Cell Cycle: The Role Of Nucleic Acids In The Nucleus And Cytoplasm

Nucleic acids are molecules made up of nucleotides that direct cellular activities such as cell division and protein synthesis. Each nucleotide is made up of a pentose sugar, a nitrogenous base, and a phosphate group. There are two types of nucleic acids: DNA and RNA. DNA carries the genetic blueprint of the cell and is passed on from parents to offspring (in the form of chromosomes). It has a double-helical structure with the two strands running in opposite directions, connected by hydrogen bonds, and complementary to each other. RNA is single-stranded and is made of a pentose sugar (ribose), a nitrogenous base, and a phosphate group. RNA is involved in protein synthesis and its regulation. Messenger RNA (mRNA) is copied from the DNA, is exported from the nucleus to the cytoplasm, and contains information for the construction of proteins. Ribosomal RNA (rRNA) is a part of the ribosomes at the site of protein synthesis, whereas transfer RNA (tRNA) carries the amino acid to the site of protein synthesis. microRNA regulates the use of mRNA for protein synthesis.

The Generation Of Specialized Tissues From Embryonic Stem Cells

The process of generating embryonic stem cell line is somewhat inefficient, so lines are not produced each time cells from the preimplantation-stage embryo are placed into a culture dish. However, if the plated cells survive, divide and multiply enough to crowd the dish, they are removed gently and plated into several fresh culture dishes. The process of re-plating or subculturing the cells is repeated many times and for many months. Each cycle of subculturing the cells is referred to as a passage. Once the cell line is established, the original cells yield millions of embryonic stem cells. Embryonic stem cells that have proliferated in cell culture for six or more months without differentiating, are pluripotent, and appear genetically normal are referred to as an embryonic stem cell line. At various points during the process of generating embryonic stem cell lines, scientists test the cells to see whether they exhibit the fundamental properties that make them embryonic stem cells.

At any stage in the process, batches of cells can be frozen and shipped to other laboratories for further culture and experimentation.

The embryonic stem cells are usually derived from in vitro fertilisation, where the eggs have been fertilised in vitro (not in a woman's body) and donated for research with donor consent. The embryos are generally utilised when they are approximately four or five days old and constitute a tiny ball of cells known as a blastocyst. Pluripotent embryonic stem cells are derived from the blastocyst. Embryonic stem cells can, however, be either totipotent or pluripotent cells. Those cells that are totipotent include the fertilised egg itself as well as the cells produced during the very early divisions.

The Importance Of Interphase And Factors That Initiate Cell Division

Despite the millions of sperm produced and released with each ejaculation, only one can fertilize an egg – this is the case even for identical twins. The sex of the resulting embryo depends on which type of sperm burrows into the egg first. Sperm with a Y chromosome make a baby boy, and sperm with an X chromosome make a girl.

Every day, every hour, every second one of the most important events in life is going on in your body cells are dividing. When cells divide, they make new cells. A single cell divides to make two cells and these two cells then divide to make four cells, and so on. We call this process 'cell division' and 'cell reproduction,' because new cells are formed when old cells divide. The ability of cells to divide is unique for living organisms.

Cells divide for many reasons. For example, cells divide to replace old, dead, or damaged cells. Cells also divide so living things can grow. Organisms grow because cells are dividing to produce more and more cells. In human bodies, nearly two trillion cells divide every day.

Human beings began as a single cell or as an egg. By the time you become an adult, you will have trillions of cells. That number depends on the size of the person. In cell division, the cell that is dividing is called the 'parent' cell. The parent cell divides into two 'daughter' cells. The process then repeats in what is called the cell cycle.

Cells regulate their division by communicating with each other using chemical signals from special proteins called cyclins. These signals act like switches to tell cells when to start dividing and later when to stop dividing. It is important for cells to divide so you can grow and so your cuts can heal. It is also important for cells to stop dividing at the right time. If a cell can not stop dividing when it is supposed to stop, this can lead to a disease called cancer.

Depending on the kind of cell, there are two ways in which cells divide. Mitosis and meiosis. Each of these methods of cell division has special characteristics. One of the key differences in mitosis is a single cell divides into two cells that are replicas of each other and have the same number of chromosomes. This type of cell division is good for basic growth, repair, and maintenance. In meiosis a cell divides into four cells that have half the number of chromosomes. Reducing the number of chromosomes by half is important for sexual reproduction and provides for genetic diversity.

In mitosis, the important thing to remember is that the daughter cells each have the same chromosomes and DNA as the parent cell. The daughter cells from mitosis are called diploid cells. Diploid cells have two complete sets of chromosomes. Since the daughter cells have exact copies of their parent cell's DNA, no genetic diversity is created through mitosis in normal healthy cells.

The Mitosis Cell Cycle

Before a cell starts dividing, it is in the 'Interphase.' It seems that cells must be constantly dividing (remember there are 2 trillion cell divisions in your body every day), but each cell actually spends most of its time in the interphase. Interphase is the period when a cell is getting ready to divide and start the cell cycle. During this time, cells are gathering nutrients and energy. The parent cell is also making a copy of its DNA to share equally between the two daughter cells.

The mitosis division process has several steps or phases of the cell

cycle interphase, prophase, prometaphase, metaphase, anaphase, telophase, and cytokinesis to successfully make the new diploid cells.

How The Same Genetic Information Is Received By Each Daughter Cell

Mitosis cell division creates two genetically identical daughter diploid cells. The mitosis cell cycle includes several phases that result in two new diploid daughter cells. When a cell divides during mitosis, some organelles are divided between the two daughter cells. For example, mitochondria are capable of growing and dividing during the interphase, so the daughter cells each have enough mitochondria. The Golgi apparatus, however, breaks down before mitosis and reassembles in each of the new daughter cells.

Meiosis is the other main way cells divide. Meiosis is cell division that creates sex cells, like female egg cells or male sperm cells. In meiosis, each new cell contains a unique set of genetic information. After meiosis, the sperm and egg cells can join to create a new organism.

Meiosis is why we have genetic diversity in all sexually reproducing organisms. During meiosis, a small portion of each chromosome breaks off and reattaches to another chromosome. This process is called 'crossing over' or 'genetic recombination.' Genetic recombination is the reason full siblings made from egg and sperm cells from the same two parents can look very different from one another.

The meiosis cell cycle has two main stages of division -- Meiosis I and Meiosis II. The end result of meiosis is four haploid daughter cells that each contain different genetic information from each other and the parent cell.

(Image from Science Primer from the National Center for Biotechnology Information.)

The Meiosis Cell Cycle

Meiosis has two cycles of cell division, conveniently called Meiosis I and Meiosis II. Meiosis I halves the number of chromosomes and is also when crossing over happens. Meiosis II halves the amount of genetic information in each chromosome of each cell. The end result is four daughter cells called haploid cells. Haploid cells only has one set of chromosomes - half the number of chromosomes as the parent cell.

Before meiosis I starts, the cell goes through interphase. Just like in mitosis, the parent cell uses this time to prepare for cell division by gathering nutrients and energy and making a copy of its DNA. During the next stages of meiosis, this DNA will be switched around during genetic recombination and then divided between four haploid cells.

So remember, Mitosis is what helps us grow and Meiosis is why we are all different!

Normal Cells

- Contact inhibition
- Control growth
- Specialized cells
- Normal chromosomes
- Undergo apoptosis

Cancer Cells

- No contact inhibition
- Uncontrolled growth (tumor)
- Non specialized cells
- Abnormal chromosomes
- No apoptosis

References:

1. Bianconi E, Piovesan A, Facchin F, Beraudi A, Casadei R, Frabetti F, Vitale L, Pelleri MC, Tassani S, Piva F, Perez-Amodio S, Strippoli P, Canaider S. Ann. An estimation of the number of cells in the human body. accessed January 3, 2020 from https://www.ncbi.nlm.nih.gov/pubmed/23829164.