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Dr. Hansmeet Kour

Assistant Professor, Department
of Veterinary Microbiology,
CoV&AS, BUAT, Banda, Uttar
Pradesh, India

Dr. Shalini Pandey

Assistant Professor, Department
of Veterinary Microbiology,
CoV&AS, BUAT, Banda, Uttar
Pradesh, India

Dr. Umakant Verma

Assistant Professor, Department
of Animal Genetics & Breeding,
CoV&AS, BUAT, Banda, Uttar
Pradesh, India

Dr. Archita Singh

Assistant Professor, Department
of Veterinary Physiology and
Biochemistry, CoV&AS, BUAT,
Banda, Uttar Pradesh, India

Dr. Swarup Debroy

Assistant Professor, Department
of Veterinary Anatomy,
CoV&AS, BUAT, Banda, Uttar
Pradesh, India

Dr. Tarundeep Singh

VAS, Department of Animal
Husbandry, Jammu, Jammu and
Kashmir, India

Dr. RP Diwaker

Assistant Professor, Department
of Veterinary Microbiology,
College of Veterinary Science and
Animal Husbandry, ANDUA&T,
Uttar Pradesh, India

Corresponding Author:

Dr. Hansmeet Kour

Assistant Professor, Department
of Veterinary Microbiology,
CoV&AS, BUAT, Banda, Uttar
Pradesh, India

Animal cell culture: Biology, culture environment, and characterization: A review

**Hansmeet Kour, Shalini Pandey, Umakant Verma, Archita Singh, Swarup
Debroy, Tarundeep Singh and RP Diwaker**

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Abstract

Cell culture is a fundamental *in vitro* technique that enables the growth and maintenance of animal cells under controlled laboratory conditions, providing valuable models for studying cellular physiology, disease mechanisms, drug screening, vaccine production, and regenerative medicine. This review describes the biological characteristics of cultured cells, environmental requirements for successful cell growth, and the principles of cell characterization and authentication. It highlights the importance of maintaining optimal culture conditions, including temperature, pH, oxygen, carbon dioxide, humidity, and sterility, while discussing the roles of cell adhesion, extracellular matrix interactions, and cell adhesion molecules in regulating cellular behavior. The review further outlines morphological, cytogenetic, biochemical, immunological, and molecular approaches for cell identification, along with methods for detecting microbial contamination and transformed cells. Recent advances in three-dimensional culture systems, organoids, and organ-on-chip technologies have significantly improved the physiological relevance of *in vitro* models. Proper cell culture practices and routine authentication are essential for ensuring reliable, reproducible, and biologically meaningful research outcomes.

Keywords: Cell culture, *in vitro* culture, cell characterization, cell authentication, extracellular matrix

Introduction

Cell culture is one of the most important techniques in modern biological studies that, enables researchers to study living cells under precisely controlled *in-vitro* conditions. This technique involves separating cells from tissues and maintaining outside the body in a nutrient-rich culture medium that supports their survival, growth, and proliferation (Freshney, 2016) ^[10]. Cell culture offers a simplified and highly reproducible system that allows for more precise investigation of cellular physiology, metabolism, differentiation, and responses to biological, chemical, and physical stimuli when compared to tests conducted on whole animals. (Masters, 2000) ^[19].

The ability to develop cells *in vitro* has transformed research in the domains of microbiology, molecular biology, genetics, toxicology, pharmacology, and regenerative medicine. Under specific laboratory settings, cultured cells are useful experimental models for understanding the normal functioning of cells, assessing therapeutic efficacy and toxicity of drugs, and researching host–pathogen interactions. (Davis, 2011; Freshney, 2016) ^[5, 10]. In line with the 3Rs (Replacement, Reduction, and Refinement) principles in biomedical research, the use of cell culture has greatly reduced reliance on experimental animals. (Russell & Burch, 1959) ^[23]. The invention of animal cell culture dates back to Ross Harrison's groundbreaking work in 1907, when he successfully preserved frog embryonic nerve tissue outside the body, proving that animal cells could endure and grow in the right lab settings. (Harrison, 1907) ^[13]. Since then, incredible advances in sterile procedures, culture media, incubator technology, and molecular biology have transformed cell culture into a vital tool in both study and industry. Cell culture is now widely employed in vaccine development, viral isolation and multiplication, monoclonal antibody production, cancer biology, stem cell research, tissue engineering, gene therapy, and a wide range of biopharmaceutical products. (Freshney, 2016;

Doyle & Griffiths, 1998) [10, 6].

Biology of cultured cells

Cells maintained *in vitro* retain many of their fundamental physiological traits, although their behavior is greatly influenced by the artificial culture environment. The numerous structural and functional alterations that take place when an organized tissue is converted into a culture vessel must be considered while designing experiments.

Reduced Cell–Cell Interactions

Cells in living tissues continuously communicate with each other through extracellular matrix proteins, gap junctions, adhesion molecules, soluble cytokines, growth hormones, and direct membrane contacts. These connections control a variety of cellular processes, including as proliferation, differentiation, migration, apoptosis, and tissue homeostasis (Alberts *et al.*, 2022) [1]. During cell isolation, enzymatic or mechanical dissociation disrupts many of the natural cell–cell and cell–matrix interactions. As a result, cells grown in culture tend to migrate and spread more easily because they are no longer constrained by the surrounding tissue environment. In addition, the reduced contact inhibition seen in some cultured cells allows them to proliferate more actively, especially during the logarithmic (log) phase of growth. Nevertheless, prolonged culture may alter signalling pathways responsible for maintaining tissue-specific functions, resulting in changes in cellular phenotype and responsiveness to extracellular stimuli. Recent advances in physiologically relevant three-dimensional (3D) culture systems and organoid models have been developed to better preserve native cell–cell and cell–matrix interactions and overcome these limitations of conventional two-dimensional (2D) cell culture (Ko *et al.*, 2024; Tan *et al.*, 2024) [17, 24].

Loss of Three-Dimensional Architecture

The highly organized three-dimensional (3D) extracellular matrix (ECM) that surrounds cells *in-vivo* offers both mechanical support and physiological signals necessary for proper tissue function. However, the conventional two-dimensional (2D) monolayer systems relies on the adherence of cells to a hard plastic surface and forms the foundation of the traditional cell culture. Absence of proper 3 D system affects the polarity of cell, its shape, cytoskeletal organization, distribution of receptors, intracellular signaling, and even gene expression. As a result, cells grown in traditional monolayer cultures often behave differently physiologically than cells found in intact tissues. (Edmondson *et al.*, 2014) [8]. Recent advances in tissue engineering have led to the development of three-dimensional culture systems, spheroids, organoids, and organ-on-chip technologies that better reproduce the architecture and physiological characteristics of living tissues. (Fang *et al.*, 2023) [9].

Altered Hormonal and Nutritional Regulation

Amino acids, vitamins, glucose, inorganic salts, and buffering agents necessary for cellular metabolism are among the essential nutrients found in widely used media including Dulbecco's Modified Eagle Medium (DMEM), Minimum Essential Medium (MEM), and RPMI-1640. These media are usually supplemented with fetal bovine serum (FBS) or chemically defined growth supplements to further support cell survival, attachment, and proliferation. These supplements provide hormones, growth factors, lipids, and other bioactive molecules that help replicate important elements of the

cellular microenvironment (Freshney, 2021) [11]. Despite these supplements, cultured cells do not have the dynamic endocrine regulation present inside living organisms. Consequently, cellular metabolism, receptor expression, and differentiation patterns may differ substantially from their physiological counterparts.

Changes in Cellular Differentiation

Specialized cells inside tissues perform certain physiological functions that are maintained by continuous interactions with extracellular matrix components and nearby cells. After being isolated and repeatedly subcultured, many initial cells gradually lose their differentiated phenotype; this process is known as dedifferentiation. For example, primary hepatocytes eventually lose their ability to generate albumin and metabolize xenobiotics, while chondrocytes may cease producing extracellular matrix proteins specific to cartilage after prolonged monolayer culture. When evaluating experiments, these changes must be considered because they reduce the physiological importance of grown cells (Lodish *et al.*, 2021) [18]. Modern culture techniques employing extracellular matrix coatings, co-culture systems, and three-dimensional scaffolds have significantly improved the maintenance of differentiated cellular functions (Duval *et al.*, 2017) [17].

Limited Lifespan of Primary Cells

Most primary animal cells have a limited proliferative capacity. They go into a state of irreversible growth stoppage called replicative senescence after a certain number of cell divisions. This phenomenon, first described by Hayflick and Moorhead (1961) [14], is primarily attributed to progressive telomere shortening and accumulation of cellular stress. Senescent cells continue to be metabolically active but stop proliferating. They frequently exhibit distinctive morphological changes, such as increased granularity, larger cell size, and changed gene expression. As a result, primary cultures are best suited for brief studies that need to be physiologically relevant. For survival and proliferation, several cell types—such as fibroblasts, endothelial cells, and epithelial cells—need to be attached to a solid substrate. On treated plastic surfaces, these cells typically develop as monolayers.

Suspension Cells

Many hematopoietic and lymphoid cells are inherently adapted to grow in suspension, in contrast to anchorage-dependent cells. Because these cells either dwell in situations where attachment is not necessary or circulate freely in the circulation *in-vivo* conditions, therefore, a surface that promotes cell attachment is not necessary for the successful growth of these cells in suspension. Suspension cultures provide a number of useful benefits, including as more consistent exposure to nutrients and dissolved gasses, simpler scale-up for bioreactor production, and simpler harvesting. For vaccine development, antibody manufacturing, and immunological research, a variety of hybridoma, leukemia, lymphoma, and immune cell lines are frequently cultured as suspension cultures. (Davis, 2011) [5].

The Cell Culture Environment

For cultured cells to be successfully maintained, physiological conditions must be precisely replicated. Numerous environmental factors impact development, survival, and functional integrity of the cells maintained in cell culture.

Temperature

The optimal incubation temperature generally reflects the normal physiological temperature of the organism from which the cells originate. Mammalian cells are routinely cultured at 37°C, corresponding to their average body temperature (Freshney, 2016) ^[10]. Avian cells require slightly higher temperatures, typically 39–41 °C, to support optimal growth and cellular function (Pattison *et al.*, 2008) ^[21]. In contrast, insect cell lines are commonly maintained at 27–28 °C, which closely matches their natural physiological conditions and supports efficient growth and recombinant protein production (Merten, 2015) ^[20]. Deviations from the optimum temperature adversely affect membrane fluidity, enzyme activity, protein synthesis, and cellular metabolism (Freshney, 2016) ^[10].

pH

Most mammalian cells grow optimally at a pH between 7.2 and 7.4. The pH is commonly maintained using bicarbonate–carbon dioxide buffering systems or HEPES buffer. Insect cell cultures are generally maintained at a slightly lower pH of 6.2–6.4, reflecting the conditions of insect hemolymph. Unlike mammalian cells, most insect culture media (e.g., Sf-900 or Grace's Insect Medium) are buffered with phosphate and organic buffers instead of bicarbonate. Even slight fluctuations in pH influence enzyme activity, nutrient transport, and cell viability (Freshney, 2016) ^[10].

Carbon Dioxide

Culture media containing sodium bicarbonate require incubation in an atmosphere containing approximately 5% CO₂ to maintain physiological pH especially for Mammalian and avian cell cultures. In contrast, most insect cell cultures are maintained without supplemental CO₂ because their media are buffered with phosphate or organic buffering systems that remain stable under atmospheric conditions. (Thermo Fisher Scientific, 2021) ^[25].

Oxygen

Cellular respiration, energy production, and proliferation are all influenced by oxygen availability. While most cell cultures are kept at atmospheric oxygen levels (roughly 18–21% O₂), many primary cells and stem cells show better growth and physiological function under lower oxygen conditions (2–10% O₂), which more closely resemble the *in vivo* tissue environment. As a result, oxygen requirements may differ depending on the type of cell and the goal of the experiment (Freshney, 2016) ^[10].

Humidity

In order to reduce evaporation of the culture media and preserve consistent osmolarity, high humidity of approximately 95% is maintained in cell culture incubators (Freshney, 2016) ^[10].

Sterility

One of the most important prerequisites for animal cell culture is the maintenance of aseptic conditions. Bacterial, fungal, yeast, mycoplasma, or viral contamination can change

cellular metabolism, affect the expression, and eventually ruin the entire experiment. As a result, all processes involving cultivated cells must be carried out in biological safety cabinets, utilizing sterile media, chemicals, plasticware, and equipment. (Uphoff & Drexler, 2014) ^[27]. Amphotericin B (0.25–2.5 µg/mL) may be added when fungal contamination is a concern, although antibiotics like penicillin (100 U/mL) and streptomycin (100 µg/mL) are frequently added to the culture media of many mammalian and avian cell lines to lower the risk of bacterial contamination. Although antibiotic-antimycotic combinations may be used during primary culture establishment or when contamination is suspected, insect cell cultures are often maintained without antibiotics under proper aseptic conditions. (Freshney, 2016) ^[10].

Characterization of Cultured Cells

Accurately characterizing growing cells is crucial in cell culture studies. Reliable identification ensures the biological importance, credibility, and repeatability of experimental outcomes. Over the years, a number of studies have reported cell line misidentification and cross-contamination, leading to inaccurate scientific conclusions and a substantial loss of research resources. (Capes-Davis *et al.*, 2010; ATCC Standards Development Organization Workgroup ASN-0002, 2010) ^[4, 3]. Consequently, international organizations such as the American Type Culture Collection and the International Cell Line Authentication Committee recommend routine authentication of cell lines before their use in research (Freshney, 2016; Almeida *et al.*, 2016) ^[10, 2]. Characterization involves determining the identity and biological properties of cultured cells, including their:

- morphology,
- species of origin,
- tissue source,
- differentiation status,
- genetic stability, and
- expression of lineage-specific markers.

No single method is sufficient for complete identification; instead, a combination of morphological, cytogenetic, biochemical, immunological, and molecular techniques provides the highest degree of accuracy.

Morphological Characterization of Cultured Cells

Examining the morphology of grown cells with an inverted phase-contrast microscope is the first step in identifying them. Cell morphology provides important initial information about a culture's identification, physiological state, and growth traits. However, morphological observations should always be interpreted cautiously because a number of factors, including cell density, culture medium composition, substrate properties, passage number, and ambient conditions, affect cell shape. (Freshney, 2016) ^[10].

Cells maintained under optimal culture conditions generally display characteristic shapes that permit tentative classification into three major morphological categories.

Morphological category	Morphological characteristics	Growth characteristics	Typical tissue origin	Representative cell lines
Epithelial-like cells	typically polygonal or cuboidal with clearly defined cell boundaries; strong cell-cell adhesion	Adherent; form compact monolayers with contact inhibition	Skin, kidney, liver, intestine, mammary gland, respiratory epithelium	HeLa, Vero, MDCK, CHO, etc.
Fibroblast-like cells	Elongated, spindle-shaped cells with bipolar or multipolar extensions	Adherent; grow in parallel arrays or irregular networks with migratory behavior	Connective tissue, dermis, embryonic tissue, mesenchyme	NIH/3T ₃ , L929, BHK-21,
Lymphoblast-like cells	Round or spherical cells with a large nucleus and scant cytoplasm	Non-adherent; grow as single cells or small aggregates in suspension	Blood, bone marrow, lymphoid tissues	FeLV-3281, CL-1

Species Identification of Cultured Cells

To ensure experimental reproducibility and avoid cross-species contamination, it is crucial to identify the species of origin. Chromosome and isoenzyme analysis were the methods used previously for species identification. Today, molecular genetic techniques have largely replaced these classical approaches because of their superior sensitivity and specificity.

Common approaches include

Chromosome Analysis

Cytogenetic differentiation is made possible by the diverse chromosome counts and karyotypes of various animal species. Chromosomal anomalies or alterations due to cellular transformations or prolonged culture *in vitro* can be detected by Karyotyping and offer important information on genomic stability. However, this method requires actively dividing cells, competent personnel, and superior metaphase preparations that limits use of this method (Freshney, 2016) [10].

Isoenzyme Analysis

The electrophoretic mobility of isoenzymes varies depending on the species. It is possible to distinguish between closely related species by analyzing enzymes including lactate dehydrogenase (LDH), malate dehydrogenase (MDH), glucose-6-phosphate dehydrogenase (G6PD), and peptidase B.

DNA-Based Identification

For species authentication, molecular genetic methods are currently the gold standard. For precise identification of cultured cells, modern labs are increasingly using PCR amplification, DNA sequencing, mitochondrial DNA analysis, and species-specific molecular probes. These techniques provide rapid and highly reliable results while requiring only small quantities of DNA (Almeida *et al.*, 2016) [12].

Identification of Tissue of Origin

Determining the tissue or organ from which the cells originated is the next goal after proving species identity. In research involving stem cells, cancer biology, regenerative medicine, and developmental biology, understanding tissue genesis is very crucial. The following are the main standards for tissue identification:

- Cellular growth features and morphology
- Level of cellular differentiation
- Expression of indicators unique to a given tissue
- Characteristic enzyme present
- Expression of intermediate filament proteins
- Profile of cell surface antigens
- Expression of genes unique to tissues
- Functional properties of cultured cells

Tissue-Specific Markers

Differentiation Products

Differentiated cells synthesize characteristic proteins that serve as highly specific biomarkers. Examples include

Cell Type	Marker
Hepatocytes	Albumin
Melanocytes	Melanin, Tyrosinase
Skeletal muscle	Myosin, Tropomyosin
Erythroid cells	Hemoglobin
Pancreatic β -cells	Insulin
Chondrocytes	Type II collagen
Osteoblasts	Osteocalcin

Detection of these products may be performed using immunocytochemistry, ELISA, Western blotting, or molecular techniques.

Enzyme Markers

Certain enzymes exhibit tissue-specific expression and are therefore valuable diagnostic markers. Examples include:

Enzyme	Cell Type
Tyrosine aminotransferase	Hepatocytes
Tyrosinase	Melanocytes
Creatine kinase (MM)	Skeletal muscle
Creatine kinase (BB)	Neural tissue
Alkaline phosphatase	Osteoblasts
Acetylcholinesterase	Neurons

Loss of enzyme activity during prolonged culture may indicate cellular dedifferentiation.

Intermediate Filament Proteins

Intermediate filament proteins represent one of the most widely used classes of lineage markers because their expression remains relatively stable during culture. Common markers include

Cytokeratin	Epithelial cells
Vimentin	Mesenchymal cells
Desmin	Muscle cells
Glial fibrillary acidic protein (GFAP)	Astrocytes
Neurofilament proteins	Neurons

Immunofluorescence staining of intermediate filaments is routinely employed for confirming cellular identity.

Cell Surface Antigens

Cell surface proteins provide additional information regarding lineage and differentiation. Examples include

CD3	T lymphocytes
CD19 and CD20	B lymphocytes
CD34	Hematopoietic stem cells
CD44	Mesenchymal stem cells
CD90	Fibroblasts and mesenchymal stem cells
Integrins (CD49 family)	Cell adhesion and extracellular matrix interaction

Monoclonal antibodies directed against these antigens are widely used in flow cytometry and immunocytochemistry for cell identification.

Characterization of Transformed Cells

The acquisition of genetic changes that lead to permanent shifts in cellular phenotype is referred to as transformation. Transformation can happen on its own, as a result of deliberate genetic modification, viral infection, or exposure to chemicals. Compared with normal cells, transformed cells typically exhibit:

- Accelerated proliferation
- Reduced dependence on growth factors
- Loss of contact inhibition
- Anchorage-independent growth
- Increased saturation density
- Chromosomal instability
- Altered metabolism
- Enhanced invasiveness

Because transformed cells differ substantially from normal primary cells, their identification is essential when selecting experimental models.

Importance of Cell Line Authentication

Since continuous and long term passaging may cause certain phenotypic and genetic changes in the original cell line, authentication is very crucial. Routine authentication offers several advantages:

- Ensures reproducibility of experimental results.
- Detects interspecies and intraspecies cross-contamination.
- Confirms the genetic identity of cultured cells.
- Prevents publication of misleading scientific data.

Detection of Microbial Contamination

Microbial contamination is one of the leading causes of experimental variability in cell culture laboratories. Common contaminants include- Bacteria, Virus, Fungi, Yeasts and Mycoplasmas. Among these, mycoplasmas are particularly problematic because they do not produce visible turbidity and frequently remain undetected while altering cellular metabolism, DNA replication, gene expression, etc. Routine screening methods include- PCR, DNA fluorochrome staining (Hoechst or DAPI), culture techniques and enzymatic detection assays. Regular monitoring combined with strict aseptic practices significantly reduces contamination risks.

Cell Adhesion and Extracellular Matrix Interactions in Cell Culture

Cell adhesion is a fundamental processes in biology that enables cells to attach to their neighboring cells and to the extracellular matrix (ECM). These interactions are not just a passive attachment, its deeply related to how tissues maintain their shape and how cells carry out regular cellular functions such as cell division, migration, differentiation into specialized types, survival, and intracellular signaling. In cell culture, successful adhesion is particularly important because cells that fail to adhere often struggle to maintain their normal physiological characteristics and eventually die. Consequently, understanding the mechanisms by which cells adhere is crucial for applications in modern research involving cell biology, regenerative medicine, tissue engineering, cancer research, and vaccine production (Hynes, 2002; Freshney, 2016) ^[15, 10].

Most cells isolated from solid tissues- fibroblasts, epithelial cells, endothelial cells, and mesenchymal stem cells- usually donot grow unless they attach to some solid surface, hence are called anchorage-dependent. After seeding, these cells start establishing a weak contact with the culture vessel which in due course of time convert into a firm attachment through interactions between cell surface receptors and extracellular matrix proteins. Once attached, cells then reorganize their cytoskeleton to spread out across the surface eventually enter the cell cycle. Cells originating from blood, bone marrow, spleen, and lymphoid tissues behave differently. They generally grow in suspension because no attachment is needed for their survival or proliferation (Masters, 2000) ^[19].

When anchorage-dependent cells fail to establish proper adhesion, they often undergo a specialized form of programmed cell death known as anoikis and plays an important role in maintaining normal tissue organization. However, many transformed and metastatic cancer cells manage to develop resistance to anoikis, allowing them to survive during circulation and invade distant tissues (Frisch &

Francis, 1994) ^[12].

The extracellular matrix (ECM) is a highly organized scaffold of proteins and polysaccharides that surrounds cells in living tissues. Besides providing structural support, it plays an important role in regulating cell behaviour- migration, differentiation, proliferation, and survival. The major components of the ECM include collagen, laminin, fibronectin, elastin, proteoglycans, and glycosaminoglycans. In conventional two-dimensional cultures, the native ECM is largely absent, which explains why cultured cells often behave differently from cells *in vivo*. To overcome this limitation, culture surfaces are frequently coated with ECM proteins such as collagen, fibronectin, laminin, or gelatin to improve cell attachment and maintain specialized cellular functions (Hynes, 2009) ^[16].

Cell Adhesion Molecules (CAMs)

Cell adhesion is mediated by specialized transmembrane proteins collectively known as cell adhesion molecules (CAMs). These molecules in addition to providing mechanical attachment, also activate signaling pathways inside the cells that regulate various cellular activities.

Integrins

Among the different families of CAMs, integrins are the principal receptors responsible for cell-ECM interactions. They bind to extracellular matrix proteins such as collagen, fibronectin, laminin, and vitronectin through specific recognition motifs. Binding of integrins activates signaling pathways thereby regulating cell proliferation, migration, differentiation, and survival (Ruoslahti, 1996; Hynes, 2002) ^[22, 15].

Cadherins

Cadherins constitute another important family of adhesion molecules that primarily mediate calcium-dependent cell-to-cell adhesion. They hold tissue at structural level, forming adherens junctions between adjacent cells (Thiery *et al.*, 2009) ^[26].

Other adhesion molecules also contribute to cellular interactions- Selectins, members of the immunoglobulin superfamily and proteoglycans, etc.

Recent advances in cell culture has centered on one goal- recreating the native extracellular environment. Three-dimensional (3D) culture systems, biomaterial scaffolds, organoids, and organ-on-chip technologies mimic the architecture and mechanical properties of living tissues much better than the conventional monolayer cultures by better preserving cell-cell and cell-matrix interactions (Edmondson *et al.*, 2014) ^[8].

Conclusion

The successful maintenance of cultured cells depends on setting up conditions that mirror their natural physiological environment. Cells require an appropriate culture medium containing essential nutrients, proper physical and chemical conditions to ensure normal cellular growth and function (Masters, 2000) ^[19]. Strict aseptic techniques are equally important because contamination by bacteria, fungi, mycoplasma, or viruses can compromise experimental results and lead to loss of valuable cell cultures. A clear understanding of extracellular matrix interactions and adhesion molecules is also essential for maintaining healthy cell cultures and for advancing research in developmental biology, tissue engineering, oncology, immunology, and

veterinary biotechnology.

Conflict of Interest

Not available

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References

- Alberts B, Johnson A, Lewis J, Morgan D, Raff M, Roberts K, *et al.* Molecular biology of the cell. 7th ed. New York: Garland Science; 2022.
- Almeida JL, Cole KD, Plant AL. Standards for cell line authentication and beyond. *PLoS Biol.* 2016;14(6):e1002476.
- American Type Culture Collection (ATCC) Standards Development Organization Workgroup ASN-0002. Cell line misidentification: The beginning of the end. *Nat Rev Cancer.* 2010;10(6):441-448.
- Capes-Davis A, Theodosopoulos G, Atkin I, Drexler HG, Kohara A, MacLeod RAF, *et al.* Check your cultures! A list of cross-contaminated or misidentified cell lines. *Int J Cancer.* 2010;127(1):1-8.
- Davis JM. Basic cell culture: A practical approach. 3rd ed. Oxford: Oxford University Press; 2011.
- Doyle A, Griffiths JB. Cell and tissue culture: Laboratory procedures. Chichester: John Wiley & Sons; 1998.
- Duval K, Grover H, Han LH, *et al.* Modeling physiological events in 2D vs. 3D cell culture. *Physiology.* 2017;32(4):266-277.
- Edmondson R, Broglie JJ, Adcock AF, Yang L. Three-dimensional cell culture systems and their applications in drug discovery and cell-based biosensors. *Assay Drug Dev Technol.* 2014;12(4):207-218.
- Fang G, Chen YC, Lu H, Jin D. Advances in spheroids and organoids on a chip. *Adv Funct Mater.* 2023;33:2215043.
- Freshney RI. Culture of animal cells: A manual of basic technique and specialized applications. 7th ed. Hoboken (NJ): John Wiley & Sons; 2016.
- Freshney RI. Culture of animal cells: A manual of basic technique and specialized applications. 8th ed. Hoboken (NJ): Wiley-Blackwell; 2021.
- Frisch SM, Francis H. Disruption of epithelial cell-matrix interactions induces apoptosis. *J Cell Biol.* 1994;124(4):619-626.
- Harrison RG. Observations on the living developing nerve fiber. *Proc Soc Exp Biol Med.* 1907;4(1):140-143.
- Hayflick L, Moorhead PS. The serial cultivation of human diploid cell strains. *Exp Cell Res.* 1961;25(3):585-621.
- Hynes RO. Integrins: Bidirectional, allosteric signaling machines. *Cell.* 2002;110(6):673-687.
- Hynes RO. The extracellular matrix: Not just pretty fibrils. *Science.* 2009;326(5957):1216-1219.
- Ko J, Park D, Lee J, *et al.* Microfluidic high-throughput 3D cell culture. *Nat Rev Bioeng.* 2024;2:453-469.
- Lodish H, Berk A, Kaiser CA, *et al.* Molecular cell biology. 9th Ed. New York: W. H. Freeman; 2021.
- Masters JRW. Animal cell culture: A practical approach. 3rd ed. Oxford: Oxford University Press; 2000.
- Merten OW. Advances in cell culture: Insect cells as production platforms for recombinant proteins. *Cytotechnology.* 2015;67(2):187-212.
- Pattison M, McMullin PF, Bradbury JM, Alexander DJ. Poultry diseases. 6th Ed. Edinburgh: Saunders Elsevier; 2008.
- Ruoslahti E. RGD and other recognition sequences for integrins. *Annu Rev Cell Dev Biol.* 1996;12:697-715.
- Russell WMS, Burch RL. The principles of humane experimental technique. London: Methuen; 1959.
- Tan J, Virtue S, Norris DM, *et al.* Limited oxygen in standard cell culture alters metabolism and function of differentiated cells. *EMBO J.* 2024;43:2127-2165.
- Thermo Fisher Scientific. Gibco cell culture basics handbook. Waltham (MA): Thermo Fisher Scientific; 2021.
- Thiery JP, Acloque H, Huang RYJ, Nieto MA. Epithelial-mesenchymal transition in development and disease. *Cell.* 2009;139(5):871-890.
- Uphoff CC, Drexler HG. Detection of mycoplasma contamination in cell cultures. *Curr Protoc Mol Biol.* 2014;106:28.4.1-28.4.14.

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