Abnormal regulation of genes

The products of proto-oncogenes and tumor-suppressor genes control cell division. A DNA change that makes a proto-oncogene overly active converts it to an oncogene, which then may promote extra cell division and cancer. A tumor-suppressor gene encodes a protein that inhibits abnormal cell division. A mutation that reduces activity of its protein product may lead to excessive cell division and cancer.

Many proto-oncogenes and tumor-suppressor genes encode components of growth-stimulating and growth-inhibiting signaling path-ways, respectively, and mutations in them can interfere with normal signaling pathways. A hyperactive version of a protein in a stimulatory pathway, such as Ras (a G protein), functions as an oncogene protein. A defective version of a protein in an inhibitory pathway, such as p53 (a transcription activator), fails to act as a tumor suppressor.

In the multistep model of cancer development, normal cells are converted to cancer cells by the accumulation of mutations affecting proto-oncogenes and tumor-suppressor genes. Technical advances in DNA and mRNA sequencing are enabling cancer treatments that are more individually based.

Genomics studies have resulted in four proposed subtypes of breast cancer, based on expression of genes by tumor cells.

Individuals who inherit a mutant allele of a proto-oncogene or tumor-suppressor gene have a predisposition to develop a particular cancer. Certain viruses promote cancer by integration of viral DNA into a cell's genome.

Identical daughter cells

The genetic material (DNA) of a cell- its genome- is partitioned among chromosomes. Each eukaryotic chromosome consists of one DNA molecule associated with many proteins. Together, the complex of DNA and associated proteins is called chromatin. The chromatin of a chromosome exists in different states of condensation at different times. In animals, gametes have one set of chromosomes, and somatic cells have two sets.

Cells replicate their genetic material before they divide, each daughter cell receiving a copy of the DNA. Prior to cell division, chromosomes are duplicated. Each one then consists of two identical sister chromatids joined along their lengths by sister chromatid cohesion and held most tightly together at a constricted region at the centromeres. When this cohesion is broken, the chromatids separate during cell division, becoming the chromosomes of the daughter cells. Eukaryotic cell division consists of mitosis (division of the nucleus) and cytokinesis (division of the cytoplasm).

Cell cycle regulated by system

Signaling molecules present in the cytoplasm regulate progress through the cell cycle.

The cell cycle control system is molecularly based; key regulatory proteins are cyclins and kinases. The cell cycle clock has specific checkpoints where the cell cycle stops until a go-ahead signal is received; important checkpoints occur in the Gi, G2, and M phases. Cell culture has enabled researchers to study the molecular details of cell division. Both internal signals and external signals control the cell cycle checkpoints via signal transduction pathways. Most cells exhibit density-dependent inhibition of cell division as well as anchorage dependence.

Cell cycle regulated by system (cont)

Cancer cells elude normal cell cycle regulation and divide un-checked, forming tumors. Malignant tumors invade nearby tissues and can undergo metastasis, exporting cancer cells to other sites, where they may form secondary tumors. Recent cell cycle and cell-signaling research, and new techniques for sequencing DNA, have led to improved cancer treatments.

Mitotic and Interphase alternate

Between divisions, a cell is in interphase: the G1, S, and G2 phases. The cell grows throughout interphase, with DNA being replicated only during the synthesis phase, that being S. Mitosis and cytokinesis make up the Mitotic phase of the cell cycle, also referred to as the M phase.

The mitotic spindle, made up of microtubules, controls chromosome movement during mitosis. In animal cells, it arises from the centrosomes and includes spindle microtubules and asters. Some spindle microtubules attach to the kinetochores of chromosomes and move the chromosomes to the metaphase plate. After sister chromatids separate, motor proteins move them along kinetochore microtubules toward opposite ends of the cell. The cell elongates when motor proteins push nonkinetochore microtubules from opposite poles away from each other.

Mitosis is usually followed by cytokinesis. Animal cells carry out cytokinesis by cleavage, and plant cells form a cell plate.

During binary fission in bacteria, the chromosome replicates and the daughter chromosomes actively move apart. Some of the proteins involved in bacterial binary fission are related to eukaryotic actin and tubulin. Since prokaryotes preceded eukaryotes by more than a billion years, it is likely that mitosis evolved from prokaryotic cell division.

Enzyme activity regulation

Many enzymes are subject to allosteric regulation: Regulatory molecules, either activators or inhibitors, bind to specific regulatory sites, affecting the shape and function of the enzyme. In cooperativity, binding of one substrate molecule can stimulate binding or activity at other active sites. In feedback inhibition, the end product of a metabolic pathway allosterically inhibits the enzyme for a previous step in the pathway.

Some enzymes are grouped into complexes, some are incorporated into membranes, and some are contained inside organelles, increasing the efficiency of metabolic processes.