Stem Cells Class

PhD students

Lecture-1

General introduction to stem cells

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https://stemcells.nih.gov/info/basics/1.htm

Introduction: What are stem cells, and why are they important?

- Stem cells have the remarkable potential to develop into many different cell types in the body during early life and growth. addition, in many tissues they serve as a sort of internal repair system, dividing essentially without limit to replenish other cells as long as the person or animal is still alive. When a stem cell divides, each new cell has the potential either to remain a stem cell or become another type of cell with a more specialized function, such as a muscle cell, a red blood cell, or a brain cell.

Stem cells types

- 1- embryonic stem cells
- 2-non-embryonic "somatic" or "adult" stem cells.
- Stem cells are unspecialized.
- Stem cells can give rise to specialized cells.

What are embryonic stem cells?

- 1- Embryonic stem cells, derived from embryos
- 2- Most embryonic stem cells are derived from embryos that develop from eggs that have been fertilized in vitro—in an in vitro fertilization clinic—and then donated for research purposes with informed consent of the donors.
- 3- They are not derived from eggs fertilized in a woman's body.

Terms

- **Totipotent**—The state of a cell that is capable of giving rise to all types of differentiated cells found in an organism, as well as the supporting extra-embryonic structures of the placenta. A single totipotent cell could, by division in utero, reproduce the whole organism.
- **Pluripotent**—The state of a single cell that is capable of differentiating into all tissues of an organism, but not alone capable of sustaining full organismal development.

- Scientists demonstrate pluripotency by providing evidence of stable developmental potential, even after prolonged culture, to form derivatives of all three embryonic germ layers from the progeny of a single cell and to generate a teratoma after injection into an immunosuppressed mouse.
- **Multipotent**—Having the ability to develop into more than one cell type of the body.

Germline stem cells (GSCs):

- which can self-renew and generate differentiated progeny, are unique stem cells in that they are solely dedicated to reproduction and transmit genetic information from generation to generation.

Definition
In biology and genetics:

- In biology and genetics:
- The germline in a multicellular organism is that population of its bodily cells that are so differentiated or segregated that in the usual processes of reproduction they may pass on their genetic material to the progeny.
- * As a rule this passing on happens via a process of sexual reproduction; typically it is a process that includes systematic changes to the genetic material, changes that arise during recombination, meiosis and fertilization.
- * The cells of the germline commonly are called germ cells.

- For example, gametes such as the sperm or the egg are part of the germline.
- So are the cells that divide to produce the gametes, called gametocytes,
- The cells that produce those, called gametogonia, and all the way back to the zygote, the cell from which the individual developed
- * In sexually reproducing organisms, cells that are not in the germline are called somatic cells.
- * The term refers to all of the cells of body apart from the gametes.
- * According to this view mutations, recombinations and other genetic changes in the germline may be passed to offspring, but a change in a somatic cell will not be.
- * Sperm and egg production requires a robust stem cell system that balances self-renewal with differentiation. Self-renewal at the expense of differentiation can cause tumorigenesis, whereas differentiation at the expense of self-renewal can cause germ cell depletion and infertility.

- * In most organisms, and sometimes in both sexes, germline stem cells (GSCs) often reside in a defined anatomical niche. Factors within the niche regulate a balance between GSC self-renewal and differentiation.
- * Asymmetric division of the germline stem cell to form daughter cells with alternative fates is common. The exception to both these tendencies is the mammalian testis where there does not appear to be an obvious anatomical niche and where GSC homeostasis is likely accomplished by a stochastic balance of self-renewal and differentiation and not by regulated asymmetric cell division. Despite these apparent differences, GSCs in all organisms share many common mechanisms, although not necessarily molecules, to guarantee survival of the germline.

- * In males and in females or hermaphrodites of many species, gametes are produced throughout reproductive life from adult stem cells dedicated to the germline.
- *GSCs commonly reside in a special microenvironment, a stem cell niche, provided by somatic support cells. GSCs in this niche both self-renew to maintain the generative population and also produce progeny germ cells that exit the niche and begin the process of differentiation.
- *These progeny commonly execute several rounds of mitotic division before switching to the germ cell-specific cell cycle of meiosis and subsequent differentiation into mature gametes

- *GSCs are normally unipotent, producing only differentiating gametes. However, as the only adult stem cells that contribute to the next generation, it is likely that GSC potency must be strictly controlled to prevent teratoma formation.

Telomeres in GSC

- * Telomeres are located at the outermost ends of all eukaryotic chromosomes and provide for the maintenance of genomic stability and integrity during the life span of organisms.
- * The length of telomeres shortens due to each round of DNA replication, genotoxic insults, and/or reactive oxygen species.
- * To counteract this shortening, certain types of cells, including stem cells, male/female germline cells, granulosa cells, early embryos, and most cancerous cells, express an enzyme known as telomerase, which has the potential of restoring the shortened telomeres.
- * Presence of telomerase activity in the male germ cells ensures maintenance of telomere length at maximum levels during spermatogenesis despite telomere attrition due to DNA replication or other genotoxic factors.