



Cell Biology 101

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Introduction

Mammalian tissue or cell culture techniques were developed in the early 1900s, as a method of maintaining animal organs outside of the body. During the 1940s and 1950s cell culture technology emerged as an essential tool to support virology research by enabling vaccine production through viral purification. Today, cell culture is used worldwide as a model for a variety of studies, including intra- and intercellular communication, tissue/organ development or organization, and different disease states, such as cancer, Parkinson's disease, and diabetes. In this guide the most common cell types used in cell biology are described.

Cell Types

There are four tissue types in the human body: epithelial, connective, nervous, and muscle tissues. Each tissue type is derived during embryonic development from the primary germ layer, which itself is composed of three layers known as the ectoderm, mesoderm, and endoderm. Epithelial tissue covers and lines the organs and cavities in the human body; it makes up the secretory and excretory areas of organs, the glands, and transport and lubrication membranes that are found in different organs. Connective tissue forms the structural supports within the body, such as bone, cartilage, tendons, and ligaments, and stores nutrients. Reticular connective tissue supports the lymph nodes, bone marrow, and spleen. Nervous tissue functions to relay information between the brain and muscles in the form of chemical/electrical impulses, while muscle tissue found integrated with

the skeleton, in the GI tract, and in the heart contracts and relaxes to perform movements.

Cell types are often categorized into primary cells or cell lines (immortal cells). Primary cells are cultured cells freshly derived from a living organism. Once in culture they undergo a limited, predetermined number of cell divisions. For this reason, primary cells can be passaged a finite number of times and are considered to be very delicate and sensitive. Cell lines, in contrast to primary cells, typically undergo unlimited cell division and have an infinite lifespan.

Common Cell Types

Adipocytes

Adipocytes are fat cells that primarily compose adipose tissue; they are differentiated and become specialized in the synthesis and storage of fat. There are two types of adipose tissue, white adipose tissue (WAT) and brown adipose tissue (BAT), which are also known as white fat (composed of white fat cells) and brown fat (composed of brown fat cells), respectively.

Common adipocyte cell lines include 3T3-L1, HIB 1B, LS14, and TA1 cells.

Endothelial cells

Endothelial cells make up the lining of all blood vessels, and the lymphatic and circulatory systems. Endothelial cells are flat and form a single layer of endothelium to allow for the rapid and efficient exchange of gases (oxygen and carbon dioxide).

The most common primary cell lines derived from endothelial cells are the HUVEC cell lines, which are isolated from the umbilical cord.

Epidermal cells

Epidermal cells make up the epidermis, a single cell layer that comprises the outermost layer of the skin.

Common epidermal cell lines include H5-MNNG and REK cells.

Epithelial cells

Epithelial cells are derived from all three germ layers — ectoderm, mesoderm, and endoderm — and form closely packed tissue structures, characterized by a basal membrane that is anchored to a surface and a free apical surface. The shape of epithelial cells can be squamous (thin, flat), cuboidal (cube-shaped), or columnar (column-shaped) depending upon the specific organ and microenvironment. For example, the surface of the body's skin (epidermis) has a stratified squamous epithelium. As much as 85% of all cancers are derived from epithelial cells, and are known as “carcinomas.” You will find epithelial cells defined by the terms epithelial, epithelioid, and epithelial-like.

- Common epithelial cell lines include CHO, FRTL-5, MM3MG, and NRK52E cells
- Common epithelial carcinoma cell lines include A549, C41, HeLa, Hep-2, Hep3b2, HepG2, MCF-7, MEL, and U373 cells

Fibroblasts

Fibroblasts are the most common cells of connective tissue in animals. Fibroblasts actively synthesize and secrete matrix proteins that provide the structural framework for many connective tissues. Fibroblasts in cell culture are characterized by their elongated, elliptical, or spindle-shaped appearance and typically do not form monolayer structures. They are often used to model wound healing as they play a critical role in this mechanism. Mouse embryonic fibroblasts (MEFs) are commonly used in stem cell cultures to provide a structural framework by secreting the extracellular matrix and “feeding” the stem cells. Fibroblasts are often defined by the terms fibroblast-like and fibroblastoid.

- Common fibroblast cell lines include 293, 3T3, BHK, COS, L929, Ltk-, MEFs, NHDF-neo, NIH 3T3, SBAC, V79, and Vero cells
- Common fibroblast carcinoma cell lines include C127, D202CC, and LNCaP cells

Glial cells

Glial cells are supportive cells in the central nervous system — the brain and spinal cord. Unlike neurons, glial cells do not conduct electrical impulses. Instead, they surround neurons and provide support and insulation. However, glial cells are capable of extensive

signaling in response to diverse stimuli. Glial cells are the most abundant cell type in the central nervous system. Common glial cells include astrocytes, oligodendrocytes, and LN229 cells.

Human embryonic kidney cells

Human embryonic kidney cells, also referred to as HEK 293 or 293 cells, are a specific cell line originally derived from human embryonic kidney cells grown in tissue culture. HEK 293 cells are very easy to grow, transfect very readily, and are widely used in cell biology research.

Keratinocytes

Keratinocytes are the primary cells of the epidermis, making up approximately 95% of epidermal cells; they are specialized epidermal cells that synthesize keratin. Common keratinocyte cell lines include NCTC 2544 and PM1–4 cells.

Mesenchymal cells

Mesenchymal cells are undifferentiated cells found in mesenchyme and are capable of differentiating into various specialized connective tissues.

Common mesenchymal cell lines include C3H10T1/2 cells.

Myoblasts

Myoblasts are undifferentiated cells on the mesoderm of the vertebrate embryo that are precursors of muscle cells. Myoblasts differentiate into cells such as vascular smooth muscle cells (VSMCs) and myocardial cells.

Neuronal cells

Neuronal cells function as information processing and transfer cells in the nervous system.

Common neuronal cell lines include IMR-32 and SNKSH cells.

Squamous cells

Squamous cells are thin, flat epithelial cells localized in most organs of the body. The term squamous is most commonly associated with cancer pathology, for example, squamous cell carcinoma, one of the more common forms of skin cancer, and squamous carcinoma of the lung.

Common squamous cell lines include KOSCC-11 and SCC-83-01-82 cells.

Stem cells

Stem cells are the human body's master cells and have the ability to differentiate into any one of the body's more than 200 cell types. All stem cells are unspecialized (undifferentiated) cells that characteristically are of the

same family type (lineage). They retain the ability to divide throughout life and give rise to cells that can become highly specialized and take the place of cells that die or are lost. Stem cells can be categorized into embryonic and adult stem cells. Embryonic stem cells are undifferentiated cells derived from the inner cell mass of the blastocyst that can give rise to any of the three embryonic germ layers and, thus, can form any cell or tissue type of the body. Adult stem cells are undifferentiated cells found throughout the body that divide to replenish dying cells and regenerate damaged tissues. Also known as somatic stem cells, they can be found in children, as well as in adults.

Common stem cell lines are human stem cell lines, such as hpSC-Hhom-4 cells, and mouse embryonic stem cell lines, such as IOUD2 cells.

Stromal cells

Stromal cells are connective tissue cells of an organ found in the loose connective tissue. They are most often associated with the uterine mucosa and the ovary as well as the haematopoietic system.

Common stromal cell lines include PA6 and ST2 cells.

Trophoblasts

Trophoblasts comprise the outermost layer of cells of the blastocyst; this cell layer attaches the blastocyst to the uterine wall and becomes the placenta and the membranes that nourish and protect the developing organism.

Common trophoblast cell lines include AC1-M59 and ACH-3P cells.

Blood/Immune-Response Cell Types

B cells

B cells are a type of lymphocyte; B cells generate antibodies to form an immune response to foreign bodies (bacteria, toxins). You may also see the term “pre-B” cells — these are also B cells.

Common B-cell lines include Jeko-1, Raji, and Ramos cells.

Basophils

Basophils are a type of leukocyte (white blood cell) with coarse bluish-black granules of uniform size within the cytoplasm and, typically, a bilobate (two-lobed) nucleus. Basophils are so named because their cytoplasmic granules stain with basic dyes. They normally constitute 0.5–3% of the peripheral blood leukocytes and they contain (and can release) histamine and serotonin. Basophils are also called basophilic leukocytes.

Common basophil cell lines include KU812-F and RBL-2H3 cells.

Erythrocytes

Erythrocytes are cells that contain hemoglobin and can carry oxygen throughout the body. They are also called red blood cells (RBCs). The reddish color is due to the hemoglobin. Erythrocytes are biconcave in shape, which increases the cell's surface area and facilitates the diffusion of oxygen and carbon dioxide. This shape is maintained by a cytoskeleton composed of several proteins. Erythrocytes are very flexible and change shape when flowing through capillaries. Immature erythrocytes, called reticulocytes, normally account for 1–2% of red blood cells.

Common erythrocyte cell lines include HEL 92.1.7 and MEL cells.

Granulocytes

Granulocytes are a type of white blood cell filled with microscopic granules. These granules are sac-like structures containing enzymes that digest microorganisms. Granulocytes are part of the innate immune system and have somewhat nonspecific, broad-based activities. They do not respond exclusively to specific antigens, as do B cells and T cells. Neutrophils, eosinophils, and basophils are all types of granulocytes. Their names come from the characteristic staining features of their granules.

Common granulocyte cell lines include HMC-1, Ku812, and RBL cells.

Hematopoietic cells

Hematopoietic cells are stem cells found in the bone marrow of adults that give rise to all blood cell types. They constantly renew blood by producing billions of new cells per day. Common hematopoietic cells include CD34+ cells, Langerhans cells, and mesenchymal stem cells (MSCs).

Leukocytes

Leukocytes are also known as white blood cells. They participate in the inflammatory and immune responses to protect the body against infection and to repair injuries to tissues. White blood cells are formed mainly in the bone marrow and, unlike red blood cells, have a nucleus. The major types of white blood cells are granulocytes, lymphocytes, and monocytes. White blood cells are far less numerous in the blood than red blood cells, but their amount usually increases in response to infection and can be monitored as part of a clinical assessment.

Common leukocyte cell lines include BJAB, CML, Daudi, and HL-60 cells.

Lymphoblasts

Lymphoblasts are often called blast cells; a lymphoblast is a dividing cell that gives rise to a mature lymphocyte in response to an antigenic stimulus. The lymphocyte usually develops by enlargement of a lymphoblast, active re-entry to the S phase of the cell cycle, mitogenesis, and elevated production of mRNA and ribosomes.

Common lymphoblast cell lines include MCL-5 and MOLT-4 cells.

Lymphocytes

Lymphocytes, also known as leukocytes, are small white blood cells that have a significant role in the body's immune system. There are two main types of lymphocytes: B cells, which generate antibodies to attack bacteria and toxins, and T cells, which attack body cells after they have been infected with viruses or have become cancerous. Lymphocytes are generated from lymphoblasts, also known as lymphocytoblasts. In cell culture lymphocytes appear as spherical cells, with a single nucleus and a granular exterior. They are approximately the same size as a red blood cell (7 μm). Cell surface staining is used to distinguish between B cells and T cells.

- Common lymphocyte or lymphoblast-derived cell lines include 517-17, B95-8, CEMx174, DT40, EL4, H9, J558L, Jurkat, JY, LCL, Ramos, SP2/0, and UC729-6 cells
- Common lymphocyte-derived cancer cell lines include BC-3, HCT116, and HL-60 cells

Macrophages

Macrophages are found in the alveoli of the lungs, and are characterized as round, granular mononuclear phagocytes (cells that engulf microorganisms and particulate matter in the bloodstream).

Common macrophage cell lines include J774 and RAW 264.7 cells.

Mast cells

Mast cells are found in connective tissue that contains numerous basophilic granules and release substances such as heparin and histamine in response to injury or inflammation of body tissues.

Common mast cell lines include HMC-1 and P815 cells.

Monocytes

Monocytes, a type of white blood cell, are precursors of macrophages.

Common monocyte cell lines include 416B, MOLM-14, and THP-1 cells.

Myelocytes

Myelocytes are young cells of the granulocytic series, normally occurring in bone marrow, but not in circulating blood. Common myelocytes include dendritic cells (Langerhans cells and follicular dendritic cells), granulocytes (neutrophils, eosinophils, and basophils), and mast cell precursors.

Myelomonocytes

Myelomonocytes are abnormal leukocytes (white blood cells) which resemble both myelocytes and monocytes (immature cells that develop into different types of immune system cells). These cells occur in myelomonocytic leukemias.

Common myelomonocyte cell lines include THP-1 and U-937 cells.

Neutrophils

Neutrophils are a type of white blood cell, specifically, a form of granulocyte. Neutrophils are filled with neutrally-staining granules, which contain enzymes that help the cell kill and digest microorganisms it has engulfed by phagocytosis. The mature neutrophil has a segmented nucleus, while the immature neutrophil has a band-shaped nucleus. The neutrophil has a lifespan of approximately 3 days.

Common neutrophil-like cell lines include HL-60, NB-4, and THP-1 cells.

Reticuloendothelial cells

Reticuloendothelial cells make up the reticuloendothelial system (RES). The RES is part of the immune system, and is comprised of monocytes and macrophages that accumulate in the lymph nodes and spleen.

Common reticuloendothelial cell lines include Kupffer and THP-1 cells.

T cells

T cells are a type of lymphocyte; the T cell plays an integral role in the immune response by attacking the body's own cells when they have become infected with a foreign entity (virus, bacteria, cancer).

Common T-cell lines include Jurkat, MOLT-4, TG40, and U-937 cells.

Thymocytes

Thymocytes are lymphocytes that are derived from the thymus and are the precursors of the T cells.

Common thymocyte cell lines include CD4+ and CD8+ cells.

Cancer Cell Types

Adenocarcinoma

Adenocarcinoma is a cancer derived from epithelial cells of the glandular tissue. Common adenocarcinomas develop in the breast and lung, but most frequently in the colon.

Common adenocarcinoma cell lines include A549, MCF-7, and TE-7 cells.

Carcinoma

Carcinoma is a cancer that begins in the lining (epithelial cells) or covering of an organ or gland.

Common carcinoma cell lines include HT29, MCF-7, and SW626 cells.

Embryonal carcinoma

Embryonal carcinoma is a cancer derived from germ cells (sperm and egg cells). The most common form of embryonal carcinoma is testicular cancer.

A common embryonal carcinoma cell line is the F9 mouse cell line.

Erythroleukemia

Erythroleukemia is a rare form of acute myeloid leukemia (AML), a cancer derived from myeloid cells or white blood cells.

Common erythroleukemia cell lines include GM979, HEL, and K5621 cells.

Fibrosarcoma

Fibrosarcoma is a cancer derived from fibroblasts.

Common fibrosarcoma cell lines include KHT, QT-35, and W7.2c cells.

Hepatoma

Hepatoma is a cancer derived from hepatic cells of the liver.

Common hepatoma cell lines include FTO2B, HepG2, Huh-7, and SK-Hep1 cells.

Lymphoma

Lymphoma is a cancer derived from lymphocytes (a type of white blood cell).

Common lymphoma cell lines include A20, BC-3, CA46, HCT116, and ST-486 cells.

Lymphoblastoma

Lymphoblastoma is a cancer derived from lymphoblasts (immature lymphocytes).

Common lymphoblastoma cell lines include ESb and TCLB cells.

Leukemia

Leukemia is a cancer originating in the white blood cells or bone marrow.

Common leukemia cell lines include HL-60 and K562 cells.

Myeloma

Myeloma is a cancer originating in the plasma cells, which are immune system cells in the bone marrow.

Common myeloma cell lines include Karpas 707H, spEBr-5, and U266-B1 cells.

Neuroblastoma

Neuroblastoma is a cancer of the nervous system that usually originates in the tissues of the adrenal gland, in the ganglia of the abdomen, or in the ganglia of the nervous system. It presents as solid tumors in the chest or around the spinal cord.

Common neuroblastoma cell lines include N1E-115, SH-SY5Y, SK-N-AS, SK-N-BE, SK-N-SH, and SMS-KAN cells.

Glossary

Antigen — any substance that antagonizes or stimulates the immune system to produce antibodies (protein complexes that target and neutralize antigens). Antigens are generally foreign substances or organisms such as bacteria or viruses.

Cancer — an abnormal growth of cells; the cells tend to proliferate in an uncontrolled manner and, in some cases, spread in the body (metastasis).

Cytoplasm — the entire contents of the cell, exclusive of the nucleus, and bounded by the plasma membrane.

Differentiated cells — cells that maintain in culture all or much of the specialized structure and function they normally carry in vivo.

Eukaryote — a cell or organism having a membrane-delimited nucleus and, usually, other organelles.

Gamete — a mature male (sperm cell) or female (ovum or egg cell) germ cell.

Germ cells — the reproductive cells, namely, sperm and egg cells.

Hemoglobin — an iron-containing protein in red blood cells that transports oxygen from the lungs to the rest of the body.

Histamine — a protein present in cells throughout the body that is released during an allergic reaction. It is one of the substances responsible for the symptoms of inflammation.

Immune system — the collection of cells and organs which protect the body from foreign substances. It includes the thymus, spleen, lymph nodes, B and T cells, and antigen-presenting cells.

Mesenchyme — the part of the embryonic mesoderm, consisting of loosely packed, unspecialized cells set in a gelatinous ground substance, from which connective tissue, bone, cartilage, and the circulatory and lymphatic systems develop.

Mitogenesis — induction of mitosis, which is the process by which a eukaryotic cell separates the chromosomes in its nucleus into two identical sets prior to cell division.

Multipotent cells — stem cells that can differentiate into a limited number of cell types.

Nervous system — the system of nerves, ganglia, and, in vertebrates, the spinal cord and brain that regulates and coordinates all the body's activities.

Nucleus — the part of the cell which contains the chromosomes. Transcription of genes takes place in the nucleus.

Phagocytosis — the process whereby cells engulf and destroy solid substances, for example, bacteria and foreign particles.

Pluripotent cells — stem cells that are able to differentiate into many cell types.

Primary cells — cells in culture that are freshly derived from tissues or organ pieces. They undergo a limited, predetermined number of cell divisions before arresting permanently in G₀ phase — a process that is called cellular senescence.

Progenitor cells — partially specialized cells in fetal and adult tissues that divide and develop into differentiated cells.

Prokaryote — a cell that lacks a membrane-enclosed nucleus and organelles (bacterial cell).

Ribosomes — cellular bodies made of RNA and protein that exist within the cytoplasm of all living cells; ribosomes are the site of protein synthesis.

Serotonin — a neurotransmitter that helps regulate sleep and appetite, mediate moods, and inhibit pain.

Somatic cell — any cell in the body that is not a germ cell.

Undifferentiated cells — unspecialized cells, for example, stem cells.

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