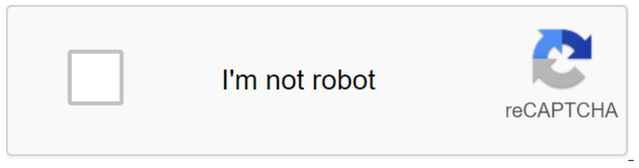

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Secondary cell culture pdf

The process by which cells are grown under controlled conditions by cell culture in a small cup of petri epithelial cells in culture, painted for keratin (red) and DNA (green) cell culture is the process by which cells are grown under controlled conditions, usually outside their natural environment. Once the cells of interest have been isolated from living tissue, they can then be maintained in carefully controlled conditions. These conditions vary for each type of cell, but usually consist of a suitable vessel with a substrate or environment that supplies the necessary nutrients (amino acids, carbohydrates, vitamins, minerals), growth factors, hormones and gases (CO_2, O_2), and regulates the physiochemical environment (buffer pN, osmotic pressure, temperature). Most cells require a surface or artificial substrate (adept culture or monolayer) whereas others can be grown free floating in the culture medium (suspension culture). The lifespan of most cells is genetically defined, but some cell cultivation cells have been converted into immortal cells that will multiply indefinitely if optimal conditions are provided. In practice, the term cell culture currently refers to the cultivation of cells derived from multicellular eukaryotes, especially animal cells, unlike other types of culture that also grow cells, such as plant tissue culture, fungal culture and microbiological culture (microbes). The historical development and methods of cell culture are closely related to tissue culture and organ culture. Viral culture is also associated with cells as hosts for viruses. Laboratory techniques for maintaining living cell lines (cell population, originating from the same cell and containing the same genetic composition), separated from the original source of tissues, became more reliable in the middle of the 20th century. The 19th century story by English physiologist Sidney Ringer developed saline solutions containing sodium, potassium, calcium and magnesium chlorides suitable for maintaining the beating of an isolated animal heart outside the body. In 1885, Wilhelm Roux removed part of the embryonic chicken's medullary plate and maintained it in a warm salt solution for several days, establishing the principle of tissue culture. Ross Granville Harrison, who worked at Johns Hopkins School of Medicine and then Yale University, published the results of his experiments from 1907 to 1910, establishing a methodology for tissue culture. Cell culture techniques were greatly improved in the 1940s and 1950s to support virology research. Growing viruses in cell cultures has made it possible to prepare purified viruses for vaccine production. The injection of polio vaccine, developed by Jonas Salk, was one of the mass-produced products using cellular culture techniques. This vaccine has been made possible by John Franklin Enders, Thomas Huck Weller and Frederick Chapman Robbins, who were awarded the Nobel Prize for discovering the method of growing the virus in monkey kidney cell cultures. Concepts in mammalian cell culture Cell Isolation Cell Main article: Cell isolation Cells can be isolated from tissues for ex vivo culture in several ways. Cells can be easily cleaned of blood; however, only white cells are capable of growth in culture. Cells can be isolated from solid tissues by digesting the extracellular matrix using enzymes such as collagenase, trypsin, or pronases, before agitating the tissue to release the cells into the pendant. In addition, pieces of tissue can be placed in the growth media, and the cells that grow are available for culture. This method is known as the culture of explant. Cells that culture directly from the subject are known as primary cells. With the exception of some tumor derivatives, most primary cell cultures have a limited lifespan. The established or immortalized cell line has acquired the ability to reproduce indefinitely either by accidental mutation or by deliberate modification, such as the artificial expression of the telomerase gene. Numerous cell lines are well established as representative of particular cell types. Maintaining cells in culture For most isolated primary cells, they undergo a process of senescence and stop dividing after a certain number of population doubling, while generally maintaining their vitality (described as the Hayflick limit). Cells are grown and maintained at appropriate temperature and gas mixture (usually 37 degrees Celsius, 5% CO_2 for mammalian cells) in a cell incubator. Culture conditions vary greatly for each cell type, and changing conditions for a particular type of cell can lead to different phenotypes. Bottle DMEM cell culture environmentS Apart from temperature and gas mixture, the most commonly diverse factor in culture systems is the growth environment of cells. Recipes for media growth can vary in pH, glucose concentration, growth factors, and availability of other nutrients. Growth factors used to supplement the media often stem from animal blood serum such as fetal cattle serum (FBS), cattle calf serum, equestrian serum and whey pigs. One of the complications of these blood-derived components is the possibility of contracting culture with viruses or prion, especially in the field of medical biotechnology. The current practice is to minimize or eliminate the use of these ingredients where possible and to use human licks (hPL). This eliminates concern about interspecies pollution when using FBS with human cells. hPL has become a safe and reliable alternative as a direct replacement for FBS or other animal serum. In addition, chemically defined media can be used to eliminate any traces of serum (human or or But this can't always be achieved with different cell types. Alternative strategies include finding the blood of animals from countries with minimal BSE/TSE risk, such as the United States, Australia and New ealand, and using purified nutrient concentrates derived from serum instead of all animal serum for cell culture. Coverage density (the number of cells per cultural environment) plays a crucial role for some cell types. For example, a lower coating density makes granulose cells demonstrate estrogen production, while higher coating density makes them appear as progesterone-produced lutein cells. Cells can be grown either in suspension or in adept cultures. Some cells naturally live in suspension without being attached to the surface, such as cells that exist in the blood. There are also cell lines that have been modified to be able to survive in suspension culture so they can be grown to a higher density than adept conditions will allow. Adherents of cells require surfaces such as tissue culture plastic or microtransfer that can be covered with extracellular matrix (e.g. collagen and laminin) components to increase the properties of adhesion and provide other signals needed for growth and differentiation. Most cells derived from solid tissues are adherents. Another type of adherent culture is organotypical culture, which involves growing cells in a three-dimensional (3-D) environment, as opposed to two-dimensional crops. This 3D culture system is biochemically and physiologically more similar to tissues in vivo, but is technically difficult to maintain due to many factors (e.g. diffusion). Components of the Cell Culture Media Component Function Carbon Source (glucose/glutamine) Energy Source Amino acid Building blocks of protein vitamins promote cell survival and growth of a balanced saline solution Isotonic mixture of ions to maintain optimal osmotic pressure in cells and provide the necessary metal ions to act as cofactors for enzimatic reactions, cellular adhesion and adhesion. The color of phenol red varies from orange/red at pH 7-7.4 to yellow at sour (lower) pH and purple at base (above) pH. Bicarbonate /HEPES Buffer It is used to maintain a balanced pH in the media Typical growth conditions Parameter Temperature 37 DEGREE CO_2 5% Relative humidity 95% Cell Line cross-contamination Main article: The list of contaminated cell lines of cell line cross-contamination can be a problem for scientists working with cultural cells. Studies show that in 15 to 20% of cases, the cells used in experiments were identified or contaminated by another cell line. Problems with cross-contamination of the cell line have even been detected in the NCI-60 panel lines, which are commonly used for drug screening research. The main storage facilities of cell lines, including The Culture Type Collection (ATCC), the European Cell Cultures Collection (ECACC) and the German Collection of Microorganisms and Cell Cultures (DSM), received submissions of the cell line from researchers who were incorrectly identified by them. Such pollution poses a challenge to the quality of research produced using cell culture lines, and the main repositories are now authenticating all cell line representations. The ATCC uses short tandem re-dna fingerprinting (STR) to verify the authenticity of its cell lines. To address this problem of cross-contamination of the cell line, researchers are encouraged to verify the authenticity of their cell lines at an early stage to establish the identity of the cell line. Authentication should be repeated before cell lines are frozen, every two months during active cultivation and prior to the publication of data from studies generated using cell lines. Many methods are used to identify cell lines, including isoenzyme analysis, human lymphocyte antigen (HLA) typing, chromosomal analysis, cariothing, morphology and STR analysis. One of the significant cross-contaminants of the cell line is the immortal line of HeLa cells. Other technical problems, like cells, tend to continue to divide in culture, they tend to grow to fill an accessible area or volume. This can generate several problems: Nutritional depletion in the media of the growth of changes in the pH growth of media Accumulation of apoptotic /necrotic (dead) cell cells to cell contact can stimulate the arrest of the cell cycle, causing the cells to stop the division, known as contact inhibition. Cellular contact can stimulate cellular differentiation. Genetic and epigenetic changes, with the natural selection of altered cells potentially leads to the growth of abnormal, culture-adapted cells with reduced differentiation and increased proliferativity. Manipulation of cultural cells Among the common manipulations carried out on cultural cells are changes in the sm, pass-by the cells and transfectionation of cells. They are usually performed using tissue culture techniques that rely on aseptic techniques. Aseptic technique is designed to avoid contamination by bacteria, yeast or other cell lines. Manipulations are usually carried out in a biosecurity office or laminar flow closet to eliminate contamination of microorganisms. Antibiotics (e.g. penicillin and streptomycin) and antifungal drugs (e.g. amphotericin B and antimicrobial solution) can also be added to the media growth. As cells metabolic processes, acid produced and pH reduces. Often the pH indicator is added to the environment to measure nutrient depletion. Changes in the media In the case of cultures of adherents, the media can be removed directly by the aspiration and then replaced. Changes in the media in non-adherent cultures include the centralization of culture and the re-engagement of cells in the fresh media. Passing Cells Main article: Passaging Passaging (also known as as or cell breakdown) involves transferring a small number of cells to a new vessel. Cells can be cultured for a longer time if they divide regularly, as this avoids the senescence associated with prolonged high cell density. Suspension cultures are easily flown with a small amount of culture containing several cells diluted by a large volume of fresh media. For culture adepts, cells must first be separated; This is usually done with a mixture of trypsin-EDTA; however, other enzyme mixtures are now available for this purpose. A small number of individual cells can be used to seed a new crop. Some cell cultures, such as RAW cells, are mechanically scraped off the surface of their vessel by rubber scrapers. Transfection and Transduction Main articles: Transfection and Transformation (Genetics) Another common method for cell manipulation involves the introduction of non-abnormal DNA through transfection. It is often performed to cause cells to express gene interest. Recently, RNA transfection has been implemented as a convenient mechanism for suppressing the expression of a particular gene/protein. DNA can also be inserted into cells through viruses, in methods called transduction, infection or conversion. Viruses, like parasitic agents, are well suited for injecting DNA into cells, as this is part of their normal reproduction course. The established human cell lines of The Cultural Cells of HeLa were painted in Hoechst turning their nucleus blue, and are one of the earliest human cell lines to have originated from Henrietta Lux, who died of cervical cancer from which these cells originated. The cell lines that occur with humans have been somewhat controversial in bioethics, as they can outlive their parent body and then be used in discovering lucrative medical procedures. In a groundbreaking decision in this area, the California Supreme Court held in Moore v. Regents of the University of California stating that patients do not have property rights in cell lines derived from organs removed with their consent. Additional information: Hybridoma can fuse normal cells with a perpetuated cell line. This method is used to produce monoclonal antibodies. In short, lymphocytes isolated from the spleen (or possibly blood) of an immunized animal are combined with the immortal line of myeloma cells (B-cell line) for the production of a hybridoma that has the specificity of primary lymphocyte antibodies and the immortality of myeloma. Selective growth environment (HA or HAT) is used to select against unenced myeloma cells; primary lymphocytes die rapidly in culture, and only fused cells survive. They are tested for the production of the necessary antibodies, usually in to start with, and then after one cloning. Cell strain Cell Strain comes either from primary culture or cell line of choice of choice cloning of cells with specific properties or characteristics that need to be identified. Cell strains are cells that have been adapted to culture but, unlike cell lines, have the ultimate fission potential. Immoderate cells stop dividing after 40-60 populations, and then they lose the ability to reproduce (a genetically defined event known as senescence). The application of cell culture Mass culture to animal cell lines is fundamental to the production of viral vaccines and other biotechnology products. Human stem cell culture is used to expand the number of cells and differentiate cells into different types of somatic cells for transplantation. Stem cell culture is also used to collect molecules and exosome that stem cells release for therapeutic development purposes. Biological products produced by recombinant DNA technology (rDNA) in animal cell cultures include enzymes, synthetic hormones, immunobiological (monoclonal antibodies, interlequins, lymphocytes) and anti-cancer agents. While many simple proteins can be produced using rDNA in bacterial cultures, more complex proteins that are glycosylated (carbohydrate modified) now have to be made in animal cells. An important example of such a complex protein is the hormone erythropoietin. The cost of growing mammalian cell cultures is high, so research is underway to produce such complex proteins in insect cells or in higher plants, the use of one embryonic cell and somatic embryos as a source for direct transmission of genes through particle bombardment, expression of transit genes and observation of confocal microscopy is one of its applications. He also proposes to confirm the origin of single-celled somatic embryos and the asymmetry of the first cell division that triggers the process. Cell culture is also a key method for cellular agriculture, which aims to provide both new products and new ways of producing existing agricultural products such as milk, (cultural) meat, flavors and rhino horns from cells and microorganisms. Therefore, it is considered one of the means of achieving animal-free agriculture. It is also a central tool for learning cell biology. Cell culture in two dimensions Research in tissue engineering, stem cell and molecular biology primarily includes cell cultures on flat plastic utensils. This method is known as two-dimensional (2D) cell culture, and was first developed by Wilhelm Roux, who in 1885 removed part of the embryonic chicken's medullary plate and maintained it in a warm salt for a few days on a flat glass plate. In view of the development of polymer technology, today's standard plastic plate for 2D cell culture, commonly known as petri dish, emerged. German bacteriologist Julius Richard Petri is usually credited with this invention while working as an assistant to Robert Koch. Various researchers today also also cultivation of laboratory flasks, koniks and even disposable bags such as disposable bioreactors. Aside from petri dishes, scientists have long grown cells in biologically derived matrix such as collagen or fibrin, and more recently, on synthetic hydrogels such as polyacrylamide or PEG. They do this in order to identify phenotypes that are not expressed on conventionally rigid substrates. There is a growing interest in controlling matrix rigidity, leading to discoveries in areas such as: Self-mutilation of stem cells The function of hepatocytes in three dimensions of Cellular Culture in three dimensions has been touted as the New Dimension of Biology. Currently, the practice of cell culture is still based on different combinations of one- or several cellular structures in 2D. Forest-based cultures use a cellular 3D matrix or liquid matrix. Methods free of scaffolding are usually generated in suspensions. There are various platforms used to facilitate the growth of 3D cellular structures, including scaffold systems such as hydrogel matrix and solid scaffold-free systems such as low-adhesion plates, nanoparticles promoted by magnetic levitation, and hanging drop plates. The culture of 3D cells on Eric Simon's scaffolding in a 1988 NIH SBIR grant report showed that electrospinning could be used to produce polystyrene and polycarbonate fibrous forests specifically designed for use as substrate cells in vitro. This early use of electrospon fibrotic lattice for cell culture and tissue engineering has shown that different cell types, including human Foreskin Fibroblasts (HFF), converted human carcinomas (HEp-2), and mink lung epithelium (MLE) will adhere to and multiply on polycarbonate fibers. It was noted that, unlike the flattened morphology commonly observed in 2D culture, cells grown on electrospoon fibers demonstrated a more histotypic rounded 3-dimensional morphology, usually observed in vivo. The culture of 3D cells in hydrogels As a natural extracellular matrix (ECM) is important in the survival, proliferation, differentiation and migration of cells, different hydrogel culture matrix, imitating the natural structure of ECM, are considered as potential approaches to in vivo - as cell cultivation. Hydrogels consist of interconnected pores with high water retention, which allows for the efficient transport of substances such as gases. Several different types of hydrogel from natural and synthetic materials are available for 3D cell culture, including ecm animal hydrogel extract, protein hydrogels, peptide hydrogel, polymer hydrogels and wood-based nanocellulose hydrogel. 3D Cell Culturing by magnetic levitation of 3D cult cells by magnetic levitation method (MLM) is the application of growing 3D tissue by inducing cells treated with magnetic nanoparticles assembled in spatially different magnetic fields using neodimi magnetic drivers and promoting cellular interaction by levitating cells to air/liquid interface of the standard Petri cup. Magnetic nanoparticles consist of magnetic iron oxide nanoparticles, gold nanoparticles and polymer polyline. The cultivation of 3D cells is scalable, with the ability to cultivate 500 cells to millions of cells or from a single dish to systems with low bandwidth. The fabric of cell culture and engineering culture is one of the main components of tissue culture and tissue engineering, as it establishes the basis for growing and maintaining cells in vitro. The main application of human cell culture is in the stem cell industry, where mesenchymal stem cells can be culturally and cryopreserved for future use. Fabric engineering potentially offers a dramatic improvement in the low cost of care for hundreds of thousands of patients a year. Vaccines against polio, measles, mumps, rubella and chickenpox are now made in cell cultures. Due to the threat of the H5N1 pandemic, research into the use of cell culture for influenza vaccines is funded by the United States government. New ideas in this area include recombinant DNA-based vaccines, such as vaccines made using human adenovirus (cold virus) as a vector, and new adjuvants. The culture of non-mammalian cells In addition to the culture of well-established perpetuated cell lines, the cells of the primary explants of many organisms can be learned for a limited period of time before the senescence occurs (see Heiflik limit). Cultural primary cells are widely used in studies, as in the case of fish keratocytes in cell migration studies. The plant cell culture methods Of the plant Main article: Plant tissue culture See also: By-2 Plant cell culture Plant factory are typically grown as cell suspension cultures in a liquid environment or as callus cultures on a solid medium. The cultivation of undifferentiated plant and kalli cells requires a proper balance of growth hormones of plants auxin and cytokinin. Insect culture cells derived from Drosophila melanogaster (most notably, Schneider 2 cells) can be used for which can be difficult to do on live flies or larvae such as biochemical research or research using siRNA. Cell lines derived from the army worm Spodoptera frugiperda, including Sf9 and Sf21, as well as from the cabbage loop loop ni, High Five Cells, are commonly used to express recombinant proteins using baculovirus. Bacterial and Yeast Culture Techniques Main article: Microbiological Culture For Bacteria and Yeast, a small number of cells are usually grown on solid support, which contains nutrients embedded in it, usually gel, such as agar, while large-scale crops are grown with cells suspended in a nutrient broth. Methods of Viral Culture Main article: Viral Culture Culture Virus Culture requires a culture of cells of mammals, plants, fungal or bacterial origin as hosts for the growth and replication of the virus. Whole wild viruses, recombinant viruses or viral products can be created in cell types, except for their natural hosts in the right conditions. Depending on the type of virus, infection and viral replication can lead to the lysion of host cells and the formation of viral plaque. General cell lines of human cell lines DU145 (prostate cancer) H295R (adrenocortic cancer) HeLa (cervical cancer) KBM-7 (chronic myeloid leukemia) LNCaP (prostate cancer MCF-7 (breast cancer) MDA-MB-468 (breast cancer) PC3 (prostate cancer) SaOS-2 (bone cancer) SH-SY5Y (neuro-SYblas, cloned from myeloma) T-47D (breast cancer) THP-1 (acute myeloid leukemia) U87 (glioblastoma) National Cancer Institute 60 cancer cell line panel lines (NCI60) Primat cell lines Vero (African green monkey Chlorocebus renal epithelial cell line) Mouse cell lines MC3 Calvary) Rat GH3 (pituitary tumor) PC12 (feohromocytoma) Plant cell lines Tobacco cells BY-2 (preserved as a culture of cell suspension, they are a model system of plant cells) Other types of cell lines Dog MDCK kidney epithelial Xenopus A6 renal epitelal zebrafish AB9 List of cell lines you can help by expanding it. Cell Line Meaning Tissue Of The Body's Origin Morphology Links 3T3-L1 3-Day Translation, inoculum 3 x 10'5 Cell Mouse Embryo Fibroblast ECACC Cellosaurus 4T1 Mouse Dairy Iron ATCC Cellosaurus 9L Rat Brain Glioblastoma ECACC Cellosaurus A172 Human Brain Glioblastoma ECACC Cellosaurus A20 Mouse B lymphocytes Cellosaurus A253 Human submandibular Head and neck carcinoma ATCC Cellosaurus A2780 human ovarian carcinoma ECACC Cellosaurus A2780ADR human ovarian Adriamycin resistant derivatives A2780 ECACC Cellosaurus A2780 human ovarian cisplatin resistant derivativeS A2780 ECACC Calosaurus A431 Human skin epithelium squamous cell carcinoma ECACC Cellosaurus A549 human lung carcinoma ECACC Cellosaurus AB9 zebrafish Fin Fibroblast ATCC Cellosaurus AHL-1 Armenian lung hamster-1 Lightweight ECACC Cellosaurus A CLA Mouse Bonebarrow Stroma PMID 243541261 Cellosaurus B16 Mouse Melanoma ECACC Cellosaurus B35 Rat Neuroblastoma ATCC Cellosaurus BCP-1 Human PBMC HIV-primary effucation lymphoma ATCC Cellosaurus BEAS-2B Bronchi epithelium 12-SV40 Hybrid Virus (Ad12SV40) Human Lung Epithelial ECACC Cellosaurus bEnd.3 End.3 Endothelial Brain Brain 3 Mouse Brain / Brain Endothely Cellosaurus BHK-21 Baby Hamster Kidney-21 Hamster Kidney Fibroblast ECACC Cellosaurus BOSC23 Cellor derived from HEK 293 Human Kidney (embryonic) Epithelium Cellosaurus BT-20 Breast Tumor-20 Human Breast Epithelium Breast Carcinoma ATCC Cellosaurus BxPC-3 Biopsy xenotransplant line of pancreatic carcinoma 3 Human adenocarcinoma Epithelial ECACC Cellosaurus C2C12 Mouse Myoblast ECACC Cellosaurus C3HT1/2 Mouse Embryonic Mesenchymal Cell Line ECACC Cellosaurus C6 Rat Brain Astrocyte Glioma ECACC Cellosaurus C6/36 Insect - Asian Tiger Mosquito Larval ECACC Cellosaurus Caco-2 Human Colorectal Carcinoma ECACC Cellosaurus Cal-27 Human Tongue Squamous cell carcinoma ATCC 3 Human lungs Adenocarcinoma ATCC Cellosaurus CGR8 Mice Embryonic Stem Cells ECACC Cellosaurus CHO Chinese Hamster Ovary Hamster Ovary Epithelium ECACC Cellosaurus CML T1 Chronic Myeloid Leukemia T lymphocyte 1 CellOC 1 Man CML Acute Phase T-Cell Leukemia DSM' Cellosaurus CMT12 Canine Mammary Tumor 12 Dog Mammary Cellosaurus COR-L23 Man ECACC Cellosaurus COR-L23/5010 human lung carcinoma ECACC Cellosaurus COR-L23/CPR human lung carcinoma ECACC Cellosaurus COR-L23/R23- Human lung carcinoma ECAC Cellosaurus COS-7Pc Cercopith Origin defective SV-40 Century Old Monkey - Cerchik Fibroblast ECACC Cellosaurus COV-434 Human ovarian granulosis cell carcinoma PMD 843643556 Mouse Colon Colorectal Carcinoma Cellosaurus D17 Dog Lung Metastasy Osteosarcoma ATCC DAOY Human Brain Medulloblastoma ATCC Cellosaurus DH82 Dog Hysticocito Monot/MacroFage OCCC Gene insensitive prostate carcinoma ATCC Cellosaurus DuCaP Dura Mater Prostate Cancer Man Metastatic Prostate Epitheal PMID 11317521'63Cellosaurus E14Tg2a Mouse Embryonic Stem Cells ECACC Cellosaurus EL4 Mouse T Cellular Leukemia ECACC Cellosaurus EM-2 Human Crisis CML Crisis Explosion CML Ph' CML Line DSM' Cellosaurus EMT6/AR1 Mouse Dairy Iron Epithelial-like ECACC Cellosaurus EMT6/AR10.0 Mouse Dairy Iron Epithelial-like ECACC Cellosaurus FM3 Human lymph node metastasse Melanoma ECACC Cellosaurus GL261 Glioma 261 Mouse Brain Glioma Cellosaurus ATCC Cellosaurus HaCaT Human Skin Keratinocyte CLS Cellosaurus HCA2 Human Colon Adenocarcinoma ECACC Cellosaurus HEK293 Human Embryonic Kidney 293 Human Kidney (Embryonic) Epithelium ECACC Cellosaurus HEK 293T HEK 293 Human Kidney Derivatives Epithelium ECACC Cellosaurus HeLa Henrietta Lux Human cervix epithelial cervix carcinoma ECACC ECACC Hepa1c1c7 Клон 7 клона 1 гепатомы линии 1 мышь гепатома эпителиальный ECACC Cellosaurus Hep G2 человека печени гепатобластома ECACC Cellosaurus High Five Insect (моль) - Trichoplusia ni Ovary Cellosaurus HL-60 Human Blood Myeloblast ECACC Cellosaurus HT-1080 Human Fibrosarcom ECACC Cellosaurus HT-29 Человеческой толстой кишки эпителия Аденокарцинома ECACC Cellosaurus J558L Мышь Миелома В лимфоцитовая клетка ECACC Cellosaurus Jurkat Человеческие белые кровяные тельца Т-клеточный лейкоз ECACC Cellosaurus JY человека Лимфобластоид EBV-преобразованный В-клеток ECACC Cellosaurus K562 Человеческий лимфобластоидный CML 7 Человеческий лимфобластоидный кризис взрыва ХМЛ Cellosaurus KCL-22 Человека Лимфобластоидный CML DSM' Cellosaurus KG1 Человеческий лимфобластоидный AML ECACC Cellosaurus Ku812 Человеческий лимфобластоид эритролейкемия ECACC Cellosaurus KYO-1 Human Lymphoblastoid CML DSM- Cellosaurus L1210 Мышиная лимфоцитная ECACC Cellosaurus L243 Мышь Гибридома Секретирует L243 mAb (против HLA-DR) ATCC Cellosaurus LNCaP лимфатический узел Рак предстательной железы человека простаты простаты простаты предстательной аденокарциномы Эпителиальный ECACC Cellosaurus MA-104 Микробиологические Associates-104 Африканская зеленая обезьяна почки Эпителиальный кельзоавр MA2.1 Мышь Гибридная mAb (against HLA-A2 and HLA-B17) ATCC Cellosaurus Ma-Mel 1 , 2, 3....48 Human Skin A range of melanoma cell lines ECACC Cellosaurus MC-38 Mouse Colon-38 Mouse Colon Adenocarcinoma Cellosaurus MCF-7 Michigan Cancer Foundation-7 Human Breast Invasive breast ductal carcinoma ER+, PR+ ECACC Cellosaurus MCF-10A Michigan Cancer Foundation-10A Human Breast epithelium ATCC Cellosaurus MDA-MB-157 M.D. Anderson - Metastatic Breast-157 Human Pleural effusion metastasis Breast carcinoma ECACC Cellosaurus MDA-MB-231 M.D. Anderson - Metastatic Breast-231 Human Pleural effusion metastasis Breast carcinoma ECACC Cellosaurus MDA-MB-361 M.D. Anderson - Metastatic Breast-361 Human Melanoma (contaminated by M14) ECACC Cellosaurus MDA-MB-468 M.D. Anderson - Metastatic Breast-468 Human Pleural effusion metastasis Breast carcinoma ATCC Cellosaurus MDCK II Madin Darby Canine Kidney II Dog Kidney Epithelium ECACC Cellosaurus MG63 Human Bone Osteosarcoma ECACC Cellosaurus MIA PaCa-2 Human Prostate Pancreatic Carcinoma ATCC Cellosaurus MOR/0.2R Human Lung Lung carcinoma ECACC Cellosaurus Mono-Mac-6 Human White blood cells Myeloid metaplasic AML DSMZ Cellosaurus MRC-5 Medical Research Council cell strain 5 Human Lung (fetal) Fibroblast ECACC Cellosaurus MTD-1A Мышь Эпителий Cellosaurus MyEnd Миокарда Эндотелиальный мышь Эндотелий Cellosaurus NCI-H69 человека легких карциномы ECACC Cellosaurus NCI-H69/CPR человека легких карцинома ECACC Cellosaurus NCI-H69/LX10 Рак легких человека ECACC Cellosaurus NCI-H69/LX20 Карцинома легких человека ECACC Cellosaurus NCI-H69/LX4 Карцинома легких человека ECACC Neuro-2a Mouse Mouse ECACC Cellosaurus NIH-3T3 NIH Neural Stem Cells, 3-Day Transmission, inoculum 3 x 105 Cell Mouse Embryon Fibroblast ECACC Cellosaurus NALM-1 Human Peripheral Blood Blast-Crisis CML ATCC Cellosaurus NK-92 Human Leukemia/Lymphoma ATCC Cellosaurus NTERA-2 Human Lung MetastasicAl Carcinoma ECACC Cellosaurus NW-145 Melanoma EST Skin Ossum Kidneys Virginia Possum - Didelphis virginiana Kidneys ECACC Cellosaurus OPCN / OPCT Cell Lines Human Prostate Cellosaurus Range Cellosaurus P3X63Ag8 Mouse Myeloma ECACC Cellosaurus PANC-1 Human duct Epithelioid carcinoma ATCC Cellosaurus PC12 Ratren Adal medu ECACC Cellosaurus PC-3 Prostate Cancer-3 Metastases of Human Bone Prostate Carcinoma ECACC Cellosaurus Peer Man T-Cell Leukemia DSM' Cellosaurus PNT1A Human Prostate SV40-Transformed Tumor Line ECACC Cellosaurus PNT2 Human Prostate SV40-Transformed Tumor Line LCECA Cellosa Pt2 Cell Line From Potorus tridactylis Long-legged Pottoru - Potorus tridactylus kidney Epithelial ECACC Cellosaurus Raji human B lymphoma lymphoblast-like ECACC Cellosaurus RBL-1 Rat Basophiline Leukemia-1 Rat Leukemia Cell Basophilus ECACC Cellosaurus RenCa Renal Carcinoma карциномы ATCC Cellosaurus RIN-5F Мышь Поджелудочная железа ECACC Cellosaurus RMA-S Мышь Т-клеточная опухоль Cellosaurus S2 Шнайдер 2 Насекомое - Drosophila меланогастер Поздняя стадия (20-24 часов) эмбрионы ATCC Cellosaurus SaOS-2 Sarcoma OSteogenic-2 Человеческий остеосаркомы ERDA 21 Насекомое (ночная бабочка) - Spodoptera frugiperda Ovary ECACC Cellosaurus Sf9 Spodoptera frugiperda 9 Насекомое (моль) - Spodoptera frugiperda Ovary ECACC Cellosaurus SH-SY5Y Метастазы костного мозга человека Нейробластома ECACC Cellosaurus SiHa Human Cervix BR-3 Слоан-Kettering рака молочной железы 3 рака молочной железы человека DSM' Cellosaurus SK-OV-3 Слоан-Kettering рака яичников 3 человека яичников карцинома ECACC Cellosaurus SK-N-SH человеческого мозга Эпителиальный ATCC Cellosaurus T2 Человека Т-клеточная лейкемия / В клеточной линии гибридома ATCC Cellosaurus T-47Dosaurus T84 Человеческие метастазы легких Колоректальная карцинома ECACC Cellosaurus T98G Человека Глиобластома-астроцитома Эпителия ECACC Cellosaurus THP-1 Человек Моноцит Острый моноцитарный лейкоз ECACC Cellosaurus U2OS Человека Остеосаркома Эпителиальный ECACC Cellosaurus U373 Человеческий Глиобластома-астроблай Человек Глиобластома-астроцитома Эпителиал-как ECACC Cellosaurus U937 Человека Лейкемическая моноцитатическая лимфома ECACC Cellosaurus VCaP Vertebral Cancer метастазов простаты простаты карцинома ECACC Cellosaurus Vero от эсперанто : verda (green, for green monkey) rhino (kidneys) Effucin Lymphoma Cellosaurus WM39 Human Skin Melanoma ESTDAB Cellosaurus WT-49 Human Lymphoblastic ECACC Cellosaurus YAC-1 Mouse Lymphoma ECACC Cellosaurus YAR Human Lymphoblastoid EBV-transformed B-cell immunologist Human EnCC Cellosaurus See also Biological Immortality Cell Culture Analyses Electrical Cell-Substrate Sensing List of Contaminated Cell Lines List NCI-60 Cell Lines List of Breast Cancer Lines Links and Notes - Some Landmarks in Tissue Development and Cell Culture.

Received 2006-04-19. Cell culture. Received 2006-04-19. Whonamedit is Ringer's solution. whonamedit.com. Received 2014-06-09. Animals and alternatives in testing. Archive from the original 2006-02-25. Received 2006-04-19. Schiff J (February 2002). The unsung hero of medical research. Journal of Yale University graduates. Received 2006-04-19. W entered N, Pirman SM, Dobrev D., Dibb KM (September 2015). Methods of isolating the atrium from large mammals and humans. In the journal Molecular and Cell Cardiology. 86: 187–98. doi:10.1016/j.yjmcc.2015.07.006. PMID 26186893. - Louch WE, Sheehan K.A., Wolska BM (September 2011). Techniques in cardiomyocyte isolation, culture and gene transfer. In the journal Molecular and Cell Cardiology. 51 (3): 288–98. doi:10.1016/j.yjmcc.2011.06.012. PMC 3164875. PMID 21723873. Hemeda, H., Death, B., Wagner, W. (16Feb2014) Evaluation of human platelet lysate compared to whey cattle fruit for the culture of mesenchymal stromal cell cytotherapy p170-180 issue 2 doi.10.1016 BOval BioSolutions, LLC. bovalco.com. Received 2014-12-02. LipiMAX cleans a solution of lipoproteins from cattle serum. Selborn Biological Services. 2006. Received 2010-02-02. Portela VM, Sumberlam G, CA Price (April 2010). Cell coating density changes the ratio of estrogen to the expression of the progestogen enzyme gene in the cultural cells of granulose. Fertility and sterility. 93 (6): 2050–5. doi:10.1016/j.fertnstert.2009.01.151. PMID 19324349. Hampel C (October 2015). Organotypical cultures slice the brain: review. Neuroscience. 305: 86–98. doi:10.1016/j.neuroscience.2015.07.086. PMC 4699268. PMID 26254240. Neymark J (February 2015). The line of attack. Science. 347 (6225): 938–40. doi:10.1126/science.347.6225.938. PMID 25722392. Drexler HG, Dirks WG, MacLeod RA (October 1999). False human hematopoetic cell lines: cross-contamination and misinterpretation. Leukemia. 13 (10): 1601–7. doi:10.1038/sj.leu.2401510. PMID 10516762. Drexler HG, McLeod RA, Dirks W (December 2001). Cross-contamination: HS-Sultan is not myeloma, but a cell line of Burkitt's lymphoma. Blood. 98 (12): 3495–6. doi:10.1182/blood. V98.12.3495. PMID 11732505. Cabrera CM, Kobo F, Nieto A, Cortez JL, Montes RM, Catalina P, Concha A (June 2006). Identity tests: Definition contamination of the cell line. Cytotechnology. 51 51 45–50. doi:10.1007/s10616-006-9013-8. PMC 3449683. PMID 19002894. a b Chatterjee R (February 2007). Cell biology. Cases of mistaken identity. Science. 315 (5814): 928–31. doi:10.1126/science.315.5814.928. PMID 17303729. S2CID 13255156. Liskovic M., Ravid D. (January 2007). An example in misidentification of cancer cell lines: MCF-7/AdrR cells (re-identified NCI/ADR-RES) are derived from OVCAR-8 human ovarian carcinoma cells. Cancer letters. 245 (1–2): 350–2. doi:10.1016/j.canlet.2006.01.013. PMID 16504380. MacLeod RA, Dirks W, Matsuo Y, Kaufmann M, Milch H, Drexler HG (November 1999). Widespread intra-appearance cross-contamination of human tumor cell lines originating at the source. International Journal of Cancer. 83 (4): 555–63. doi:10.1002/(SICI)1097-0215(19991112)83:4<555::AID-IJC19>3.0.CO;2-2. PMID 10508494. Masters JR (April 2002). HeLa cells are 50 years old: good, bad and ugly. Nature reviews. Cancer. 2 (4): 315–9. doi:10.1038/nrc775. PMID 12001993. S2CID 991019. a b Dunham J, Guthmiller P (2008). Doing good science: Cell line identity authentication (PDF). Cell notes. 22: 15–17. Archive from the original (PDF) for 2008-10-28. Received 2008-10-28. Nguyen HT, Gins M, Spits C (2012). Genetic and epigenetic instability in human pluripotent stem cells. Updating human reproduction. 19 (2): 187–205. doi:10.1093/humupd/dms048. PMID 23223511. Moore is against it. UCLA Regents (1990) 51 C3d 120. Online.ceb.com. received 2012-01-27. Haiflik L (September 1998). A brief history of mortality and immortality of cultural cells. Keio Medical Journal. 3. 47 (3): 174–82. doi:10.2302/kjm.47.174. PMID 9785764. Worthington's tissue guide. Received 2013-04-30. Cian L, Salzman WM (2004). Improve the expansion and neural differentiation of mesenchymal stem cells by changing the surface of the culture. Biomaterials. 25 (7–8): 1331–7. doi:10.1016/j.biomaterials.2003.08.013. PMID 14643607. Maguire G (May 2016). Therapy from adult stem cells and the Hype Curve. ACS Medical Chemistry Letters. 7 (5): 441–3. doi:10.1021/acsmedchemlett.6b00125. PMC 4867479. PMID 27190588. b Prieto D, Aparicio G, Sotelo-Silveira JR (November 2017). Cell Migration Analysis: An inexpensive laboratory experiment for cell and developmental biology courses using keratocytes from fish scales. Education in biochemistry and molecular biology. 45 (6): 475–482. doi:10.1002/bmb.21071. PMID 28627731. Discher DE, Janmey P, Wang YL (November 2005). Tissue cells feel and react to the rigidity of their substrate. Science. 310 (5751): 1139–43. Bibkod:2005Sci... 310.1139D. CiteSeerX 10.1.1.318.690. doi:10.1126/science.1116995. PMID 16293750. S2CID 9036803. Gilbert PM, Havenstel KL, Magnusson KE, Sacco A, Leonardi NA, Kraft P, et al (August 2010). Substrate elasticity skeletal muscle stem cells are self-ingordging in culture. Science. 329 (5995): 1078–81. Bibkod:2010Sci... 329.1078G. doi:10.1126/science.1191035. PMC 2929271. PMID 20647425. Chowdhury F, Lee Y, Poh YC, Yokohama-Tamaki T, Wang N, Tanaka TS (December 2010). Soft substrates promote homogeneous self-renewal of embryonic stem cells using down-regulatory cell matrix. 515655C. doi:10.1371/journal.pone.0015655. PMC 3001487. PMID 21179449. Engler AJ, Saint S, Sweeney HL, Discher DE (August 2006). The elasticity of the matrix directs the specification of the stem cell line. Cell. 126 (4): 677–89. doi:10.1016/j.cell.2006.06.044. PMID 16923388. - Paszek MJ, Sahir N, Johnson KR, Lakins J.N., Rosenberg G.I., Gefen A. et al. (September 2005). Tense homeostasis and malignant phenotype. Cancer cell. 8 (3): 241–54. doi:10.1016/j.ccr.2005.08.010. PMID 16169468. Leventhal KR, Yu H, Cass L, Lakins JN, Egeblad M, Erler JT, et al (November 2009). The matrix of cross-force tumor progression by enhancing integrin signaling. Cell. 139 (5): 891–906. doi:10.1016/j.cell.2009.10.027. PMC 2788004. PMID 19931152. Tilgman RW, Cowan CR, Mich JD, Koryakina Y, Gioeli D, Slack-Davies JK, et al (September 2010). Hotchin N.A. (Md.matrix stiffness regulates the growth of cancer cells and cell phenotype. PLO ONE. 5 (9): e12905. Bibkod:2010PLoSO... 512905T. doi:10.1371/journal.pone.0012905. PMC 2944843. PMID 20886123. Liu F, Mich JD, Shih BS, Ho AT, Sharif AS, Tager AM, Tschumperlin DJ (August 2010). Increased fibrosis feedback through matrix tightening and suppression of COX-2. In the journal Cell Biology. 190 (4): 693–706. doi:10.1083/jcb.201004082. PMC 2928007. PMID 20733059. Wipff PJ, Rifkin DB, Maester JJ, Hinz B (December 2007). Myofibroblastic contraction activates the hidden TGF-beta1 from the extracellular matrix. In the journal Cell Biology. 179 (6): 1311–23. doi:10.1083/jcb.200704042. PMC 2140013. PMID 18086923. George PC, Hui JJ, Gombos, McCormick ME, Wang AY, Ue Mmura, et al (December 2007). The increased stiffness of the rats' liver precedes matrix deposition: the effects on fibrosis. American Journal of Physiology. Physiology of the gastrointestinal tract and liver. 293 (6): G1147-54. doi:10.1152/ajpgi.00032.2007. PMID 17932231. S2CID 201357. Li L, Sharma N, Chippada U, Jiang X, Schloss R, Yarmoush ML, Langrana NA (May 2008). Functional modulation of cells of the line of hepatocytes obtained by ES by changing the conformity of the substrate. Annals of Biomedical Engineering. 36 (5): 865–76. doi:10.1007/s10439-008-9458-3. PMID 18266108. S2CID 21773886. - Semler EJ, Lancin PA, Dasgupta A, Moghe PV (February 2005). Engineer hepatocellular morphogenesis and function with ligand-representing hydrogels with graded mechanical conformity. Biotechnology and bioengineering. 89 (3): 296–307. PMID 15744840. Friedland JC, Lee MH, Boettiger D (January 2009). The mechanically activated integrin switch controls the function of alpha5beta1. Science. 323 (5914): 642–4. doi:10.1126/science.1168441. PMID 19179533. S2CID 206517419. Chan CE, Odde DJ (December 2008). Dynamics of the pull of philopody on the corresponding substrates. Science. 322 (5908): 1687–91. Bibkod:2008Sci... 322.1687C. doi:10.1126/science.1163595. PMID 19074349. S2CID 28568350. Dupont S, Morsut L, Aragon M, Enzo E, Giulitti S, Cordenonsi M, et al (June 2011). The role of JP/TAS in mechanical transmission. Nature. 474 (7350): 179–83. doi:10.1038/nature10137. hdl:11380/673649. PMID 21654799. S2CID 205225137. drugs discovery@nature.com. Nature.com. Received 2013-03-26. Duell BL, Cripps AW, Schembri MA, Ulett GC (2011). Epithelial models of joint cell culture to study infectious diseases: benefits and limitations. In the journal Biomedicine and Biotechnology. 2011: 852419. doi:10.1155/2011/852419. PMC 3189631. PMID 22007147. Barrila J, Radtke AL, Crabbe A, Sarker SF, Herbst-Kralovec MM, Rath CM, Nickerson CA (November 2010). Organotypical models of 3D cell culture: the use of a rotating wall vessel to study the interactions of host pathogens. Nature reviews. Microbiology. 8 (11): 791–801. doi:10.1038/nrmicro2423. PMID 20948552. S2CID 6925183. Mapanao, Ana Katrina; Voliani, Valerio (June 2020). 3D Tumor Models: Promoting Breakthroughs in Nanotierication Translational Research. Applied materials today. 19: 100552. doi:10.1016/j.apmt.2019.100552. Cassano, Domenico; Santi, Melissa; D'Outilea, Francesca; Mapanao, Ana Katrina; Stefano Luin; Voliani, Valerio (2019). The photothermal effect of the NIR-reaction is an excretable ultra-small in nano architecture. Materials Horizons. 6 (3): 531–537. doi:10.1039/C9MH00096H. ISSN 2051-6347. Edmondson R., Brogley J.J., Adcock AF, Ian L (May 2014). 3D cell culture systems and their use in cell-based drug and biosensor detection. Drug analysis and development technologies. 12 (4): 207–18. doi:10.1089/adt.2014.573. PMC 4026212. PMID 24831787. Bhattacharya M, Malinen MM, Lauren, Lu YR, Kuisma SW, Canninen L, et al (December 2012). Nanophyllar cellulose hydrogel promotes three-dimensional culture of liver cells. In the journal Controlled Issue. 164 (3): 291–8. doi:10.1016/j.jconrel.2012.06.039. PMID 22776290. DeRoza MC, Montreal C, Schnitzer M, Walsh R, Sultan Y (February 2010). Nanotechnology in fertilizers. The nature of nanotechnology. 5 (2): 91. Bibkod:2010NatNa... 5...91D. doi:10.1038/nnano.2010.2. PMID 20130583. Macy I, Tung YC, Tsu X, Patel LR, Pienta KJ, Takayama S (May 2012). 384 hanging drop arrays give excellent q-factors and allow the universal formation of spheroids of the joint culture. Biotechnology and bioengineering. 109 (5): 1293–304. doi:10.1002/bit.24399. PMC 3306496. PMID 22161651. Mapanao Santi M, Farachi., Capello V, Cassano D, Voliani V (September 2018). EndogenousLy Trigger Ultrasmall-in-Nano Architecture: Targeting Score on 3D Pancreatic Spheromy Carcinomas. ACS Omega. 3 (9): 11796–11801. doi:10.1021/acsomega.8b01719. PMC 6173554. PMID 30320273. Simon EM (1988). NIH Phase I Final Report: Fiber Substrate for Cell Culture (R3RR03544A) (PDF Download Available). Researchgate. Received 2017-05-22. Tibbitt MW, Aset KS (July 2009). Hydrogeli as an extracellular matrix mimics for 3D cell culture. Biotechnology and bioengineering. 103 (4): 655–63. doi:10.1002/bit.22361. PMC 2997742. PMID 19472329. A quick bird flu vaccine is created. Wired. Wired.com. Reuters. 2006-01-26. Received 2010-01-31. Gao W, Soloff AC, Lu X, Montecalvo A, Nguyen DC, Matsuoka Y, et al (February 2006). Protecting mice and poultry from the deadly H5N1 avian influenza virus by immunization based on adenovirus. Virology. 80 (4): 1959–64. doi:10.1128/JVI.80.4.1959-1964.2006. PMC 1367171. PMID 16439551. NIAID Cranes Chiron to develop a vaccine against H9N2 avian influenza. National Institute of Allergy and Infectious Diseases (NIAID). 2004-08-17. Received 2010-01-31. Rapanan JL, Cooper KE, Leiva KJ, Hull EE (August 2014). Collective cellular migration of primary zebra keratocytes. Experimental cell studies. 326 (1): 155–65. doi:10.1016/j.yexcr.2014.06.011. PMID 24973510. Lee J, Jacobson K (November 1997). The composition and dynamics of cellular substrate adhesives in lokototin fish keratocytes. In the journal Cell Science. 110 (pt 22): 2833-44. PMID 9427291. Hunt P, Robertson D, Weiss D, Rennick D, Lee F, Witte ON (March 1987). One type of stromal bone marrow cell supports the growth of early lymphoid and

myeloid cells in vitro. Cell. 48 (6): 997–1007. doi:10.1016/0092-8674(87)90708-2. PMID 2435412. S2CID 31499611. Van den Berg-Bakker CA, Hagemayer A, Franken-Postma EM, Smith VT, Kuppen PJ, van Ravenswaay Claasen HH, et al (February 1993). Installation and characteristic of 7 lines of ovarian carcinoma cells and one line of tumor cells granulose: features of growth and cytogenetics. International Journal of Cancer. 53 (4): 613–20. doi:10.1002/ijc.2910530415. PMID 8436435. Lee YG, Korenchuk S, Lehr J, Whitney S, Vessela R, Pienta KJ (2001). Creating and characterisation of a new line of human cancer cells: DuCaP. Vivo. 15 (2): 157–62. PMID 11317521. Ou D, Mitchell L.A., Decari D, Tingle AJ, Nepom GT (March 1998). Unintelligible T-cell recognition of the rubella capsid protein epitope limited to DRB1-0403 and DRB1-0901 molecules separating the HLA DR. Supertype. 59 (3): 149–57. doi:10.1016/S0198-8859(98)00006-8. PMID 9548074. Next reading are Pacey L, Stead S, Gleave J, Tomczyk K, Doering L (2006). Neural stem cell culture: the neurosphere generation, analysis and cryopreservation. Exchange protocols. doi:10.1038/nprot.2006.215. Gilabert JA, Montalvo GB, Artalejo AR (2006). Rat Chromafffin cells primary cultures: standardization and quality assessment for single-celled analyses. Exchange protocols. doi:10.1038/nprot.2006.294. Losardo RJ, Cruz-Gutierrez R, Prates JC, Moscovici M, Rodriguez-Torres A, Arteaga-Martinez M (2015). Sergey Fedorov: Pioneer of neural regeneration. Tributes from the Pan American Anatomy Association. International Journal of Morphology. 33 (2): 794. doi:10.4067/S0717-95022015000200059. MacLeod RA, Dirks W, Matsuo Y, Kaufmann M, Milch H, Drexler HG (November 1999). Widespread intra-appearance cross-contamination of human tumor cell lines originating at the source. International Journal of Cancer. 83 (4): 555–63. doi:10.1002/(SICI)1097-0215(19991112)83:4<555::AID-IJC19>3.0.CO;2-2. PMID 10508494. Masters JR (April 2002). HeLa cells are 50 years old: good, bad and ugly. Nature reviews. Cancer. 2 (4): 315–9. doi:10.1038/nrc775. PMID 12001993. S2CID 991019. Witkowski (July 1983). Experimental pathology and the origins of tissue culture: leo Lebe's contribution. The history of the disease. 27 (3): 269–88. doi:10.1017/S0025727300042964. PMC 1139336. PMID 6353093. External Links Library Resources about Cellular Cultural Resources in your Library Resources in other Libraries Table common cell lines from Alberts 4th ed. Cancer Cells in Culture Evolution of Cell Culture Surface Hypertext version of cell Line Data Base Microcarrier Cell Culture Handbook GE Healthcare Life Sciences Cell Culture Applications - Resources including application notes and protocols to create the perfect environment for cell cultivation from the beginning. Cell Culture Basics - Introduction to cell culture, covering topics such as set-up lab, safety and aseptic technique including basic cell culture protocols and a Who's Who videotape database in cell culture and related coriell cell strategies for protein cleansing guide to cell culture. This webinar introduces the history, theory, basic methods and potential pits of mammalian cell culture. National Center for Cellular Science (NCCS), Pune, India; Public Health England, Public Health England Cultural Collection (ECACC) Obtained from 2Free-floating three-dimensional cell culture 3D cell culture is an artificially created environment in which biological cells can grow or interact with their surroundings. Unlike 2D environments (such as petri dishes), the culture of 3D cells allows cells in vitro to grow in all directions, just as they will in vivo. These three-dimensional crops are usually grown in small capsules in which cells can grow into spheroids, or 3D cells of colonies. Approximately 300 spheroids are usually culturally on the bioreactor. Background 3D cell cultures have been used in research for several decades. One of the first recorded approaches to their development was the beginning of the 20th century, when Alexis Carrel tried to develop methods of long-term tissue cultures in vitro. Early 1980s studies led by Mina Bissell of the Lawrence Berkeley National Laboratory highlighted the importance of 3D methods for creating accurate in vitro cultivation models. This work focused on the importance of the extracellular matrix and the ability of cultures in artificial 3D matrixes to produce physiologically relevant multicellular structures such as acinar structures in healthy and cancerous models of breast tissue. These methods have been applied to in vitro disease models used to assess cellular reactions to pharmaceutical compounds. In 1988, a nih SBIR grant report showed that electrospinning could be used to produce polystyrene and polycarbonate fibrous mats on a nano- and sub-merron scale (now known as scaffolding) specifically designed to be used as substrate cells in vitro. This early use of electrospon fibrotic lattice for cell culture and tissue engineering has shown that different cell types, including human Foreskin Fibroblasts (HFF), converted human carcinomas (HEp-2), and mink lung epithelium (MLE) will adhere to and reproduce on fibers. It has been observed that unlike the flattened morphology commonly observed in 2D culture, cells grown on electrospoon fibers have a more histotypic rounded three-dimensional morphology, usually observed in vivo. Properties in living tissue, cells exist in 3D micro-windows with intricate cell cell and cellular matrix interactions and complex dynamics of nutrient and cell transportation. Standard 2D, or monolayer, cell cultures are inadequate representations of this environment, which often makes them unreliable predictors of the effectiveness and toxicity of the drug in vivo. 3D spheroids are more like in vivo tissues in terms of cellular communication and the development of extracellular matrix. These matrixes help cells move within the spheroid, just as cells move in living tissue. Thus, spheroids are improved models of cell migration, differentiation, survival and growth. In addition, 3D cell cultures provide a more accurate depiction of cell polarization, as 2D cells can only be partially polarized. Moreover, 3D-grown cells show different gene expressions than those grown in 2D..8 Cell growth measurement provides more contact space for mechanical inputs and for cellular adhesion, which is needed to bandage integrin, cell cell and even intracellular alarms. Normal soluble diffusion and binding with effect proteins (e.g. Growth factors and enzymes) also depends on the 3D cell matrix, so it is extremely important to create salt concentration gradients in the tissue scale for toxicological screening purposes, it is much more useful to check the expression of genes of in vitro cells grown in 3D than 2D, as the expression of 3D spheroid genes will be more like the expression of genes in vivo. Finally, 3D cell cultures have greater stability and longer lifespan than cell cultures in 2D. 3D environments also allow cells to grow quietly. In 2D, cells must undergo regular thripsinization in order to provide them with enough nutrients for normal cell growth. 3D spheroids were hatched in the lab for up to 302 days, while maintaining healthy, non-cancerous growth. Classification methods 3D culture There are a large number of commercially available cultivation tools that claim to provide the benefits of 3D cell culture. In general, platforms can be classified into two types of 3D cultivation methods: scaffolding techniques and scaffold-free methods. A model showing three examples of the methods used to cultivate cells in a 3D environment. Scaffold methods of Scaffold techniques include the use of solid forests, hydrogels and other materials. In a recent study, the potential of human CD34 stem cells explored by creating a tube-in vitro agarosa gel is a 3D model to understand the process of bone ordnation. Hydrogeli as a natural extracellular matrix (ECM) is important for the survival, proliferation, differentiation and migration of cells, various hydrogel matrix, imitating the natural structure of ECM, are considered as potential approaches to in vivo - as cell cultivation. Hydrogels consist of interconnected pores with high water retention, which ensures efficient transportation of nutrients and gases, for example. Several different types of hydrogel from natural and synthetic materials are available for 3D cell culture, including, for example, animal-based ECM hydrogel extract, protein hydrogels, peptide hydrogel, polymer hydrogels and wood-based nanocellulose hydrogel. Scaffold-free scaffold methods use a different approach, independent of scaffolding. Forest-free methods include, for example, the use of plates low in adhesion, hanging drop plates, micropathined surfaces and rotating bioreactors, magnetic levitation and magnetic 3D bioprinting. Spheroids Electron microscopy spheroid mesothelioma (NCI-H226). Bar scale, 200 microns. Spheroids are a type of 3D cell simulation that better mimics the conditions surrounding live cells compared to cell model, in particular, with reactions between cells and reactions between cells and the matrix. Spheroids are useful in the study of the changing physiological characteristics of cells, the difference in the structure of healthy cells and tumor cells, as well as the changes that cells undergo in tumor formation. Spheroids, co-cultural with tumors and healthy cells, were used to simulate the interaction of cancer cells with normal cells. Spheroids can be grown in several different ways. One common method is to use low-cell adhesive plates, usually 96 good plates, for mass production of spheroid cultures, where aggregates are formed in the rounded bottom of the cell plates. Spheroids can also be learned using the suspension drop method, which involves the formation of cell units in droplets that hang on the surface of the cell plate. Other research methods include the use of rotating wall vessel bioreactors, which rotates and cultures cells when they are constantly in free fall, and has formed aggregates in layers recently, some protocols have been standardized in order to produce homogeneous and reliable spheroids. Bioreactors Bioreactors Bioreactors, used for 3D cell cultures, are small plastic cylindrical chambers that are specifically designed to grow cells in three dimensions. The bioreactor uses biologically active synthetic materials, such as polyethylene terephtalat membranes, to surround spheroid cells in an environment that supports high levels of nutrients. They open easily and close so that cell spheroids can be removed for testing, but the camera is able to maintain 100% humidity throughout. This humidity is important to achieve maximum cell growth and function. The bioreactor's camera is part of a larger device that rotates to ensure equal cell growth in each direction in three dimensions. COMPANY MC2 Biotek has developed a bioreactor for the incubation of proto-tissues, which uses gas filtration to maintain high oxygen levels in the cell chamber. This is an improvement over previous bioreactors because higher oxygen levels help the cell grow and undergo normal cellular respiration. Microfluids Various cellular structures in the human body must be vascularized to obtain nutrients and help in the exchange of gas that they need for survival. Similarly, 3D cell cultures in vitro require certain levels of fluid circulation, which can be problematic for dense, 3D cultures where cells may not all have adequate nutrient exposure. This is especially important in hepatocyte cultures because the liver is vascularized organ. One study of cultural hepatocytes and vascular cells combined on a collagen gel scaffold between the microfluidic channels, and compared cell growth in static and flowing environments, and showed the need for models with tissues and microvascular networks. High bandwidth The advanced development of 3D models for high-speed screening in high-density formats has recently been achievable thanks to technological advances associated with increasing the density of microplatforms. They can be found in 384 and 1536-nu formats that are cell repellents, cost effective, and under the power of fully automated screening platforms. Two variants that allow themselves 1536-well formats are available from either Greiner Bio-One using m3D Magnetic 3D Bioprinting and Corning Life Sciences, which includes ultra-low surface covering attachments, along with microcavitation geometry and gravity to create 3D models. Thanks to the fast and accessible methods and technologies developed for 3D screening, parallel approaches to high-bandwidth screening have been incorporated to test isogenic pairs of oncogenic mutants compared to wild-type. Pharmacology and Toxicology The main purpose of growing cells in 3D scaffolds and as 3D cell spheroids in vitro is to test pharmacokinetic and pharmacodynamic effects of drugs and nanomaterials in preclinical trials. Toxicological studies have shown that the cultures of 3D cells are almost on par with in vivo studies for the purpose of testing the toxicity of drug compounds. When comparing LD50 values for 6 common drugs: acetaminophen, amiodarone, diclofenac, metformin, fenformin and valproic acid, 3D spheroid values are directly correlated with values in vivo. Although 2D cell cultures have previously been used to test toxicity along with in vivo studies, 3D spheroids are better able to test the toxicity of chronic exposure due to their longer lifespan. The matrix in 3D spheroids causes cells to support actin strands and is more relevant physiologically in the cytoskelet organization and the polarity of cells and the shape of human cells. The three-dimensional arrangement allows cultures to provide a model that more accurately resembles human tissue in vivo without the use of test animals. Criticism Of existing 3D methods are not without limitations, including scalability, reproducibility, sensitivity and compatibility with high-bandwidth screening (HTS) tools. Cell-based GTS relies on a rapid determination of the cellular response to drug interactions, such as the viability of dose-dependent cells, cell/cell interactions and/or cell migration, but the available analyses are not optimized for the cultivation of 3D cells. Another problem faced by the cultivation of 3D cells is a limited amount of data and publications that deal with the mechanisms and correlations of drug interaction, cell differentiation and cell signaling in these 3D environments. Neither 3D methods have not yet replaced 2D cultivation on a large scale, including in the drug development process; although the number of publications on the cultivation of 3D cells is growing rapidly, growing, 3D tissue reduces adoption of new methods. There are also problems with the use of spheroids as a model for cancerous tissues. While it is useful for the culture of 3D tissues, spheroids of tumors have been criticized for challenging or unable to manipulate the gradients of soluble molecules in the structures of 3D spheroids, and to characterize cells in these complex gradients, as opposed to paper-supported 3D cell culture for bioassas on the basis of tissues studied by Ratmir et al. also Cellular Culture Cellular Lines Cellular Culture Analysis Hydrogel Madin-Darby Dogs Cell Line Microphysiomety Links - b c d e Fey S, Wrzesinski K (2013). Identify acute deadly and chronic death thresholds of valproic acid using 3D spheroids built from the immortal human cell line HEPG2/C3A (PDF). In Bush A. ISBN 978-1-62417-952-5. Archive from the original (PDF) for 2013-12-02. Mapanao AK, Voliani V (June 2020). 3D Tumor Models: Promoting Breakthroughs in Nanotherication Translational Research. Applied materials today. 19: 100552. doi:10.1016/j.apmt.2019.100552. Carrel A (May 1912). About the permannet life of tissues outside organisms. In the Journal of Experimental Medicine. 15 (5): 516–28. doi:10.1084/jem.15.5.516. PMC 2124948. PMID 19867545. MERIT Award Recipient: Mina Bissell, Ph.D. (n.d.). Received on June 16, 2016, from Simon, Eric M. (1988). NIH PHASE I FINAL REPORT: FIBROUS SUBSTRATES FOR CELLS CULTURE (R3RR03544A) (PDF Download available). Researchgate. Received 2017-05-22. Vivienne Marx (April 11, 2013). It is better to cook (PDF). Nature. Received on July 9, 2013. Souza GR, Molina JR, Rafael RM, Ozaawa MG, Stark DJ, Levine CS, et al (April 2010). A three-dimensional culture of tissues based on the levitation of magnetic cells. The nature of nanotechnology. 5 (4): 291–6. Bibkod:2010NatNa... 5..291S. doi:10.1038/nnano.2010.23. PMC 4487889. PMID 20228788. a b c d Pampaloni F, Reynaud EG, Stelzer EH (October 2007). The third dimension eliminates the gap between cell culture and living tissue. Nature examines the molecular biology of cells. 8 (10): 839–45. doi:10.1038/nrm2236. PMID 17684528. S2CID 23837249. Chung TH, Hotary KB, Sabe F, Saltiel AR, Allen ED, Weiss SJ (May 2006). Pericellular collagenase directs three-dimensional development of white adipose tissue. Cell. 125 (3): 577–91. doi:10.1016/j.cell.2006.02.050. PMID 16678100. S2CID 15822397. Yamada KM, Kukerman E 2007). Modeling tissue morphogenesis and cancer in 3D. Cells. 130 (4): 601–10. doi:10.1016/j.cell.2007.08.006. PMID 17719539. S2CID 9233152. Friedrich J, Eydel C, Ebner R, Kunz-Sugart LA (February 12, 2009). Spheroid-based drug screen: considerations and hands-on approach. Protocols of nature. 4 (3): 309–24. doi:10.1038/nprot.2008.226. PMID 19214182. S2CID 21783074. a b Prestwich GD (August 2007). Simplification of the extracellular matrix for 3-D cell culture and tissue engineering: a pragmatic approach. In the journal Cell Biochemistry. 101 (6): 1370–83. doi:10.1002/jcb.21386. PMID 17492655. a b c griffith LG, Schwartz MA (March 2006). Capture the complex physiology of 3D tissues in the test tube. Nature examines the molecular biology of cells. 7 (3): 211–24. doi:10.1038/nrm1858. PMID 16496023. S2CID 34783641. Lee J, Cuddihi MJ, Kotov NA (March 2008). Three-dimensional matrix of cell culture: modern state (PDF). Tissue engineering. Part B, Reviews. 14 (1): 61–86. doi:10.1089/teb.2007.0150. hdl:2027.42/63369. PMID 18454635. - Haycock JW (2011). 3D Cell Culture: An overview of modern approaches and methods. Molecular biology methods. 695. p. 1-15. doi:10.1007/978-1-60761-984-0'1. ISBN 978-1-60761-983-3. PMID 21042962. Suronen EJ, Shirdown H, Newman KD, McLaughlin CR, Griffith M (2005). Create models of organs in vitro. Review of cell biology. International Review of Cytology. 244. p. 137-73. doi:10.1016/s0074-7696(05)44004-8. ISBN 9780123646484. PMID 16157180. Luekari K (October 2004). The status and perspective of in vitro trials in risk assessment. Alternatives to laboratory animals. 32 (4): 431–5. doi:10.1177/026119290403200416. PMID 15651929. S2CID 25708371. Knight B, Laukaitis C, Akhtar N, Hotchin NA, Edlund M, Horwitz AR (May 2000). Visualization of the migration of muscle cells in place. Current biology. 10 (10): 576–85. doi:10.1016/s0960-9822(00)00486-3. PMID 10837222. S2CID 5830501. - Roskelley CD, Desprez PY, Bissell MJ (December 1994). Extracellular matrix-dependent tissue-specific expression of genes in epithelial breast cells requires both physical and biochemical signal transduction. Works of the National Academy of Sciences of the United States of America. 91 (26): 12378–82. Bibkod:1994PNAS... 9112378R. doi:10.1073/pnas.91.26.12378. PMC 45441. PMID 7528920. a b Wrzesinski K, Magnone MC, Hansen LV, Kruse ME, Bergauer T, Bobadilla M, Gubler M, Mizrahi J, Zhang K, Andreasen CM, Joensen KE (2013). Spheroids HepG2/C3A have stable physiological functionality for at least 24 days after recovery from thripsinization. Toxicol. Res. 2 (3): 163-172. doi:10.1039/C3TX20086H. After thripsinization, 3D Spheroids C3A hepatocytes need 18 days to restore similar levels of key physiological functions that are seen in the liver (PDF). Archive from the original (PDF) for 2015-04-02. Get Srikant L, Sunita MM, Kumar PS, Chandrasekhar S, Wenhamma B, Sarma P.V. (November 2016). Stem cells. Molecular Biology Reports. 43 (11): 1233–1242. doi:10.1007/s11033-016-4053-4. PMID 27497820. S2CID 13230517. Sadat Shojai M (2018). Controlled model of cell growth in modulated protein nanocomplexes: regulating cell distribution in three dimensions. Materials today. 21 (6): 686–688. doi:10.1016/j.mattod.2018.06.003. Tibbitt MW, Aset KS (July 2009). Hydrogeli as an extracellular matrix mimics for 3D cell culture. Biotechnology and bioengineering. 103 (4): 655–63. doi:10.1002/bit.22361. PMC 2997742. PMID 19472329. H-H, Xiu F, Chang X, Luna S, Demirci U (April 2010). Engineered hydrogels as an extracellular matrix imitates. Nanomedicine. London, England. 5 (3): 469–84. doi:10.2217/nnm.10.12. PMC 2892416. PMID 20394538. a b Xiang X, Phung Y, Feng M, Nagashima K, zhang J, Broaddus VC, et al (January 2011). The development and characteristic of human mesothelioma in the 3D model test tube for immunotoxin therapy research. OOP ONE. 6 (1): e14640. Bibkod:2011PLoSO... 614640X. doi:10.1371/journal.pone.0014640. PMC 3031536. PMID 21305058. a b Fennema E, Rivron N, Rouwkema J, van Blitterswijk C, de Boer J (February 2013). Spheroid culture as a tool for creating 3D complex fabrics. Trends in biotechnology. 31 (2): 108–15. doi:10.1016/j.tibtech.2012.12.003. PMID 23336996. Jiang Y, Pjesivac-Grbovic J, Cantrell C, Frayer JP (December 2005). A large-scale model for the growth of vascular tumors. Biophysical journal. 89 (6): 3884–94. Bibcode:2005BpJ.... 89.3884J. doi:10.1529/biophysj.105.060640. PMC 1366955. PMID 16199495. Guttilla IK, Phoenix KN, Hong X, Tirnauer JS, Claffey KP, White BA (February 2012). The long-term mammospheric culture of MCF-7 cells causes emT and suppression of the estrogen receptor microRNA. Research and treatment of breast cancer. 132 (1): 75–85. doi:10.1007/s10549-011-1534-y. PMID 21553120. S2CID 6930899. Kunz-Sugart L.A., Heider, Schroeder J., Kneueschel R.(May 2001). Heterologous 3-D model of the coculture of tumor cells of the breast and fibroblasts to study tumor fibroblasts differentiation. Experimental cell studies. 266 (1): 74–86. doi:10.1006/excr.2001.5210. PMID 11339826. - Phung YT, Barbone D, Broaddus VC, Ho M (2011). A fast generation of multicellular spheroids in vitro to study monoclonal antibody therapy. Cancer journal. 2: 507–14. doi:10.7150/jca.2.507. PMC 3204399. PMID 22043235. - Tung YC, Hsiao AY, Allen SG, Torisawa YS, Ho M, Takayama S (February 2011). High bandwidth is a 3D spheroid culture and drug testing using 384 hanging drop array. Analyst. 136 (3): 473–8. Bibkod:2011Ana... 136..473T. doi:10.1039/c0an00609b. PMC 7454010. PMID 20967331. Xu X, Farah-Carson MC, Jia X (November 2014). 3D models in vitro for cancer and drug evaluation. Advances in biotechnology. 32 (7): 1256–1268. doi:10.1016/j.biotechadv.2014.07.009. PMC 4171250. PMID 25116894. Santi, Melissa; Mapanao, Ana Katrina; Capello, Valentina; Voliani, Valerio (2020-07-01). Production of 3D models of tumor squamous cell carcinoma of the head and neck to assess nanotery. AcS Biomaterials Science: acsbiomaterials.0c00617. doi:10.1021/acsbiomaterials.0c00617. ISSN 2373-9878. Du Y, Han R, Wen F, Ng San S, Xia L, Wohland T et al (January 2008). Synthetic sandwich culture 3D monoslayous hepatocyte. Biomaterials. 29 (3): 290–301. doi:10.1016/j.biomaterials.2007.09.016. PMID 17964646. a b Derda R, Laromaine A, Mammoto A, Tang SK, Mammoto T, Ingber DE, Whitesides GM (November 2009). Paper culture of 3D cells for tissue-based bioanalysis. Works of the National Academy of Sciences of the United States of America. 106 (44): 18457–62. Bibkod:2009PNAS. 10618457D. doi:10.1073/pnas.0910666106. PMC 2773961. PMID 19846768. Faye, Stephen J. WO2012022351. European Patent Register. The magazine calls for magazine (help) - Sudo R, Chung S, Cervantonakis IK, Vickerman V, Toshimitsu Y, Griffith LG, Kamm RD (July 2009). Transport angiogenesis in 3D epithelial coculture. FASEB magazine. 23 (7): 2155–64. doi:10.1096/fj.08-122820. PMC 2718841. PMID 19246488. - Baillargeon P, Shumate J, Hou S, Fernandez-Vega V, Marquez N, Souza G; et al. (2019). Automation of magnetic 3D spheroid technology for high bandwidth. SLAS Technol. 24 (4): 420-428. doi:10.1177/2472630319854337. PMID 31225974.CS1 maint: several names: list of authors (link) - Hou S, Tiriac H, Sridharan BP, Scampavia L, Madoux F, Seldin J; et al. (2018). Extended development of primary pancreatic organoid tumor models for high bandwidth phenotypic drug screening. SLAS Discs. 23 (6): 574–584. doi:10.1177/2472555218766842. PMC 6013403. PMID 29673279.CS1 maint: several names: list of authors (link) - Madu F, Tanner A, Vessels M, Willetts L, Howe S, Scampavia L; et al. (2017). 1536-Well 3D viability analysis to assess the cytotoxic effects of the drug on spheroids. SLAS Discs. 22 (5): 516–524. doi:10.1177/2472555216686308. PMID 28346088.CS1 maint: several names: list of authors (link) - Kvereda V, Howe S, Madu F, Scampavia L, Spicer TP, Duckett D (2018). Cytotoxic three-dimensional spheroid, a high bandwidth analysis using patients obtained glioma stem cells. SLAS Discs. 23 (8): 842–849. doi:10.1177/2472555218775055. PMC 6102052. PMID 29750582.CS1 maint: several names: list of authors (link) - Kota S, Howe S, Gerrant W, Madu F, Troutman S, Fernandez-Vega V; et al. (2018). A new three-dimensional approach to high-bandwidth screening identifies THE mutant KRAS inductors of selective lethal phenotype. Oncogen. 37 (32): 4372–4384. PMID 29743592.CS1 maint: several names: list of authors (link) - Cassano D, Santi M, D'Autilia F, Mapanao AK, Luin S, Voliani V (2019). The photothermal effect of the NIR-reaction is an excretable ultra-small in nano architecture. Materials Horizons. 6 (3): 531–537. doi:10.1039/C9MH00096H. ISSN 2051-6347. Mapanao AK, Santi M, Farachi,Capello V, Cassano D, Voliani V (September 2018). EndogenousLy Trigger Ultrasmall-in-Nano Architecture: Targeting Score on 3D Pancreatic Spheromy Carcinomas. ACS Omega. 3 (9): 11796–11801. doi:10.1021/acsomega.8b01719. PMC 6173554. PMID 30320273. Sustiaq, Sylvia Petrova; Dadhwal, Smrit; Carlos Medina; Steskzina, Sonette; Chechekreghananzabi, Yasaman; Ashraf, Anisa; Asuri, Prashant (February 2016). Three-dimensional matrix stiffness and adhesive ligands affect the reaction of cancer cells to toxins. Biotechnology and bioengineering. 113 (2): 443–452. doi:10.1002/bit.25709. ISSN 1097-0290. PMID 26184715. Ologyeno, Monica A.; Xi Jinping; Proctor, William (2018), Chen, Minjun; Will, Yvonne (eds.), Status and future of 3D cell culture in testing toxicity, medicinal liver toxicity, techniques in pharmacology and toxicology, New York, NY: Springer, page 249-261, doi:10.1007/978-1-4939-7677-5'12, ISBN 978-1-4939-7677-5 - Faye SJ, Wrzesinski K (June 2012). Determining the toxicity of drugs using 3D spheroids built from the immortal line of human hepatocyte cells. Toxicological sciences. 127 (2): 403–11. doi:10.1093/toxsci/kfs122. PMC 3355318. PMID 22454432. Messner S, Agarkova I, Moritz V, Kelm JM (January 2013). A multicellular type of human liver microtas for hepatotoxicity testing. Toxicology archives. 87 (1): 209–13. doi:10.1007/s00204-012-0968-2. PMC 3535351. PMID 23143619. Jensen J, Hyllner J, Bjorkist P (June 2009). Human embryonic stem cell technology and drug detection. In the journal Cell Physiology. 219 (3): 513–9. doi:10.1002/jcp.21732. PMID 19277978. Alexander F, Eggert S, Wiest J (February 2018). A new laboratory platform to monitor the metabolism of spheroids. Cytotechnology. 70 (1): 375–386. doi:10.1007/s10616-017-0152-x. PMC 5809666. PMID 29032507. Jensen C, Teng Y (2020). Is it time to start the transition from 2D to 3D cell culture?. Boundaries in molecular biosciences. 7: 33. doi:10.3389/fmolb.2020.00033. PMC 7067892. PMID 32211418. Extracted from the secondary cell culture wikipedia. secondary cell culture biology discussion. secondary cell culture prepared from. secondary cell culture definition. secondary cell culture method. secondary cell culture diagram. secondary cell culture in animal cell culture. secondary cell culture and cell line