Cellular structures and functions essay sample

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It is the smallest unit of life that is classified as a living thing, and is often called the building block of life. The cell is the basic structural and functional unit of all known living organisms. Some organisms are unicellular (made of only one cell) while others are multicellular (made up of several cells). The word cell comes from the Latin cellula, meaning, a small room. The term was coined by Robert Hooke in a book he published in 1665 when he compared the cork cells he saw through his microscope to the small rooms monks lived in. BRIEF HISTORY OF THE CELL THEORY The cell was first discovered by Robert Hooke in 1665. He examined very thin slices of cork and saw a multitude of tiny pores that he remarked looked like the walled compartments of a honeycomb. Because of this, Hooke called them cells, the name they still bear. The first man to witness a live cell under a microscope was Antonie Phillips van Leeuwenhoek, who in 1674 described the algae Spirogyra and named the moving organisms animalcules, meaning “ little animals”.

Leeuwenhoek probably also saw bacteria. In 1839, Theodor Schwann and Matthias Jakob Schleiden suggested that cells were the basic unit of life. In 1858, Rudolf Ludwig Virchow concluded that all cells come from pre-existing cells, thus completing the classical cell theory. Classical Interpretation of the Cell Theory 1. All organisms are made up of one or more cells. 2. Cells are the fundamental functional and structural unit of life. 3. The cell is the unit of structure, physiology, and organization in living things. 4. The cell retains a dual existence as a distinct entity and a building block in the construction of organisms. 5. All cells come from pre-existing cells. Hand-out 1 in General Biology Unit 2: Cellular Structures and Function

The cell theory holds true for all living things, no matter how big or small, or how simple or complex. Since according to research, cells are common to all living things, they can provide information about all life. And because all cells come from other cells, scientists can study cells to learn about growth, reproduction, and all other functions that living things perform. By learning about cells and how they function, you can learn about all types of living things. Over time, and with the development of the electron microscope, the theory has continued to evolve. As more and more living material has been observed at higher and higher magnifications, much more has been learned, leading to the modern cell theory.

The modern cell theory includes the basic components of the classic cell theory and then adds more... Modern Interpretation of the Cell Theory 1. 2. 3. 4. All known living things are made up of cells. The cell is structural & functional unit of all living things. All cells come from pre-existing cells by division. Cells contain hereditary information which is passed from cell to cell during cell division. 5. All cells are basically the same in chemical composition. 6. All energy flow of life occurs within cells. MICROSOPE A microscope (from the Greek “ mikrós” meaning “ small” and “ skopeîn” meaning “ to look”) is an instrument to see objects too tiny for the naked eye. Microscopes can be separated into optical theory microscopes, electron microscopes, and scanning probe microscopes. The most common type of microscope—and the first invented—is the optical microscope. This is an optical instrument containing one or more lenses producing an enlarged image of an object placed in the focal plane of the lenses.

Compound Light Microscope The compound microscope uses lenses and light to enlarge the image. It is also called an optical or light microscope. The compound microscope has two systems of lenses for greater magnification: 1. the ocular, or eyepiece lens that one looks into, and 2. the objective lens, or the lens closest to the object.

Computing for Magnification 🎬 Low Power Objective (4x) 10 Ocular lens) x 4 (LPO) = 40x magnification At 40x magnification you will be able to see 5mm. Middle Power Objective (10x) 10 Ocular lens) x 10 (MPO) = 100x magnification At 100x magnification you will be able to see 2mm. High Power Objective (40x) 10 Ocular lens) x 40 (HPO) = 400x magnification At 400x magnification you will be able to see 0. 45mm.

MAJOR PARTS OF A TYPICAL CELL 1. All cells, whether prokaryotic or eukaryotic, have a membrane that envelops the cell, separates its interior from its environment, regulates what moves in and out (selectively permeable), and maintains the electric potential of the cell. 2. Inside the membrane, a salty cytoplasm takes up most of the cell volume. 3. All cells possess DNA, the hereditary material of genes, and RNA, containing the information necessary to build various proteins such as enzymes, the cell’s primary machinery. Cell Membrane Also called the plasma membrane or plasmalemma, it is the biological membrane separating the interior of a cell from the outside environment. The cell membrane surrounds all cells and it is semi-permeable, controlling the movement of substances in and out of cells.

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Nucleus The nucleus, also sometimes referred to as the control center is a membrane-enclosed organelle found in eukaryotic cells. The function of the nucleus is to maintain the integrity of these genes and to control the activities of the cell by regulating gene expression. The nucleus is the largest cellular organelle in animals. It appears as a dense, roughly spherical organelle. 1 The nuclear envelope is a double membrane that encloses the entire organelle and separates its contents from the cellular cytoplasm. The viscous liquid within it is called nucleoplasm, and is similar in composition to the cytosol found outside the nucleus. The nucleolus is a discrete densely stained structure found in the nucleus.

Cytoplasm It is the part of a cell that is enclosed within the cell membrane. The cytoplasm is the site where most cellular activities occur, such as many metabolic pathways like glycolysis, and processes such as cell division. 1. The cytosol is the portion of a cell that is not enclosed within membrane-bound organelles. It is a translucent fluid in which the other cytoplasmic elements are suspended. It makes up about 70 % of the cell volume and is composed of water, salts and organic molecules. 2. Organelles are membrane-bound compartments within the cell that have specific functions. Hand-out 1 in General Biology Unit 2: Cellular Structures and Function Page 3 of 12 S. GATUS 2011

ENTRY AND EXIT OF MATERIALS IN CELLS The ability of cells to exist and to maintain their life-sustaining activities is largely dependent upon their ability to take in and get rid of certain substances. The failure to carry out the

activities such as these will cause the death of the cell. Specifically, the cell would have to: 1. Take in food nutrients, and 2. Get rid of waste products. The entrance and exit of materials in living cells may occur through passive or active transport. The passage of materials in the cell through passive transport follows their concentration gradient. That is, the direction of movement of materials is from where they are more concentrated to where they are less concentrated. The cell does not spend energy for such natural flow of materials to occur. Passive transport of materials in a cell may be the process of diffusion or osmosis.

constantly colliding with one another. The net movement of the molecules is away from the region of high concentration to the region of low concentration. Diffusion is a random movement of molecules down the pathway called the concentration gradient. Molecules are said to move down the concentration gradient because they move from a region of higher concentration to a region of lower concentration. A drop of dye placed in a beaker of water illustrates diffusion as the dye molecules spread out and color the water.

Osmosis On the other hand, the passage of materials in the cell through active transport is against their concentration gradient. Thus, active transport involves carrier molecules and cellular energy of ATP for such process to occur. Processes that involve active transport are exocytosis and endocytosis. PASSIVE TRANSPORT Passive transport means moving biochemicals and other atomic or molecular substances across membranes. Unlike active transport, this process does not involve chemical energy, because, unlike in an active transport, the transport across membrane is

always coupled with the growth of entropy of the system. Diffusion One method of movement through the membrane is diffusion. Diffusion is the movement of molecules from a region of higher concentration to one of lower concentration. This movement occurs because the molecules are Hand-out 1 in General Biology Unit 2: Cellular Structures and Function Page 4 of 12 S. GATUS 2011

Another method of movement across the membrane is osmosis. Osmosis is the movement of water from a region of higher concentration to one of lower concentration. Osmosis often occurs across a membrane that is semipermeable. A semipermeable membrane lets only certain molecules pass through while keeping other molecules out. Osmosis is really a type of diffusion involving only water molecules.

Facilitated diffusion A third mechanism for movement across the plasma membrane is facilitated diffusion. Certain proteins in the membrane assist facilitated diffusion by permitting only certain molecules to pass across the membrane. The proteins encourage movement in the direction that diffusion would normally take place, from a region with a higher concentration of molecules to a region of lower concentration.

When the vesicle contains particulate matter, the process is called phagocytosis. When the vesicle contains droplets of fluid, the process is called pinocytosis. Along with the other mechanisms for transport across the plasma membrane, endocytosis ensures that the internal cellular environment will be able to exchange materials with the external environment and that the cell will continue to thrive and function.

ACTIVE TRANSPORT When active transport is taking place, a protein moves a certain material across the membrane from a region of lower concentration to a region of higher concentration. Because this movement is happening against the concentration gradient, the cell must expend energy that is usually derived from a substance called adenosine triphosphate or ATP. Endocytosis The final mechanism for movement across the plasma membrane is endocytosis, a process in which a small patch of plasma membrane encloses particles or tiny volumes of fluid that are at or near the cell surface. The membrane enclosure then sinks into the cytoplasm and pinches off from the membrane, forming a vesicle that moves into the cytoplasm. Receptor-mediated endocytosis which is also called clathrin-dependent endocytosis, is a process by which cells internalize molecules (endocytosis) by the inward budding of plasma membrane vesicles containing proteins with receptor sites specific to the molecules being internalized.

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HOW DO CELLS REPRODUCE? Your body consists of some hundred trillion cells, all derived from a single cell at the start of your life as a fertilized cell. Many millions of successful cell divisions occurred while your body is reaching its present form. All living organisms grow and reproduce. All living organisms produce offspring like themselves and pass on to them the hereditary information that makes them as they are. In this chapter, we begin our consideration of heredity with the examination of how cells

reproduce themselves. The ways in which cell reproduction is achieved, and their biological consequences, have changed significantly during the evolution of life on Earth. THE CELL CYCLE It is the series of events that takes place in a cell leading to its division and duplication. The cell cycle is required for cell growth and cell division into two daughter cells. In cells without a nucleus (prokaryotes), the cell cycle occurs via a process termed binary fission. In cells with a nucleus (eukaryotes), the cell cycle can be divided in two brief periods: 1. Interphase during which the cell grows, accumulating nutrients needed for mitosis and duplicating its DNA 2. Cell Division during which the cell splits itself into two distinct cells, often called “ daughter cells”

Cell Cycle in Eukaryotes: INTERPHASE

Cell Cycle in Prokaryotes Binary fission, or prokaryotic fission, is the form of asexual reproduction and cell division used by all prokaryotic and some eukaryotic organisms.

Cell Cycle in Eukaryotes: CELL DIVISION For simple unicellular organisms such as the amoeba, one cell division is equivalent to reproduction – an entire new organism is created. On a larger scale, mitotic cell division can create offspring from multicellular organisms, such as plants that grow from cuttings. Page 6 of 12 S. GATUS 2011

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Cell division is the process by which one parent cell divides into two or more daughter cells. The corresponding sort of cell division in prokaryotes is

known as binary fission. This type of cell division in eukaryotes is known as mitosis, and leaves the daughter cell capable of dividing again. In another type of cell division present only in eukaryotes, called meiosis, a cell is permanently transformed into a gamete and cannot divide again until fertilization. Why do cells have to divide? 1. To repair worn-out tissues 2. To grow (multicellular) 3. To reproduce (unicellular) 4. For genetic constancy CELL TERMINOLOGIES A chromosome is an organized structure of DNA and protein that is found in cells.

It is a single piece of coiled DNA containing many genes, regulatory elements and other nucleotide sequences. A centromere is a region of DNA typically found near the middle of a chromosome where two identical sister chromatids come in contact. The spindle fiber is the structure that separates the chromosomes into the daughter cells during cell division. It is part of the cytoskeleton in eukaryotic cells. Centrioles are cylindrical structures that are found in animal cells and help to organize the assembly of microtubules during cell division. WHAT IS MITOSIS? The word mitosis came from the Greek word mitos which means thread. It is a process that takes place in the nucleus of a dividing cell, involves typically a series of steps and results in the formation of two new nuclei each having the same number of chromosomes as the parent nucleus. Hand-out 1 in General Biology Unit 2: Cellular Structures and Function

The primary result of mitosis is the division of the parent cell’s genome into two daughter cells. The genome is composed of a number of chromosomes or complexes of tightly-coiled DNA that contain genetic information vital for proper cell function. Because each resultant daughter cell should be

genetically identical to the parent cell, the parent cell must make a copy of each chromosome before mitosis.

Stages of Mitosis I. Prophase: The two round objects above the nucleus are the centrioles. The chromatin has condensed. The nuclear membrane has degraded and microtubules have invaded the nuclear space. Spindle fibers were formed. Page 7 of 12 S. GATUS 2011

II. Metaphase: The spindle fibers are of equal length on each side. The chromosomes have aligned at the metaphase plate. III. Anaphase The spindle fibers shortened on each side, carrying with them a copy of the chromosome. Early anaphase is usually defined as the separation of the sister chromatids, while late anaphase is the elongation of the microtubules and the chromosomes being pulled farther apart. IV. Telophase The decondensing chromosomes are surrounded by nuclear membranes. Note that cytokinesis has already begun, the pinching is known as the cleavage furrow.

It is also known as " reverse prophase". V. Cytokinesis It is from the Greek word cyto which means cell and kinesis which means motion. It is the process in which the cytoplasm of a single eukaryotic cell is divided to form two daughter cells. Significance of Mitosis Mitosis is important for the maintenance of the chromosomal set. Each cell formed receives chromosomes that are alike in composition and equal in number to the chromosomes of the parent cell. WHAT IS MEIOSIS? The word meiosis came from the Greek word meioun which means to diminish. It is the cellular process that results in the number of chromosomes in sex cells that involves

a reduction division in which one of each pair of homologous chromosomes passes to each daughter cell and a mitotic division. Hand-out 1 in General Biology Unit 2: Cellular Structures and Function

In animals, meiosis always results in the formation of gametes (sex cells), while in other organisms it can give rise to spores. Meiosis is essential for sexual reproduction and therefore occurs in all eukaryotes (including unicellular organisms) that reproduce sexually. MEIOSIS IN GAMETOGENESIS Gametogenesis is a process by which diploid or haploid precursor cells undergo cell division and differentiation to form mature haploid gametes.

SPERMATOGENESIS Spermatogenesis is the process by which male spermatogonia develop into mature spermatozoa, also known as a sperm cell. Spermatozoa are the mature male gametes in many sexually reproducing organisms. Thus, spermatogenesis is the male version of gametogenesis. It starts at puberty and usually continues uninterrupted until death, although a slight decrease can be discerned in the quantity of produced sperm with increase in age. It is highly dependent upon optimal conditions for the process to occur correctly, and is essential for sexual reproduction.

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Penile erection is a physiological phenomenon where the penis becomes enlarged and firm. Ejaculation is the ejecting of semen (usually carrying sperm) from the male reproductive tract, and is usually accompanied by orgasm.

Spermatozoa are then released into the lumen of the seminiferous tubule and transported to the epididymis where they are stored. During ejaculation the sperm are propelled through the vas deferens and urethra and are mixed with secretions from the seminal vesicles, prostate and bulbourethral glands. Importance of Spermatogenesis This process produces mature male gametes, commonly called sperm but specifically known as spermatozoa, which are able to fertilize the counterpart female gamete, the oocyte, during conception to produce a single-celled individual known as a zygote. This is the cornerstone of sexual reproduction and involves the two gametes both contributing half the normal set of chromosomes (haploid) to result in a chromosomally normal (diploid) zygote. OOGENESIS It begins soon after fertilization, as primordial germ cells travel from the yolk sac to the gonads, where they begin to proliferate mitotically. The germ cells multiply from only a few thousand to almost 7 million.

They become oocytes once they enter the stages of meiosis several months after birth. Now called primordial follicles, they are made up of oogenic cells from the primordial germ cells surrounded by follicle cells from the somatic line. The oocyte is then arrested in the first meiotic prophase until puberty. In girls, between the ages of about 10 and14, the pituitary gland produces Luteinizing Hormone (LH) and Follicle Stimulating Hormone (FSH) which together stimulate the production of the sex hormones by the ovaries. The ovaries start to produce estrogen and progesterone which begin the bodily changes that happen during puberty. At puberty, between 4 to 10 follicles begin to develop, although only 1-2 are actually released. Each oocyte

finishes its first meiotic division, creating a secondary oocyte and polar body, which serves no further function. Page 9 of 12 S. GATUS 2011

At the onset of puberty the testes secrete large amounts of testosterone. Testosterone is a steroid hormone which stimulates growth of the testis and initiates maturation of the seminiferous tubules.

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It begins the next meiosis cycle and is arrested in its second metaphase, at which point it is released from the ovary in ovulation. It will not finish the meiosis cycle until it encounters the stimuli of a sperm.

Importance of Oogenesis Whereas the gamete formed by spermatogenesis is essentially a motile nucleus, the gamete formed by oogenesis contains all the materials needed to initiate and maintain metabolism and development. Therefore, in addition to forming a haploid nucleus, oogenesis also builds up a store of cytoplasmic enzymes, mRNAs, organelles, and metabolic substrates. While the sperm becomes differentiated for motility, the egg develops a remarkably complex cytoplasm. Hand-out 1 in General Biology Unit 2: Cellular Structures and Function Page 10 of 12 S. GATUS 2011

IMPORTANCE OF GAMETOGENESIS To preserve the number of chromosomes in the offspring – which differs between species – each gamete must have half the usual number of chromosomes present in other body cells. Otherwise, the offspring will have twice the normal number of chromosomes, and serious abnormalities may result. In humans, chromosomal abnormalities arising from incorrect spermatogenesis can result in Down

Syndrome, Klinefelter’s Syndrome, and spontaneous abortion. Most chromosomally abnormal zygotes will not survive for long after conception. Stages of Meiosis I Meiosis I separates homologous chromosomes, producing two haploid cells (23 chromosomes, N in humans), so meiosis I is referred to as a reduction division. A regular diploid human cell contains 46 chromosomes and is considered 2N because it contains 23 pairs of homologous chromosomes.

Prophase I: The chromatin has condensed. Spindle fibers were formed. The nuclear membrane has degraded. There is pairing up of homologous chromosomes. DNA is exchanged between homologous chromosomes in a process called crossing over. Metaphase I: The spindle fibers are of equal length on each side. Homologous pairs move together along the metaphase plate. Anaphase I: Spindle fibers shorten, severing the recombination nodules and pulling homologous chromosomes apart. The cell elongates in preparation for division down the center. Telophase I: Each daughter cell now has half the number of chromosomes but each chromosome consists of a pair of chromatids. The spindle network disappears and a new nuclear membrane surrounds each haploid set. The cell will now proceed to cytokinesis. Stages of Meiosis II In Meiosis II, a cell division similar to mitosis will occur whereby the sister chromatids are finally split, creating a total of 4 haploid cells (23 chromosomes, N) per daughter cell from the first division. It is a normal mitotic division performed by two cells.

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Telophase II: 🎬 Meiosis II ends with telophase II and is marked by uncoiling and lengthening of the chromosomes and the disappearance of the spindle. 🎬 Nuclear envelopes reform and cleavage or cell wall formation eventually produces a total of four daughter cells, each with a haploid set of chromosomes. Significance of Meiosis 👉 Meiosis facilitates stable sexual reproduction. Without the halving of chromosome count, fertilization would result in zygotes that have twice the number of chromosomes as the zygotes from the previous generation. 👉 Most importantly, recombination and independent assortment of homologous chromosomes allow for a greater diversity of genotypes in the population. This produces genetic variation in gametes that promote genetic and phenotypic variation in a population of offspring.

Prophase II: 🎬 In this prophase we see the disappearance of the nucleoli and the nuclear envelope again as well as the shortening and thickening of the chromatids. 🎬 Centrioles move to the polar regions and arrange spindle fibers for the second meiotic division. Metaphase II: 🎬 The centromeres contain two kinetochores that attach to spindle fibers from the centrosomes (centrioles) at each pole. 🎬 The new equatorial metaphase plate is rotated by 90° when compared to meiosis I, perpendicular to the previous plate. Anaphase II: 🎬 The centromeres are cleaved, allowing microtubules attached to the kinetochores to pull the sister chromatids apart. 🎬 The sister chromatids by convention are now called sister chromosomes as they move toward opposing poles.