EMBRYONIC AND ADULT STEM CELLS 1 & 2

reading p. 334; also chapter 20 for related information (on cloning)

useful website: http://stemcells.nih.gov/info/basics/basics1.asp

STEM CELLS

1. CELL DIVISION (proliferation potential)
2. DEVELOP (DIFFERENTIATE) INTO MULTIPLE CELL TYPES
3. NAMED FOR TISSUE DERIVED FROM

EMBRYONIC STEM CELLS (ES Cells)
- TOTIPOTENT - all tissues + placenta (morula = pre-blastocyst)
- PLEURIPOTENT - all tissues (ecto-, meso-, endoderm) (blastocyst inner mass)
- MULTIPOTENT - closely-related specialized cells (families of cells)(adult)
- UNIPOTENT - produces only a single cell type (but shows self-renewal)

ADULT STEM CELLS (tissue-specific stem cells)
- MULTIPOTENT - closely-related specialized cells (families of cells)(adult)
- UNIPOTENT - produces only a single cell type (but shows self-renewal)

SOURCE OF ES CELLS

ES cells derived of embryos from IVF clinic:
- Donated for research purposes w/ informed consent of donors
- Not derived from eggs fertilized in a woman's body
- Embryos 4-5 days old. Inner cell mass about 30 cells.

STEM CELLS

overview
embryo destroyed
undifferentiated

blood cells

neurons

embryoid bodies

UNDIFFERENTIATED HUMAN EMBRYONIC STEM CELLS

Stem cell colonies

Fibroblast feeder cells

Also: EMBRYONIC GERMLINE CELLS (EG Cells; egg, sperm progenitors)
and CORD BLOOD STEM CELLS (from umbilical cord)
RED BLOOD CELL COLONY FROM HUMAN EMBRYONIC STEM CELLS

Development & Differentiation

First specialized human cells to be coaxed down a specific developmental pathway

They may one day augment human blood supplies for transfusion and transplantation

FROM STEM CELLS: HUMAN NEURONS (red) GLIAL CELLS (green)

THREE ADULT CELL TYPES (PROLIFERATION)

1. DIFFERENTIATED CELLS (no longer capable of division)
   a. cardiac muscle, neurons
   b. produced during development
   c. differentiate, retained throughout life.

2. CELLS IN Go STAGE OF CELL CYCLE
   a. resume cell cycle when needed to replace cells
   b. skin fibroblasts, smooth muscle, endothelial cells
   c. epithelial cells of liver, pancreas, kidney, lung, prostate, breast (cf. cancers)

3. ADULT STEM CELLS
   a. undifferentiated cells, short life, continually replaced
   b. blood cells, epithelial cells of skin and digestive tract
   c. divide to daughter cells: differentiate or remain stem cells
BLOOD CELL LINEAGES

Figure 3. Plasticity of adult stem cells

COMPARISON: SPERMATOGENESIS vs OOGENESIS

FEMALE REPRODUCTIVE SYSTEM

FEMALE FETUS

HUMAN OOGENESIS

Structure of an Ovary

Primordial follicle
Primary follicle
Secondary follicle
Mature vascular follicle
Rupturing follicle

Corpus albinus
Mature corpus luteum

400,000 follicles remain. Grow to PRIMARY FOLLICLES.

GIRL AT BIRTH

GIRL AT PUBERTY

Primordial germ cells and oogonia undergo division. About 1 million PRIMORDIAL FOLLICLES each with a PRIMARY OOCYTE.

Loss and necrobiosis of some follicles 100,000 remain. No stem cells or oogonia. No more follicles made in lifetime. Oocytes arrested in metaphase I. arrested. Primordial follicles.

No stem cells or oogonia. No more follicles made in lifetime.

Every month 10-20 follicles respond to FOLLICLE-STIMULATING HORMONE and begin to develop to SECONDARY FOLLICLES. One continues to develop, the rest reabsorbed. Ovulates 1/month for 35y; about 420 eggs total lifetime.

Meiosis continues and arrested at metaphase II. Meiosis completed after fertilization.
HUMAN EGG WITH POLAR BODIES

MALE REPRODUCTIVE SYSTEM

Sperm production site. Sectioned seminiferous tubule. This tubule contains a swirl of the tails of forming sperm cells (blue/pink) at its centre.

TESTIS (seminiferous tubule)

STEM CELL SELF-RENEWAL

EXAMPLE: HUMAN SPERMATOGONIA

A, spermatogonia (stem cells) continued self-renewal
A, spermatogonia (paired) destined for differentiation

HUMAN MALE SPERMATOGENESIS

Fig. 5. Two possible outcomes for spermatogonial stem cell division and commitment towards differentiation. Of the two, the division of A, (paired spermatogonia) are shown. The A, spermatogonia are shaded to indicate their distinction towards differentiation. When the cell divisions are asymmetric, there is a sub-clonal category of A, spermatogonia that are destined towards A, spermatogonia. This fraction is kept constant through spermatogonia.

stem cell population

one billion spermatogonia

spermatogonia = capable of mitosis spermatocytes = undergoing meiosis spermatids = haploid (round) sperm = haploid (with tail)

total time = 64 days

50 million sperm per day for lifetime