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The Cell

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Purpose. This unit on the chemistry of the cell is being developed in order to aid the students with limited backgrounds in verbal skills, reading skills, and writing skills to understand:
1. How he or she carries substances within themselves which seriously can aid or hamper future generations.

2. How they have been affected by past generations. The assumption is that by breaking down the information into very simple factors, the child will better understand his contributions and the problems he brings to the development of a new life at his age. Perhaps by better understanding the complexity of the situation, he may defer reproduction until such time as he is better able to assume responsibility.

This unit is meant for students who have little background in genetics, and could be a part of a general science class, a biology class, a sex-education class, a physiology class, a chemistry class, or a health education class. Explorations in the laboratory to explain the Concepts is urged, and suggestions to serve as a guide have been included in the lesson plans.

Teacher Objectives

Procedure

1. Develop the concept of the cell, its various parts and functions.
2. Develop the concept of how cell information is passed from parent to offspring through the process of cell division and fertilization.
3. Develop respect for the other sex and the part each has in reproduction.
4. Develop an awareness to current research as daily reported on radio, TV, and in publications (even the poor ones).
5. Develop the skill of not only thinking about concrete facts but of utilizing reasoning, analyzing and inter-relating.

Student Objectives

In this unit emphasis will be placed on basic principles and the way they have been derived from experimental observation. You will become a scientist as you study the material within this unit. You will learn some of the effects that science and technology has had on our environment, specifically in the area of the cell—the basic unit of living things which contains genetic information from past generations. At the end of this unit you will be acquainted with only a small fraction of that which is known about the science of cell biology and genetics. You will realize, however, that all of the things that you do not know, some of which nobody knows as yet, are not unknowable. It is hoped that furthermore, you will realize that explorations of new frontiers in any science is an activity full of excitement and satisfaction.

It is expected that by the end of this unit each student will have:

1. Gained a better understanding, through the discovery method of the facts and principles of inheritance.
2. Come to appreciate the need to understand the basic processes by which cells divide and transfer their genetic information.
3. Learn to recognize and distinguish possible inherited traits.
4. Come to appreciate the importance of science and technology in today's world.

Introduction

Nearly every phase of our lives is affected by the result of scientific activity. In the last two centuries, during which man has taken a scientific approach to the understanding and control of his environment, the conditions of his life have changed more than in all the preceding hundreds of thousands of years. The influence of science on man's life will become greater in the future. In view of this, it is imperative that all of us have some understanding of what scientific activity is and how it is carried on, and how it will affect mankind. The study of cell biology and genetics is one way to become familiar with these things.

Cell biology deals with the functions of parts of the animal cell. Genetics is the study of genes, their function and organization within the chromosomes; and the process by which sets of genes are passed on by individuals from one generation to those of the next. How genes function is best studied by the chemical approach.

I. *The Cell*

All individuals are made of cells. Every human being begins as a single fertilized cell that divides over and over to make billions of cells in a mature human being. The process of cellular reproduction holds the key to heredity in all living things.

The cell theory states simply that:

1. all living matter is composed of cells,
2. all cells arise from other cells,
3. all the metabolic reactions of living organisms, including all energy exchanges and all processes, take place within the cells. Metabolism is simply the sum of all the chemical reactions taking place in a living system.

It also states that cells contain the hereditary information of the organisms of which they are a part, and that this information is passed from parent cell to daughter cell.

Organization of the cell . The cell is the smallest part of the living organism which carries on life functions. There are many different kinds of cells. Within our bodies there are more than 100 different and distinct types. Thus the first remarkable fact about cells is their diversity.

The second, even more remarkable fact is their similarity. Every cell is a self contained unit surrounded by an outer membrane that controls the passage of materials in and out of the cell; and so makes it possible for the cell to differ biochemically and structurally from its surroundings. All cells also, at least sometime in their existence, contain control centers, or nuclei. Many have a variety of internal structure, the organelles, which are similar or identical from one cell to another throughout a wide range of cell types. Also, all are composed of the same remarkably few kinds of atoms and molecules.

Cell structure . All cells are basically very similar combining many of the same structures, the same types of enzyme systems, and same kind of genetic material. An outer membrane, apparently conforming to the same biochemical design, in all cells, surrounds the cells. The cell membrane holds the cells together and separates one cell from other cells. The cell membrane is selective and allows materials in solution to pass in and out of the cell, by a process called diffusion. The living materials bounded by the membrane, sometimes called protoplasm, consists of the cytoplasm and the nucleus.

The nucleus . The nucleus is a large, spherical body, usually the most prominent structure within the cell. It is surrounded by two unit membranes which together make up the nuclear envelope. Penetrating the surface of the envelope are nuclear pores, which are covered by a thin single membrane. These pores apparently permit only specific large molecules to go through, thus keeping the chemical composition of the nuclear material different from that of the cytoplasm. The chromosomes, which are composed of DNA (deoxyribonucleic acid) and protein, are found within the nucleus. When the cell is not dividing, the chromosomes are visible only as a tangle of fine threads, called chromatin. The most conspicuous body within the nucleus is the nucleolus. The nucleolus, which is composed of DNA and protein, like the chromosomes; and is formed from a portion of a chromosome, is the site at which a particular kind of RNA (ribonucleic acid) is formed. RNA is a messenger that takes orders from the DNA and delivers them to the cell.

Functions of the nucleus . The nucleus performs two crucial functions for the cell:.

1. It carries the heredity information for the cell—the instructions that determine whether a particular organism will develop to become a paramecium, one celled bacteria , oak tree, or a human being—and not just any paramecium, oak tree, or human being, but one that resembles the parent or parents of that particular unique organism.
2. The nucleus directs the ongoing activities of the cell, ensuring that the complex molecules the cell requires are synthesized in the number and of the kind needed. The cell nucleus is usually the largest structure in the cell.

The cytoplasm . The cytoplasm is inside the cell. Water makes up 75-90% of it. The cytoplasm moves constantly and with it carries particles that are suspended called organelles. Each organelle has at least one definite job or function. Each organelle has a definite form.

The vacuoles . In some cells are vacuoles which are gas or liquid filled. They regulate the water content, store food, and give off waste.

Endoplasmic reticulum . This substance is a double membrane network in the cytoplasm. It also connects the outer layer of the nuclear membrane with the inner layer of the cell membrane.

Ribosomes . Ribosomes are made of RNA and produce protein. They are organelles of beadlike structure located along the endoplasmic reticulum. These proteins are needed for growth, reproduction, and cell part repair. Certain antibiotics stop the action of Ribosomes.

Golgi bodies . They take care of processing secretory functions of protein.

Lysosomes take care of the digestion within cells.

Mitochondria . The mitochondria contain enzymes that transfer Hydrogen to Molecular Oxygen. They also convert sugar and starch to energy, trigger the energy release, or cellular respiration.

Student Activity

At this point students can make their cell model according to the directions in the activity page. Overlays on the projector are also helpful.

Summary

All living matter is composed of cells. All cells arise from other cells. The metabolism of living systems—the sum total of their biochemical activities take place within cells and as a result of cellular activities.

Cells are units of protoplasm—living matter—separated from their environment by an outer cell membrane which restricts the passage of materials in and out of the cell and so protects the cell’s structural and functional integrity. A living cell either reproduces or dies, and each new daughter cell is an identical copy of the parent. Cells divide when they are ready, and they are ready only when they have completed certain preparations for divisions. Something limits cell size and halts the growth process. The size of a cell is limited by its nucleus to support growth. Hidden in the cell is some process that makes it possible for the cell to enter each phase.

(A quiz might be given at this point, and there is one included in the activity sheet).

II. *Genetics—Heredity*

Genetic information is passed from each parent to offspring through sex cells, and the process of fertilization and division of cells.

All humans are made of cells; no cell of the human body is self sufficient. Every human originates as a single fertilized cell that divides over and over to make billions of cells in a mature human body or being. The process of cellular reproduction holds the key to heredity in living things.

Cells contain chromosomes consisting of proteins and a giant molecule called DNA. Cells are made up of thousands of genes encoded or patterned in the DNA (deoxyribonucleic) acid molecule. These genes contain information necessary for human physical development and are sometimes thought of as blueprints for a human's structure and form. Sometimes the DNA can be thought of as a computer tape with instructions. The forty six threads of DNA have a combined length of six or more feet locked into a nucleus less than four ten thousandths of an inch in diameter.

Human cells contain 23 pairs of chromosomes (a total of 46). Half of each pair is contributed by the sperm cell from the father on fertilization, and the other half by the egg cell from the mother during the fertilization process.

There are two kinds of cells:

1. Sex cells consisting of sperm and egg or ovum cell.
2. Somatic cells which are body cells, or all of the cells except those that are sex cells. Somatic cells have the same chromosome number in each cell, 46. During reproduction a mirror image is produced, and two cells result.

There are two kinds of cellular reproduction.

1. Sex cells (Sperm and the Egg)

The process of meiosis occurs before fertilization. The Chromosome number is cut to one-half; and this is called a reduction process. Then a mitosis-like step occurs, and each of the cells split in two. The first step in meiosis is the dividing of the cells into identical cells, but replication of DNA occurs, so the number of chromosomes and genes are doubled. During the second step each of the two cells split in two and each sex cell now has only half the number of genes and chromosomes of the original parent cell. One chromosome of each pair goes into one new cell, and the other chromosome of that pair goes into the other new cell. So egg cells and sperm cells have half the number of chromosomes as body cells, as a result of the split. Each sperm has twenty three chromosomes, and each egg has twenty three chromosomes.

Meiosis in the female doesn't take place continually throughout the age of reproductive maturity as it does in the male. A primary oocyte remains in the first stage for many years, and doesn't progress until the egg is about to mature in the follicle at sexual maturity. Then it does divide, and two cells unequal in size result. The larger one receives cytoplasm. The smaller cell may or may not divide, and disintegrates. It is called a polar body.

2. Somatic (body) cells may undergo mitosis every three or four hours. Mitosis is a form of cell reproduction in which each of two daughter cells receives a set of chromosomes of the same kind and of the same number as the mother cell. The cell division occurs after the cell has reached a certain size. Growth involves increases in number of cells. Each daughter receives the same number of chromosomes.

During reproduction each new cell formed will contain combined information. When the sperm goes to the ovum it arrives with twenty-three chromosomes. The egg has twenty-three chromosomes also and so again the diploid number is restored to the zygote.

During reproduction each new cell formed will contain combined information from each parent.

Since numbers of genes from each parent are in the tens of thousands, the combinations possible are almost infinite, because of random segregation of chromosomes during meiosis and because of crossing over during meiosis.

III. *Genetic Information*

Most cells contain chromosomes made up of messages encoded in the DNA molecule. These contain genetic information and interact to determine the way the genetic potential will be expressed. There are predictable patterns to transmission of genetic information. Chromosomes carry many thousands of genes. Chromosomes are paired and genes are paired. Each pair of genes contain specific information for specific traits. One gene of each pair comes from the female parent, and the other one from the male parent. Genes determine the physical and mental traits and are contained within the nucleus of each cell. A gene has the ability to determine one's hair, eyes, color, skin pigment, ear shape rolling of tongue eye color and many other factors. These genes are found along the DNA molecules within the cell. Genes are also involved in protein production and enzyme production.

Genes that show are dominant. Those that don't show are recessive or hidden.

Genes . Life seems to be directed by a definite program. In this substance is a stimulant that has the instruction for the organism which specifies not only what the organism can do, but what its form is, whether inside or out. DNA is the substance. The tape from the cell carries messages in a series of chemical units that are linked together. The program or set of instructions consists of those genes. Each gene is a part of the DNA strand. There is a set of characteristics for each gene, and a set of instructions regulating the gene function. All different cells have a copy of their own program. This different program is known as differential expression or differentiation. Differential expression is evident during the embryonic development when an organism develops from a single fertilized egg cell. Through this differential expression, the DNA specifies each of the specialized cells that make the adult. Certain genes may function in response to environment; a dog will make a thicker coat of hair in winter. If there is an infection in the body the program directs antibodies to fight.

When a cell is fully differentiated it loses its power of dividing. Since all cells must carry out certain basic functions for life, the functions are chemical operations. The genetic program organizes these molecules in such a way that a living substance is produced. Molecules make up the material of cells, and the chemical properties unique to organized matter. Changes in the DNA pattern can result from a change in the gene pattern, and this results in a mutation.

Lesson Plans for Student Activities

These lesson plans are presented to be used as laboratory explorations. Children have a better understanding when they can handle materials. There is also the learning of a new vocabulary unconsciously, plus an opportunity for originality. These lesson plans aid the student in visualizing processes within the cell.

Introduction to Genetics —I

Concept : The cell is a unit.

Exploration : Find out parts of the cell.

Materials : Clear plastic bag for each student, styrofoam balls of various colors—nucleus nucleolus

pipe cleaners—chromosomes, etc.

Procedure :

1) Students place objects in bag as teacher introduces major parts of cell.
2) Pupil writes organized report explaining the cell is a unit.
    a. Problem, materials, procedure, observation, conclusion. I A

Concept : Cytoplasm is like a gelatinous substance in which the parts of the cell function.

Exploration : Make a mixture of Jello and warm water; pour into a paper cup after thoroughly mixing; set aside to cool. While cooling add particles to resemble parts of the cell.

Materials : Six boxes of quick dissolving Jello or similar type product, hot water, paper cups, wooden splints, very small styrofoam balls or tiny jelly beans, and any other materials to resemble cell parts.

Conclusion : Record on laboratory report the results of the exploration.

Lesson II

Concept : The cell has many parts and each part has a special function. *Exploration* :

1. Draw a diagram of a cell on a paper or a cardboard.
2. Using the various materials paste the parts of products to represent the cell parts.
   a) Try to use materials to closely resemble cell parts, for example Cheerios can resemble pores.
   b) Permit students to choose own materials; supply each one with a plastic sandwich bag to carry supplies to seat to prevent a mess.

Materials : (for 100 students) Noodles (thin)—two boxes, wooden splints, twisted noodles, two pounds, one pound white rice, one pound small kidney red beans, and one pound white pea beans or spotted beans, glue, large box Cheerios, two packages elastic bands, ball of twine, large package coffee, wooden stick stirrers, crayons, one box macaroni, one box spaghetti, package wooden splints.

Procedure :

1. Attach pieces of materials to diagram as student desires
or
2. Above materials can be used to show mitosis, meiosis, or even zipper effects.

Conclusion : Pupil completes project in two days, and then can choose one part of the cell and write a half page report about how that functions or its importance to the cell.

Lesson III

Concept : To explain how by osmosis the parts of the cell receive and return nutrition or how liquids permeate membranes.

Materials : One thistle tube, crystals of anhydrous powdered coppersulphate—enough to fill one half of inverted thistle tube, permeable paper, elastic, beaker, water, ring stand for support.

Procedure : Pour crystals into dry thistle tube about half full; invert thistle tube after permeable paper has been added; secure with elastic band; insert tube (bowled part) into beaker with one inch of water.

Observation : Using laboratory report form record changes in inverted thistle tube after about an hour; use diagram labeled to explain before and after appearances.

Conclusion : Pupil draws conclusion based on concept.

Lesson Plan IV

Concept : To see how molecules of different sizes can be absorbed. This is a process called chromatography.

Chroma means color; graph to write.

Exploration : Using strip filter paper, and a 1,000 ml. graduate, or at least a quart clean milk container, observe what happens when the pointed strip filter paper is immersed in a liquid.

Materials : Strip of filter paper pointed at one end and at least two inches longer than the container, a graduate or milk carton for each liquid; aluminum foil, black ink, tomato juice, vegetable coloring to be placed separately in a container.

Procedure : Make a point at one end of strip filter paper (l)

(figure available in print form)
Immerse point in about 5 cm of liquid (2). Don’t let paper touch sides of container. (3) Place aluminum foil over end of filter paper to prevent liquid evaporation. Leave overnight. In laboratory report record by diagram before and after results.

Concept Outline—general (partial)

(figure available in print form)
The purpose of a Concept Outline is to give the students main topics. Students seem to like this due to the fact that sentence writing is not involved, main topics can be quickly seen and recognized, and it may be stopped at any point and elaborated, or taken as a whole for a general review. This is also another way for a vocabulary review.

VOCABULARY

analyzing	encoded
atoms	endoplasmic-reticulum
biochemical	enzyme
blue-prints	exploration
cell	female parent
cell biology	fertilization
cell division	fertilize
chemical	follicle
chemical reactions	function
chromatin	generation
chromosomes	genes
concepts	genetics
crossing over	golgi bodies
cytoplasm	hereditary
daughter cell	identical
deoxyribonucleic acid	inheritance
differential expression	lysosomes
diffusion	male parent

digestion
diploid
diversity
dna
dominant
egg
embryonic
mitosis
molecules
mutation
nucleolus
nucleus
offspring
oocyte
organelles
organism
osmosis
ovum
polar body
pores
process
protein
protoplasm
reasoning
recessive
reduction
replication
reproduction
ribonucleic acid
ribosomes
sex
sex cells
nature
meiosis
metabolic
membrane
metabolism
mirror image
sexual maturity
similarity
solution
somatic cell
spermatozoa
sperm cells
spherical
structurally
synthesize
technology
twenty-three pairs
vacuoles

Sample Test

Directions: Choose one answer and circle the answer and the letter of the answer.

1) Mendel gave us the Laws of a) Heredity b) Circulation c) Gravity
2) The animal cell has a) chlorophyll b) cystocele c) ribosomes
3) RNA is a) reproduction b) gene c) messenger d) offspring
4) In the laboratory we stress a) curiosity b) experiment c) safety d) laboratory report as our motto
5) Chromatography is a) method b) plan c) idea d) shows how molecules can travel
6) The metric system is based on units of a) tens b) hundreds c) speed d) quartiles
7) One cm is a) measurement b) metric unit c) french unit
8) You receive genes from even your a) grandmother b) cousin c) aunt d) godfather
9) A zygote is a) sperm b) ova c) fertilized egg
10) Mitosis is a cell splitting process a) giving 4 cells b) mirror image c) code d) parent
11) DNA means a) reproduction b) chromatin c) mode d) deoxyribonucleic acid
12) Meiosis is a process reducing a) cells b) chromosomes c) nucleolus d) mitosis
13) Ribosomes manufacture a) sugar b) protein c) mitosis d) lysosomes
14) Nucleus of a cell is a) not important b) control center c) reduction d) osmosis
15) Replication means a) reproduction b) mutation c) ovum d) DNA splitting in two
16) Haploid means a) all chromosomes b) inherit c) 1/2 number d) chromatin
17) Genes have been found which result in a) butter b) food c) cancer d) zygotes
18) We are what we are because we a) reproduced b) sperm c) diploid d) inherited
19) An ova can be fertilized only by a) offspring b) spermatozoa c) nucleus d) messenger
20) Genetics is the study of a) fertilized egg b) chromatides c) codes d) genes interacting
21) Breaking the code meant that a) chemical structure of DNA was found b) membrane is necessary to a cell c) cytoplasm is not necessary to a cell
22) The animal cell is a) mutated b) myoptic c) microscopic d) a parent cell
23) Mitosis is a process that has at least a) 4 stages b) 6 stages c) osmosis
24) Cytoplasm is like a) jello b) salt c) pepper d) lysosomes
25) Taking antibiotics can stop the function of a) mitosis b) meiosis c) Ribosomes d) fertilization
26) When water passed through a membrane we knew the membrane was a) porous b) a compound c) litmus d) incorrect
27) ln a laboratory report problem is stated a) last b) middle c) material d) first
28) In a normal human cell are a) 23 pair of chromosomes b) 47 chromosomes c) mutations d) dominant
29) Each parent contributes 23 pair a) genes b) membrane c) cells d) chromosomes
30) The study of the human cell helps us to understand a) ourselves b) plant cells c) matter

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