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ABSTRACT

This booklet, one of a series developed by the Frederick County Board of Education, Frederick, Maryland, provides an instruction module for an individualized or flexible approach to secondary science teaching. Subjects and activities in this series of booklets are designed to supplement a basic curriculum or to form a total curriculum, and relate to practical process oriented science instruction rather than theory or module building. Included in each booklet is a student section with an introduction, performance objectives, and science activities which can be performed individually or as a class, and a teacher section containing notes on the science activities, resource lists, and references. This booklet presents a summary of the hereditary influences of deoxyribonucleic acid (DNA) and gives instructions for constructing a DNA molecule model. Estimated time for completing the activities in this module is one week. (SL)

D.N.A.

AIDS TO INDIVIDUALIZE THE TEACHING OF SCIENCE

MINI-COURSE UNITS

BOARD OF EDUCATION OF FREDERICK COUNTY

1974

Marvin G. Spencer

A VERY COMPLEX MOLECULE:

D.N.A., THE SUBSTANCE THAT CARRIES HEREDITY

Prepared by

Paul Cook

Estimated Time for Completion

1 week

Frederick County Board of Education

Frederick, Maryland

Frederick County Board of Education

Mini Courses for

Physical Science, Biology, Science Survey,

Chemistry and Physics

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1974

FOREWORD

The writing of these instructional units represents Phase II of our science curriculum mini-course development. In Phase I, modules were written that involved the junior high disciplines, life, earth and physical science. Phase II involves senior high physical science, biology, chemistry, physics and science survey.

The rationale used in the selection of topics was to identify instructional areas somewhat difficult to teach and where limited resources exist. Efforts were made by the writers of the mini-courses to relate their subject to the practical, real world rather than deal primarily in theory and model building.

It is anticipated that a teacher could use these modules as a supplement to a basic curriculum that has already been outlined, or they could almost be used to make up a total curriculum for the entire year in a couple of disciplines. It is expected that the approach used by teachers will vary from school to school. Some may wish to use them to individualize instruction, while others may prefer to use an even-front approach.

Primarily, I hope these courses will help facilitate more process (hands on) oriented science instruction. Science teachers have at their disposal many "props" in the form of equipment and materials to help them make their instructional program real and interesting. You would be remiss not to take advantage of these aids.

It probably should be noted that one of our courses formerly called senior high physical science, has been changed to science survey. The intent being to broaden the content base and use a multi-discipline approach that involves the life, earth and physical sciences. It is recommended that relevant topics be identified within this broad domain that will result in a meaningful, high interest course for the non-academic student.

ALFRED THACKSTON, JR.
Assistant Superintendent for Instruction

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CONTENTS

This mini-course was taken from E.S.E.A. Title III Project, Springfield, Illinois, Toward Humanization and Individualization of Science.

A VERY COMPLEX MOLECULE:

D.N.A., THE SUBSTANCE THAT CARRIES HEREDITY

For a long time scientists have known that hereditary characteristics: brown and blue eyes, curly and straight hair, white and red flowers, tall and short peas, black and white guinea pigs, are passed on from parents to offspring through rod-like structures in the nuclei of the cells called chromosomes. They are present in the chromosomes in the form of units called genes.

Chromosomes can be seen readily under the microscope, if the cells are properly prepared, and stained with certain dyes, but genes are too small to be seen, and can be studied only on the basis of what they do. Indeed, until recently, it was not certain whether individual genes were like "beads on a string", or were simply a set of relationships within a specific area of the chromosome. Nevertheless, by studying the action of genes and their behavior in relation to one another along the length of particular chromosomes, scientists were able to build up accurate maps showing where specific genes were located.

Now scientists have found that the actual hereditary material (the material which makes up the substance of the genes) is a complex molecule called deoxyribonucleic acid (DNA). The DNA constitutes the central portions ("cores") of the rod-like chromosomes. The DNA core of a chromosome is surrounded by a sheath of protein material.

We now have a very good understanding of what the structure of a DNA molecule is like. It consists of varied combinations of a limited number of different kinds of units or sub-units. These units are themselves molecules, which combine in DNA to make a kind of super-molecule (macromolecule). They are: (1) a sugar, called deoxyribose, (2) a phosphate, and (3) four kinds of protein bases; two smaller ones, thymine and cytosine, and two larger ones, adenine and guanine.

For our purposes, we will abbreviate the sugar as "S", the phosphate as "P", and the four bases as "T", "C", "A", and "G". The two smaller bases match one another in size, and the two larger ones also match one another. The A and the T, a large and a small one, will attach to one another, and the C and the G, a large one and a small one, will do the same. When the bases do this, they form two kinds of rod-like structures of equal length: AT and CG. This matching of bases is important in the structure of the DNA molecule. They will not normally attach to one another in any other way.

The S and P sub-molecules became linked with one another end-to-end -S-P-S-P-S-P-S-P- to form a chain. The AT and CG "rods" become attached to the S's of the chain.

The DNA molecule consists of a kind of "spiral ladder". The sides of the ladder are SP chains. The cross-pieces or rungs (steps) of the ladder are pairs of protein bases, the AT and CG rods. These link together the S's of the two sides. They may be attached to the sides as AT and CG, or they may be reversed: TA and GC. The reversals are important since they make possible four structural variables instead of only two.

The DNA ladder forms a spiral because the sizes and arrangement of the sub-molecules are such that when they are put together there is a natural "twist" to the structure. A single spiral is called a helix. A twisted ladder is called a double helix. A gene is believed to consist of a series of from 20 to 2,000 sequential rungs of the ladder. The DNA molecules are so long in proportion to the number of "rungs" that they contain that an immense number of such genes can be located in them. The total number of rungs in all human chromosomes is believed to be about six billion.

Because of the great number of different structural arrangements that the four variables make possible, the series of genes in all of the chromosomes is able to present a set of "coded directions", telling how the living organism is to develop. Therefore it is possible to say that the DNA furnishes a kind of "blueprint" for the construction and behavior of the living organism.

A. Building a Model of D.N.A.

OBJECTIVE

The student will be able to:

1. make a model that will show some of the relationships within a small section of a DNA macromolecule. Additional information obtained through reading can then be fitted into a more meaningful mental picture.

ACTIVITIES

a. Using the equipment and materials listed, construct a model of a D.N.A. molecule by following the accompanying instructions.

Equipment and Materials:

Small size rubber tubing

Round toothpicks with sharply pointed ends

Six different colors of paint, preferably blue, red, yellow, green, brown, and black

Small paint brushes

Two wooden dowels, with sharply pointed ends, the same length as the toothpicks.

A pointed instrument, such as a needle probe or dissecting pin

Ruler

Two small hooks with screws, for attachment to the two dowels

String

Building the Model Instructions:

1. Use two pieces of small size rubber tubing of equal length. Any length from 18 inches to three feet will be satisfactory.

2. Measure and mark alternating segments of one-fourth inch and one-half inch along the entire length of each piece of tubing.

3. Paint the one-fourth inch segments black, and the half-inch segments brown. Note: the smaller black segments will now represent the phosphates (P), and the larger brown segments will represent the sugars (S) along the S-P chain.

4. Use a sufficient number of round toothpicks with pointed ends to equal the number of brown segments (S) along your S-P chain.

5. Measure two segments on each toothpick: one segment to constitute one-third of its length, and the other segment two-thirds of its length.

6. Divide the toothpicks into two groups of equal size.

7. In Group I, paint the short segment of the toothpicks yellow and the long segments green. Note: the yellow segments of this group will now represent thymine (T), and the green segments adenine (A). The two together represent an AT "rod".

8. In Group II, paint the short segments of the toothpicks red, and the long segments blue. Note: the red segments of this group will now represent cytosine (C), and the green segments guanine (G). The two together represent a CG "rod".

9. Using a needle probe or dissecting pin, punch a small hole (the size of the pointed ends of the round toothpicks) at the midpoint of each of the brown segments (S's) along each piece of rubber tubing. Be sure to punch the holes in a straight line on one side of the tubing. Avoid making the holes any larger than necessary.

10. Mix the two groups of toothpicks thoroughly.

11. Insert a toothpick in each pair of holes, linking the two tubes. Insert the toothpicks in as many different arrangements and orders as possible: either yellow-green or green-yellow; either red-blue or blue-red; with a yellow and green above or below a red and blue, or with two or more of the same kind succeeding one another.

12. Now insert a small hook with a screw at the midpoint of each of two small wooden dowels pointed at each end.

13. With a needle probe, punch a hole in each end of each of the rubber tubes, on the same side of and in line with the toothpick holes, but located between the last toothpick hole and the end. Insert a wooden dowel connecting the ends of the two tubes at each end of your "ladder". The dowels will serve to stabilize the ladder, and the hooks in the dowels will furnish a means for attaching and holding it.

14. Attach a piece of string to each hook. Attach the string holding one end of the ladder to a fixed point.

15. Hold the dowel at the other end in your hand, and rotate it to the left. In doing so be careful not to put too great a strain on the ladder. You may attach the end you are holding to another fixed point if you wish.

16. You now have a model showing some of the features of a DNA molecule.

b. Read one of the following references describing the DNA molecule and answer the following questions.

1. The Cell (Life Science Library), Chapter 3, "The Architect and Master Builder", pages 68-74, by John Pfeiffer and the editors of Life, published by Time, Inc., New York, 1964

2. Biological Science, An Ecological Approach, BSCS Green Version, Third Edition, Chapter 17, "Structure of D.N.A.", pages 593-594

3. Modern Biology, Otto, Towle, 1969, pages 48-49

4. Biology, Smallwood, Green, 1971, "D.N.A.: Its Structure and Function", pages 129-137

Questions:

1. Have you verified the objective stated in Part A, "Building a Model of D.N.A."?

2. What characteristics of D.N.A. have you illustrated?

3. What characteristics are there that you have not illustrated?

B. D.N.A.'s Ability to Reproduce Itself

OBJECTIVE

The student will be able to:

2. do the following activities towards understanding the role played by D.N.A. in replicating or reproducing itself.

ACTIVITIES

a. Read:
Biology, Smallwood and Green, 1971, pages 134-135 or
Biological Science, An Ecological Approach, BSCS, Green Version, Third Edition, page 595

1. Describe on paper, using words and diagram, how D.N.A. is capable of making exact copies of itself.

2. Study the model that you made and explain on paper how you would go about illustrating the replicating process with your model.

3. Explain on paper why replication is necessary when a cell undergoes mitosis.

The function of this laboratory exercise is to carry the student as far as possible toward understanding the nature of hereditary material. The structure of D.N.A. is a very complex concept, but the working out of it is one of the most important break-throughs in modern biological research.

This laboratory experience should furnish a basis for students to build a further understanding at a more advanced level of study. The teacher, after this unit, may wish to further develop D.N.A.'s involvement in protein synthesis and enzyme influence on the cell's activity; the importance of the sequence of nucleotides in determining a particular message; and what is known about the function played by the regulator or operator gene in a cell.

A good preparation for the teacher before attempting to carry through this lab is to become familiar with the references which describe the structure and behavior of D.N.A.

UNIT OBJECTIVES

The student will be able to:

1. make a model that will show some of the relationships within a small section of a D.N.A. macromolecule.

2. do activities towards understanding the role played by D.N.A. in replicating or reproducing itself.

REFERENCES

The Cell (Life Science Library), John Pfeiffer and the editors of Life, Time, Inc., New York, 1964

Biological Science, An Ecological Approach, BSCS Green Version, Third Ed.

Modern Biology, Otto, Towle, Holt, Rinehart & Winston, 1969

Biology, Smallwood, Green, Silver Burdett Company, 197[illegible]

FILMS

The Thread of Life, Bell Telephone Company
(This film must be ordered at the beginning of the year, since the distribution center covers such a wide area from Baltimore)

Cracking the Code of Life (color, 22 minutes), American Cancer Society, Frederick, Maryland

Evaluation Form for Teachers

Name of mini-course ______________________________

Evaluation Questions	Yes	No	Comments
1. Did this unit accomplish its objectives with your students?			
2. Did you add any of your own activities? If so, please include with the return of this form.			
3. Did you add any films that other teachers would find useful? Please mention source.			
4. Were the student instructions clear?			
5. Was there enough information in the teacher's section?			
6. Do you plan to use this unit again?			

7. Which level of student used this unit? ______________________

8. How did you use this unit - class, small group, individual? __________

____

PLEASE RETURN TO SCIENCE SUPERVISOR'S OFFICE AS SOON AS YOU COMPLETE THE COURSE.

SCIENCE MINI-COURSES

	Prepared by
PHYSICAL SCIENCE	
ELECTRICITY: Part 1 (Types of Generation of Electricity)	Marvin Blickenstaff
ELECTRICITY: Part 2 (The Control and Measurement of Electricity	Marvin Blickenstaff
ELECTRICITY: Part 3 (Applications for Electricity)	Marvin Blickenstaff
CAN YOU HEAR MY VIBES? (A Mini-course on Sound)	Charles S[illegible]gton
LENSES AND THEIR USES	Beverly Stonestreet
WHAT IS IT? Identification of an Unknown Chemical Substance	Jane Tritt
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