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While there are a few cells in the body that do not suffer cell division (such as gametes, red blood cells, most neurons, and some muscle cells), most somatic cells are divided regularly. A somatic cell is a general term for a cell of the body, and all human cells, except cells that produce eggs and sperm (which are called germ cells), are somatic cells. Somatic cells contain two copies of each of their chromosomes (one copy received from each parent). A homogeneous pair of chromosomes is the two copies of a single chromosome found in each somatic cell. Man is a diploid organism, having 23 homogeneous pairs of chromosomes in each of the somatic cells. The condition of having pairs of chromosomes is known as diploidy. Cells in the body are replaced during a person's lifetime. For example, cells lining the gastrointestinal tract should be replaced frequently when they are constantly worn out by the movement of food through the intestine. But what triggers a cell to divide, and prepares for complete cell division? The cell cycle is the sequence of events in cell life from the moment it is created at the end of a previous cell division cycle until it divides, generating two new cells. A or cell cycle cycle consists of two general phases: interphase, followed by mitosis and cytokinesis. Interphase is the period of the cell cycle in which the cell does not divide. Most cells are in interphase most of the time. Mitosis of Mitosis division of genetic material, during which the cell nucleus decomposes and two new, fully functional nuclei are formed. Cytokinesis divides the cytoplasm into two distinctive cells. A cell grows and performs all normal metabolic functions and processes in a period called G1 (Figure 1). Phase G1 (phase gap 1) is the first gap, or growth phase in the cell cycle. For cells that will divide again, G1 is followed by DNA reproduction, during phase S. Phase S (synthesis phase) is the period during which a cell reproduces its DNA. Figure 1. Cell cycle. The two major phases of the cell cycle include mitosis (cell division) and interphase, when the cell grows and performs all normal functions. The interphase is subdivided into phases G1, S and G2. After the synthesis phase, the cell passes through phase G2. Phase G2 is a second phase of the gap, during which the cell continues to grow and makes the necessary preparations for mitosis. Between phases G1, S and G2, the cells will vary most in the duration of phase G1. It's here that a cell could spend a few hours, or several days. Phase S usually lasts between 8-10 hours, and phase G2 about 5 hours. Unlike these phases, phase G0 is a resting phase of the cell cycle. Cells that have temporarily stopped the division and are resting (a common condition) and cells that have permanently ceased splitting (such as nerve cells) are said to be in G0. Billions of cells in the human body are divided every day. During the synthesis phase (S, for DNA synthesis) of interphase, the amount of DNA in the cell doubles exactly. Therefore, after DNA reproduction, but before cell division, each cell actually contains two copies of each chromosome. Each copy of the chromosome is called sister chromatid and is physically bound to the other copy. The centerrom is the structure that attaches one chromatid sister to another. Because a human cell has 46 chromosomes, at this stage, there are 92 chromatids (46 × 2) in the cell. Be sure not to confuse the concept of a chromatid pair (a chromosome and the exact copy attached during mitosis) and a homogeneous pair of chromosomes (two associated chromosomes that have been inherited separately, one from each parent) (Figure 2). Figure 2. A homogeneous pair of chromosomes with their sister chromatids attached. The red and blue colours correspond to a homogeneous pair of chromosomes. Each member of the pair was inherited separately from a parent. Each chromosome in the homogeneous pair is also bound to an identical sister chromatide, which is produced by DNA replication, and results in the familiar form X. The mitotic phase of the cell usually lasts between 1 and 2 hours. During this phase, a cell goes through two major processes. First, it complements mitosis, during which the contents of the nucleus are dismembered and distributed between its two halves. Then cytokinesis appears, dividing body in two new cells. Mitosis is divided into four major stages that occur after interphase (Figure 3) and in the following order: prophase, metaphase, anaphase and telophase. The process is then followed by cytokinesia. Figure 3. Cell division: Mitosis followed by cytokines. The stages of cell division supervise the separation of identical genetic material into two new nuclei, followed by the division of the cytoplasm. Prophase is the first phase of mitosis, during which the chromatin coils are packed and condensed into visible chromosomes. During the prophase, each chromosome becomes visible with its identical partner attached, forming the familiar X-shape of the sister chromatids. The kernelol disappears early at this stage, and the nuclear envelope disintegrates. A major event during the prophase refers to a very important structure containing the place of origin for the growth of the microtube. Remember the cellular structures called centrioles that serve as points of origin from which microtubules expand. These small structures also play a very important role during mitosis. A centrosome is a pair of centrioles together. The cell contains two side-by-side centrosomes, which begin to spread during the prophase. As centrosomes migrate to two different sides of the cell, the microtubules begin to extend from each as long fingers from two hands extend to each other. The mitotic axis is the structure composed of centrosomes and their developing microtubules. Near the end of the prophase there is an invasion of the nuclear zone by the microtubules of the mitotic axis. The nuclear membrane has disintegrated, and the microtubules attach to the centromeres that border on pairs of sister chromatids. Kinetochore is a protein structure on the centromeres, which is the fixation point between the mitotic axis and the sister chromatids. This stage is called late prophase or promethaphase to indicate the transition between prophase and metaphase. Metaphase is the second stage of mitosis. At this stage, the sister chromatids, with their microtubules attached, line up along a linear plane in the middle of the cell. A metaphase plate is formed between the centrosomes that are now at each end of the cell. The metaphase plate is the name of the plane through the center of the axis on which the sister chromatids are positioned. Microtubules are now ready to separate the sister chromatids and bring one of each pair to each side of the cell. Anaphase is the third stage of mitosis. Anaphase occurs over the course of a few minutes, when sister chromatid pairs are separated from each other, forming individual chromosomes again. These chromosomes are pulled to the opposite ends of the cell by their kinetochores as the microtubules shorten. Each end of the cell receives one partner from each pair of sister chromatids, ensuring that the two new daughter cells will contain identical genetic material. Telophase final stage of mitosis. Telophase is characterized by the formation of two new daughter nuclei at each end of the dividing cell. These newly formed nuclei surround the genetic material, which peels off so that chromosomes return to packaged chromatin. The nuclei also reappear inside the new nuclei, and the mitotic axis breaks apart, with each new cell receiving its own complement of DNA, organelles, membranes and centriols. At this point, the cell is already beginning to split in half as cytokinesbegins begin. The cleavage sillon is a contractile band made up of microfilaments that form around the median line of the cell during cytokines. (Remember that microfilaments consist of actin.) This contractile tape tightens the two cells until they finally separate. Now two new cells are forming. One of these cells (stem cell) enters its own cell cycle; able to grow and share again at some point the future. The other cell turns into the functional cell of the tissue, usually replacing an old cell there. Imagine a cell that finished mitosis but did not suffer cytokines. In some cases, a cell can divide its genetic material and grow in size, but fail to submit to cytokines. This leads to larger cells with more than one nucleus. Usually, this is an unwanted aberration and can be a sign of cancer cells. A very elaborate and precise regulatory control system directs how cells move from one phase to another in the cell cycle and begin mitosis. The control system involves molecules inside the cell, as well as triggers external. These internal and external control triggers provide stop and advance signals for the cell. Precise regulation of the cell cycle is essential for maintaining the health of an organism, and loss of cell cycle control can lead to cancer. As the cell passes through its cycle, each phase involves certain processes that must be completed before the cell advances to the next phase. A checkpoint is a point in the cell cycle where the cycle can be flagged to go forward or off. At each of these checkpoints, different varieties of molecules provide stop or go signals, depending on certain conditions inside the cell. Cycline is one of the primary classes of cell cycle control molecules (Figure 4). A cycline-dependent kinase (CDK) is one of a group of molecules that work together with cyclines to determine the progression past cell control points. By interacting with many additional molecules, these triggers push the cell cycle forward unless prevented from doing so by stop signals, if for some reason the cell is not ready. At control point G1, the cell must be ready for DNA synthesis to At the G2 checkpoint the cell must be fully prepared for mitosis. Even during mitosis, a crucial checkpoint in metaphase ensures that the cell is fully prepared to complete cell division. The metaphase control point ensures that all sister chromatids are properly attached to the microtubules and align to the metaphase plate before the signal is given to separate them during anaphasis. Figure 4. Cell cycle control. Cells pass through the cell cycle under the control of a variety of molecules, such as cyclines and cycline-dependent kinases. These control molecules determine whether or not the cell is ready to move to the next stage. Most people understand that cancer or tumors are caused by abnormal cells that multiply continuously. If abnormal cells continue to divide unstopped, they can damage the tissues around them, spread to other parts of the body, and eventually lead to death. In healthy cells, the mechanisms of tight regulation of the cell cycle prevent this from happening, while cell cycle control failures can cause unwanted and excessive cell division. Control failures can be caused by inherited genetic abnormalities that compromise the function of certain stop and go signals. The environmental insult that DNA damage can also cause dysfunction in these signals. Often a combination of genetic predisposition and environmental factors leads to cancer. The process of a cell that gets rid of its normal control system and becomes cancerous can actually happen throughout the body quite frequently. Fortunately, certain cells of the immune system are able to recognize the cells that have become cancerous and their destruction. However, in some cases, cancer cells remain undetected and continue to proliferate. If the resulting tumor does not pose a threat to surrounding tissues, it is said to be benign and can usually be easily removed. If it is capable of damage, the tumor is considered malignant and the patient is diagnosed with cancer. Homeostatic Imbalances Cancer arises from homeostatic imbalances Cancer is an extremely complex condition, capable of emerging from a wide variety of genetic and environmental causes. Typically, mutations or aberrations in the DNA of a cell that compromise normal cell cycle control systems lead to cancerous tumors. Cell cycle control is an example of a homeostatic mechanism that maintains proper cellular function and health. As it progresses through the cell cycle phases, a wide variety of intracellular molecules provide stop and go signals to regulate forward movement to the next phase. These signals are maintained in a complex balance, so that the cell moves to the next phase only when it is ready. This homeostatic control of the cell cycle can be thought of as a cruise control of a car. Cruise Control will continuously apply just the right amount of acceleration to maintain a desired speed, unless the driver hits the brakes, in which case the car will slow down. Similarly, the cell includes molecular messengers, that push the cell forward in its cycle. In addition to cycline, a class of proteins that are encoded by genes called proto-oncogenes provide important signals that regulate the cell cycle and move it forward. Examples of products include cell surface receptors for growth factors, or signal cell molecules, two classes of molecules that can promote DNA replication and cell division. Instead, a second class of genes known as tumor suppressor genes sends stop signals during a cell cycle. For example, certain protein products of the tumor suppressor genes signal potential problems with DNA and thus stop cell division, while other proteins signal the cell to die if it is damaged beyond repair. Some tumor suppressor proteins also signal a sufficient surrounding cell density, indicating that the cell should not currently divide. The latter function is particularly important in preventing tumor growth: normal cells exhibit a phenomenon called contact inhibition; thus, extensive cellular contact with neighboring cells causes a signal that stops subsequent cell division. These two contrasting classes of genes, proto-oncogenes and tumor suppressor genes, are like the accelerator and brake pedal of the cell's own cruise control system, respectively. Under normal conditions, these stop and departure signals shall be maintained in a homeostatic balance. Generally speaking, there are two ways in which cell cruise control may lose control: a (hyperactive) accelerator malfunction or a faulty (subactive) brake. When compromised by a mutation or otherwise modified, proto-oncogenes can be converted into oncogenes, which produce oncoproteins that push a cell forward in its cycle and stimulate cell division even when it is not desirable to do so. For example, a cell that should be programmed to self-destruct (a process called apoptosis) due to extensive DNA damage could be triggered to proliferate through an oncoprotein. On the other hand, a dysfunctional tumor suppressor gene may not provide the cell with a necessary stop signal, which also results in unwanted cell division and proliferation. A delicate homeostatic balance between many proto-oncogenes and tumor suppressor genes delicately controls the cell cycle and ensures that only healthy cells reproduce. Therefore, a disturbance of this homeostatic balance can cause aberrant cell division and cancerous growths. Visit this link to learn more about mitosis. Visit this link to learn more about mitosis. Mitosis results in two identical diploid cells. What structures are formed during the prophase? The life of the cell consists of the stages that make up the cell cycle. After a cell is born, it passes through an interphase before it is ready to reproduce and produce daughter cells. This interphase includes two phases of the gap (G1 and G2), as well as an S phase, during which its DNA replicated in preparation for cell division. The cell cycle is under precise regulations of chemical messengers both inside and outside the cell that provide stop and go signals for movement from one phase to another. Failures of these signals can lead to cells that continue to divide uncontrollably, which can lead to cancer. Once a cell has interphase and is ready for cell division, goes through four separate stages of mitosis (prophase, metaphase, anaphase and telophase). Telophase is followed by the division of cytoplasm (cytokines), which generates two daughter cells. This process occurs in all cells that normally divide the body, except germ cells that produce eggs and sperm. Visit this link to learn more about mitosis. Mitosis results in two identical diploid cells. What structures are formed during the prophase? the third stage of mitosis (and meiosis), during which sister chromatids separate into two new nuclear regions of the cell cycle of the division of a single cell, from its birth to its division into two new daughter cells the attachment region for two sister chromatids the centrosome cellular structure that organizes microtubules during the point of progress of the cell division control point in the cell cycle where certain conditions must be met for the cell to switch to a contractile cleavage ring in the section phase that forms around a cell during cytokinesis that pinches the cell into two halves of cycline from a group of proteins that function in the progression of the cycline-dependent kinase cell cycle (CDK) from a group of cycline-associated enzymes that help them perform their cytokinesis functions final stage in cell division; if the cytoplasm is divided to form two separate daughter cells diploid state marked by the presence of a double complement of genetic material (two sets of chromosomes, one set inherited from each of the two parents) phase G0 of the cell cycle, usually introduced from phase G1; characterized by long or permanent periods in which the cell does not advance to the DNA synthesis phase Phase G1 first phase of the cell cycle, after a new cell is born phase three phase of the cell cycle, after the dna synthesis phase has described two copies of the same chromosome (not identical), one inherited from each interphase mother the entire life cycle of a cell , with the exception of the kinetocore mitosis region of a centromere where microtubules attach to a pair of sister chromatids metaphase the second stage of mitosis (and meiosis), characterized by the linear alignment of sister chromatids in the center of the cell metaphase the linear alignment of the sister chromatids in the center of the cell, which occurs during the metaphase division of the genetic material, during which the cell nucleus decomposes and two new , fully functional, the nuclei are formed the mitotic phase of the cell cycle in which a cell undergoes a network of mitotic axis mytosis of microtubules, coming from the centrioles, which arrange and divide the chromosomes during the first stage of mitosis prophase of mitosis (and meiosis), characterized by the breakdown of the nuclear coating and the condensation of chromatin to form stage S of the cell cycle during which chromatid DNA replication occurs one of a pair of chromosomes, formed during DNA replication of somatic cells all cells of the body, except telophase cells the final stage of mitosis (and meiosis), the previous cytokinesis, characterized by the formation of two new daughter nuclei