>No</u> 12. The A, C, G, and T molecules are found in any combination.

Part II:

When scientists construct a model of the DNA molecule in the shape of a twisted ladder,

Yes <u>No</u> 1. they believe that the DNA molecule looks exactly like the model.
<u>Yes</u> No 2. the model will help them understand something about the structure of the DNA molecule.
<u>Yes</u> No 3. they do not really know what the DNA molecule looks like since no one has really seen one.

If it is the arrangement of the "rungs" in the ladder-like molecule and the frequency of certain kinds of "rungs" which causes differences between DNA molecules, then

Yes <u>No</u> 4. if two DNA molecules each had 23 A-T rungs they would be alike.
Yes <u>No</u> 5. if two DNA molecules each had 15 A-T rungs and 15 C-G rungs they would be alike.
<u>Yes</u> No 6. if two DNA molecules each had 15 A-T rungs and 15 C-G rungs alternating with each other, they would then be alike.

When certain sections of the chromosome, and thus of the DNA molecule, are removed, certain activities of the cell are affected. This indicates that

<u>Yes</u> No 7. the DNA controls certain cell activities.
Yes <u>No</u> 8. the chromosome, but not the DNA, controls certain cell activities.
<u>Yes</u> No 9. parts of a DNA molecule may control certain cell activities.

When a chromosome duplicates itself, each of the DNA molecules duplicates itself.

Yes <u>No</u> 10. The chromosome and DNA molecules duplicate themselves individually.
<u>Yes</u> No 11. Since the chromosomes are largely made up of DNA molecules, the DNA duplication results in chromosome duplication.
Yes <u>No</u> 12. The chromosomes of a cell duplicate themselves, but the DNA molecules remain unduplicated.

Part III:

Suppose that in the formation of a new one-celled animal by cell division of the old, a section of a DNA molecule composed of five successive "rungs" of the A-T combination were replaced in both chromosomes of a pair by five C-G combinations. What effect could this have?

Yes <u>No</u> 1. One would expect no change in cell activity.
<u>Yes</u> No 2. One could expect some change in cell activity.
<u>Yes</u> No 3. The new cell would be somewhat different from the old.

A little animal called a shrew must eat several times its weight in food each day. Man eats a very small amount of food compared to his weight. To what might this difference be due?

Yes No 4. There might be a difference in cell activity because of differences in DNA molecules.

Yes **No** 5. The cause may be that the protein part of the chromosome of shrews is different from that of man.

Yes **No** 6. It would not have anything to do with DNA.

A scientist is studying the cells of the giant redwood trees and comparing them with the cells of the smaller white pine trees. Which of the following could he find to be true?

Yes **No** 7. The DNA molecules in both kinds of trees would be identical.

Yes No 8. Six basic kinds of smaller molecules would make up the DNA molecules of both kinds of trees.

Yes **No** 9. Since the giant redwood tree is so tall, its DNA molecules need not duplicate themselves when its cells divide.

A cell of a plant is going to divide into two cells each of which is to perform the same function. Which of the following happens?

Yes No 10. All of the DNA molecules in the dividing cell duplicate themselves.

Yes No 11. Each of the new cells gets the same kind of DNA molecules.

Yes **No** 12. Only the chromosomes in the dividing cell must duplicate themselves. The DNA does not control cell function.

TEST
LESSON 10

Part I:

All of the molecules of which DNA is composed are:

Yes No 1. manufactured in the cell.

Yes **No** 2. brought into the nucleus from other special cells.

Yes **No** 3. taken into the cell through its membrane.

Nucleotides

Yes No 4. are molecules that become part of DNA.

Yes No 5. always contain a sugar molecule.

Yes **No** 6. contain several A, G, C, and T groups.

The DNA molecule pictured as a twisted ladder made up of smaller molecules,

Yes **No** 7. has been seen by scientists.

Yes No 8. is a model which represents how we think the molecule looks.

Yes **No** 9. has been proven incorrect.

The RNA molecule

Yes **No** 10. is exactly like the DNA molecule in structure.

Yes No 11. carries "messages" from the DNA molecule to the cytoplasm.

Yes No 12. serves as a pattern on the ribosomes for making proteins.

Part II:

When scientists say that the DNA molecules "replicate" themselves, they mean that

Yes **No** 1. the molecules split into two equal halves.

Yes No 2. the molecules form an exact copy of themselves.

Yes **No** 3. each molecule forms a large number of copies of itself every time the cell divides.

Messenger RNA is believed

Yes No 4. to pass freely from the nucleus into the cytoplasm.

Yes No 5. to be made, or assembled, in the nucleus.

Yes No 6. to be a necessary link between the DNA and the ribosomes.

It is said the Messenger RNA attaches itself to the ribosomes and serves as a template or pattern for protein synthesis. By this is meant that

Yes <u>No</u> 7. Messenger RNA combines with other materials to become protein molecules.

<u>Yes</u> No 8. the building blocks of proteins are laid down to "fit" the Messenger RNA which is the model.

<u>Yes</u> No 9. the kind of protein formed depends upon the structure of the Messenger RNA.

When drawing a diagram of DNA with certain symbols standing for certain parts, such as shaded circles for the phosphates and five-sided figures, or pentagons, for the sugars, and so forth, scientists imply that

Yes <u>No</u> 10. the phosphate part of the DNA molecule really looks like a shaded circle.

Yes <u>No</u> 11. some of the smaller molecules which combine to form DNA are shaped like and hook together like pieces of a jigsaw puzzle.

<u>Yes</u> No 12. the symbols only stand for certain parts of the DNA molecule but are not drawn to look like those parts of the DNA molecule.

Part III:

A one-celled green plant has divided to form two new plants. For some unknown reason one of the two new cells cannot make its own food. It would be reasonable for a scientist wishing to find the cause of this condition, to suspect that in the cell that is unable to make its own food

<u>Yes</u> No 1. the proper enzymes are not being produced in the ribosomes.

Yes <u>No</u> 2. Transfer RNA may not be carrying the proper message to the ribosomes.

<u>Yes</u> No 3. something may be wrong in that portion of the DNA molecule that controls the food making activity.

Yes <u>No</u> 4. since food manufacture occurs in the cytoplasmic area of the cell, DNA is not involved in this problem.

Suppose that a cell is preparing to divide. The part of the DNA which controls Transfer RNA formation is destroyed. According to present knowledge, what effect will this have on the new cells?

<u>Yes</u> No 5. No directions will be prepared for Transfer RNA formation.

Yes <u>No</u> 6. Messenger RNA will not be able to attach itself to the ribosomes.

<u>Yes</u> No 7. Certain protein formation will fail to take place in the cell.

<u>Yes</u> No 8. Certain cell activities will be interfered with because the necessary enzymes will not be produced.

If the nucleus of an amoeba is removed, the amoeba continues to live for only a short while. A reason for the death soon after the removal of the nucleus might be that,

<u>Yes</u> No 9. no new enzymes can be produced without direction from the DNA found in a nucleus.

<u>Yes</u> No 10. there is no way for Messenger RNA to be formed.

Yes <u>No</u> 11. with the nucleus removed, DNA cannot carry the necessary messages to the ribosomes.

Yes <u>No</u> 12. all the RNA is removed when the nucleus is removed.

TEST LESSON 11

Part I:

Cell division may be

<u>Yes</u> No 1. a means of reproduction by single-celled animals.

<u>Yes</u> No 2. a means of increasing the size of a many-celled animal.

<u>Yes</u> No 3. a means of reproducing some many-celled animals.

Some scientists believe that cells may divide

Yes <u>No</u> 4. to prevent the nucleus from occupying most of the inside of the cell.

<u>Yes</u> No 5. so the cytoplasm will not grow beyond the control of the nucleus.

Yes <u>No</u> 6. to prevent animals from becoming too large to live in a certain place.

As the volume of a cell increases,

Yes No 7. its surface area increases.

Yes No 8. the surface area increases, but not at as great a rate.

Yes No 9. the surface area remains the same.

It is believed by scientists that

Yes No 10. the nucleus gives the signal for the cell to divide.

Yes No 11. as the volume of cytoplasm in a cell increases, the amount of material that enters through the cell membrane becomes greater than the cell can stand.

Yes No 12. nothing limits the size to which a cell may grow.

Part II:

The nucleus controls the cell's activities through the transmission of messages by Messenger RNA from the DNA of the nucleus to the ribosomes found in the cytoplasm. If the cytoplasm becomes large compared to the nucleus, this control may not be very efficient. A reason is that

Yes No 1. the distance between the nucleus and the ribosomes is so great that the Messenger RNA does not reach the ribosomes rapidly enough.

Yes No 2. the surface area of the cell membrane is so large that it allows more materials to enter than the cell can use.

Yes No 3. the amount of Messenger RNA that passes through the membrane surrounding the nucleus is not great enough to control the cell.

When a cell grows, its surface area increases more slowly than its volume. As a result,

Yes No 4. the larger a cell becomes the smaller the amount of surface area.

Yes No 5. if the cytoplasm from five cells were placed together to form one cell there would then be less surface area than the five original cells had.

Yes No 6. the greater the volume of cytoplasm in a cell, the smaller the amount of surface area per unit of cytoplasm.

By the process of diffusion, molecules of dissolved substances tend to become spread evenly throughout another substance. With regard to the cell, this means that

Yes No 7. as oxygen enters through the cell membrane it will spread to all parts of the cytoplasm.

Yes No 8. enzymes formed in the ribosomes will move to other areas of the cell.

Yes No 9. all substances will pass freely into and out of the cell through the cell membrane.

Size alone does not *cause* a cell to divide. Because of this:

Yes No 10. a cell can grow to a certain size and stop growing rather than dividing.

Yes No 11. a cell can grow to any size.

Yes No 12. when the nucleus gives a signal for the cell to divide, it may be for reasons other than size.

Part III:

Suppose a cell in a many-celled organism were to continue growing far beyond the normal size for such a cell. We would expect that:

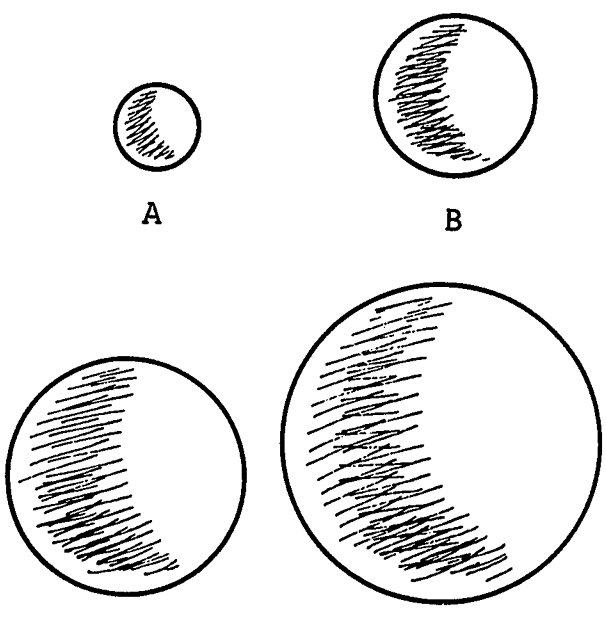
Yes No 1. it could not get rid of its wastes fast enough and would probably die prematurely.

Yes No 2. if enough oxygen were supplied it could continue to live.

Yes No 3. its cell membrane would burst because it wouldn't increase in size as fast as the cytoplasm.

Yes No 4. the cell would continue to carry on its activities and remain alive just like any other cell.

Let us imagine that we have four cells, shaped like balls, each of a different diameter. That is, the distance through the middle from one side to the other is different.



A is one unit in diameter, B is two units in diameter, C is three units in diameter and D is four units in diameter.

Yes No 5. Cell D has more surface area for each unit of volume than cell A.

Yes No 6. Materials coming in through the cell membrane of cell A can spread throughout cell A more rapidly than those entering cell B can spread throughout cell B.

Yes No 7. The nucleus of cell B can exercise control more efficiently over the cytoplasm of cell B, than can the nucleus of cell D over its cytoplasm.

Yes No 8. The cytoplasm at the center of cell D is more likely to have a shortage of oxygen than the cytoplasm at the center of cell B.

The shrew is a small mouse-like animal which must eat several times its weight in food each day because of its high rate of cell activity. As a result,

Yes No 9. the shrew probably has smaller cells than some other animals.

Yes No 10. the rate of diffusion of materials in its cells must be greater than in some other animals.

Yes No 11. the shrew does not have as many materials passing through its cell membrane and its cells can be larger.

Yes No 12. the surface area of the cell must increase more rapidly than the volume when the cell grows.

GPO 807-736-2

FROM:

ERIC FACILIT

SUITE 601

1735 EYE STR

WASHINGTON