BHARATHIDASAN UNIVERSITY

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(5 Year Integrated Program)

Course Title : Stem Cell Biology and Regenerative Medicine
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Unit-II
Stem Cells – Types and Applications

Dr. K. PREMKUMAR
Professor
Department of Biomedical Science

STEM CELL BIOLOGY AND TISSUE ENGINEERING
UNIT - II

Prof. K. Premkumar
Dept of Biomedical Science
Bharathidasan University

Embryonic Stem Cells (ESCs)

- **Definition:**
  - Derived from the inner cell mass of the blastocyst.
  - Pluripotent: Capable of differentiating into any cell type within the body
- **Isolation:**
  - Harvested from early-stage embryos (blastocysts) during in vitro fertilization (IVF).
  - Cultured in vitro on feeder layers with growth factors like LIF (leukemia inhibitory factor).
- **Clinical Applications:**
  - Regenerative therapies (e.g., Parkinson’s disease, diabetes).
  - Disease modeling and drug discovery.
  - Challenges: Ethical concerns and risk of teratoma formation.

Hematopoietic Stem Cells (HSCs)

- **Definition:**
  - Multipotent stem cells capable of forming all types of blood cells (e.g., RBCs, WBCs, platelets).
  - Found in bone marrow, peripheral blood, and umbilical cord blood.
- **Isolation:**
  - Techniques: Density gradient centrifugation, magnetic-activated cell sorting (MACS).
  - Markers: CD34+ antigen for identifying HSCs.
- **Clinical Applications:**
  - Bone Marrow Transplantation (BMT): Treatment for leukemia, lymphoma, and other blood disorders.
  - **Example:** Use of autologous HSCs in treating aplastic anemia.

Bone Marrow Transplantation (BMT)

- **Procedure:**
  - Patient preparation: High-dose chemotherapy or radiation.
  - Transplant types: Autologous (self-donated) and allogeneic (donor-derived).
- **Applications:**
  - Treats blood cancers (e.g., leukemia) and non-malignant diseases (e.g., sickle cell anemia).
  - Immune system reconstitution after high-dose therapies.
  - Example: Successful treatment of Fanconi anemia with sibling-donor BMT.

BMT for Autoimmune Diseases

- **Mechanism:**
  - Replaces the faulty immune system with healthy HSCs.
  - Resets immune tolerance and reduces autoimmunity
- **Examples:**
  - Systemic lupus erythematosus (SLE): Improved disease control with autologous BMT.
  - Multiple sclerosis: Allogeneic HSC transplants leading to symptom remission.
- **Challenges:**
  - Risk of graft-versus-host disease (GVHD) in allogeneic transplants.
  - High cost and potential complications.

Transgenic Applications of Stem Cells

- **Definition:**
  - Genetic modification of stem cells to study gene function or produce therapeutic proteins.
- **Examples:**
  - ESCs engineered to express insulin for diabetes treatment.
  - Use in gene therapy: Correcting genetic mutations in HSCs.
- **Challenges:**
  - Ethical concerns and technical difficulties in precise editing.

Trophoblast Stem Cells

- **Definition:**
  - Derived from the trophectoderm layer of the blastocyst.
  - Essential for forming the placenta.
- **Isolation:**
  - Cultured in vitro with fibroblast growth factor (FGF) and activin A.
- **Applications:**
  - Understanding placental development and disorders (e.g., preeclampsia)
  - Studying early embryo-maternal interactions.

Epidermal Stem Cells

- **Definition:**
  - Found in the basal layer of the epidermis and hair follicles.
  - Unipotent: Regenerate skin and hair under normal conditions.
- **Isolation:**
  - Biopsy of skin tissues followed by in vitro expansion.
- **Applications:**
  - Wound healing: Cultured epidermal stem cells for burn treatment.
  - Regenerative medicine: Development of skin grafts.
- **Example:**
  - Use of epidermal stem cell sheets in chronic ulcer treatment.

Comparison of Stem Cells

- **Embryonic vs. Hematopoietic Stem Cells:**
  - ESCs: Pluripotent, ethical issues, teratoma risk.
  - HSCs: Multipotent, clinical use in blood disorders, limited differentiation potential.
- **Trophoblast vs. Epidermal Stem Cells:**
  - Trophoblast: Placenta development.
  - Epidermal: Skin regeneration.

Advances in Stem Cell Technology

- **CRISPR-Cas9:** Precise gene editing in ESCs and HSCs.
- **Organoids:** 3D cultures mimicking organs for studying trophoblast stem cells.
- **Biomaterials:** Scaffolds enhancing epidermal stem cell growth.

Challenges and Ethical Considerations

- **ESC Research:**
  - Destruction of embryos raises ethical concerns.
  - Legal restrictions vary globally.
- **BMT Risks:**
  - Infection, GVHD, and donor compatibility.
- **Future Outlook:**
  - Balancing innovation with ethical practices in stem cell research.