Update

What's New in Stem Cell Research

by John H. Dirckx, M.D.

adult stem cell—an undifferentiated precursor cell, found in small numbers in the differentiated tissues of an adult, that can either divide so as to continue the line of such cells or differentiate into a specific cell type.

apoptosis—programmed death of certain cells, such as erythrocytes and epithelial cells in the adult and cells of transitional organs in the fetus; may also occur in cells damaged by environmental factors or viral infection. Cells in cultures, other than stem cells and tumor cells, undergo apoptosis after about 50 cell divisions.

blastocoel—the cavity in the blastula of the developing embryo.

blastocyst—a very early (preimplantation) embryo, consisting of 50-200 cells, produced by repeated cleavage of a zygote (fertilized oocyte). It is a roughly spherical structure consisting of an outer cell layer (the trophectoderm), which will develop into the fetal membranes and placenta; a fluid-filled cavity (the blastocoel); and a cluster of pluripotent cells (the inner cell mass), which will develop into the body of the fetus.

blastomere—a pluripotent cell of the inner cell mass of a blastocyst.

bone marrow stromal cell—any stem cell found in bone marrow that is not involved in hematopoiesis (blood cell formation). These are mesenchymal stem cells, some of which can differentiate into specialized connective tissue cells such as bone, cartilage, and fat.

cell culture—growth of cells in vitro on an artificial medium.

cell division—a process by which a single cell divides to form two daughter cells, with nothing left over; preceded by division and reapportionment of genetic material in the nucleus (mitosis in somatic cells, meiosis in gametes).

cell line—a self-perpetuating or self-renewing colony of cells grown in culture and having an indefinite life span.

cell-based therapy—a form of treatment in which stem cells are induced to differentiate into specific cells of the type required to repair damaged or depleted adult cell populations or tissues.

chimera (ki-mé-ra, named for a monster of Greek myth)—an organism composed of cells derived from at least two genetically different zygotes, from the same or different species; can occur naturally, but the term usually refers to the laboratory creation of an artificial zygote by replacement of the nucleus of a cell with a cell nucleus taken from another individual.

chromosome—any of a group of paired structures in the cell nucleus (23 pairs in human cells), consisting chiefly of long coiled strands of DNA, that determine the genetic makeup of an organism. One of each pair is contributed by each parent. Chromosomes are made up of subunits called genes, each of which codes for a specific trait.

clone—any aggregation of cells, ranging up to a complete organism, derived asexually from a single ancestral diploid cell.

cloning—generation of an embryo by somatic cell nuclear transfer.

congenital—present at birth, but not necessarily genetic.

cord blood—blood in the umbilical cord and placenta, particularly in the context of childbirth and the immediate postpartum period.

cryopreserved embryo—an embryo, usually one produced by in vitro fertilization, that has been stored in the frozen state because it exceeded the needs of the moment.

culture medium—a nutrient and protective fluid or semisolid material in which a culture is grown in vitro.

cytoplasmic inheritance—transfer of genetic material by genes present in cytoplasm.

differentiation—a developmental process characterized by an increase in the organization or complexity of a cell or tissue, accompanied by specialization of function.

directed differentiation—modification of a stem cell culture, for example by the addition of growth factors, so as to induce differentiation into a specific cell type.

DNA (deoxyribonucleic acid)—the genetic material of all cellular organisms, contained chiefly in the nucleus and forming the chromosomes. It is a polymer (long chain of repeating units) in which molecules of deoxyribose (a five-carbon sugar) are linked by phosphate bonds and carry side-chains of adenine, guanine, cytosine, and thymine. These four substances (the first two purines and the second two pyrimidines) carry the genetic blueprint for the synthesis and arrangement of all the substances and structures in the body.

dysmorphism—any developmental error resulting in an abnormal appearance or configuration.

ectoderm—the outermost of the three germ layers of the early embryo, derived from the inner cell mass of the blastocyst. As fetal development progresses it gives rise to the skin, the nervous system, dental enamel, and the ocular lenses.

embryo—an organism in the earliest stages of development; for human beings, the embryonic stage extends from fertilization until the end of the eighth week of gestation.

Update

embryo provider—a person who has custody of an embryo and the authority to make decisions regarding its disposition; not necessarily either biological parent of the embryo.

embryoid body—a spheroidal clump or colony of partially differentiated cells that develops spontaneously in a culture of embryonic stem cells. Cells isolated from embryoid bodies may be used to start lines of multipotent stem cells.

embryonic germ cell—a pluripotent stem cell derived from the gonadal ridge of a 5- to 8-week embryo. With continued normal development these cells differentiate into gametes (oocytes or sperm). Their properties and developmental potential are similar but not identical to those of embryonic stem cells.

embryonic stem cell—a primitive, undifferentiated, pluripotent stem cell derived from the inner cell mass of an embryo in the blastocyst stage.

endoderm—the innermost of the three germ layers of the early embryo, derived from the inner cell mass of the blastocyst. As fetal development progresses it gives rise to the respiratory and digestive systems, including the liver and the pancreas.

epidermal growth factor—a protein involved in the maturation of the epidermis; in the newborn it hastens eyelid opening and tooth eruption.

eugenics—the theory or practice of preserving genetic traits that are considered positive or advantageous within a population while annihilating traits considered undesirable; methods range from manipulating the reproductive behavior or outcomes of a population to involuntary sterilization and genocide.

ex vivo—outside the body; usually means about the same as in vitro.

feeder layer—a layer of cells (usually mouse embryonic fibroblasts treated with gamma radiation to prevent them from proliferating) on which a stem cell culture is maintained.

fertilization—the process whereby male and female gametes (sperm and oocyte) unite to form a zygote.

fetus—a developing organism from the end of the embryonic period (8 weeks of development in human beings) until birth.

gamete—a sex cell (sperm or oocyte) having the haploid chromosome number (23 single chromosomes)

gamete provider – one of the biological parents of an embryo; may not necessarily have legal custody of the embryo or the authority to make decisions regarding its disposition.

gastrulation—a process during embryonic development whereby the inner cell mass of the blastocyst differentiates into the three germ layers (ectoderm, mesoderm, and endoderm).

gene—a functional unit of heredity, consisting of a specific sequence of DNA and occupying a specific position (locus) on a specific chromosome. Each gene codes for the synthesis of a specific protein.

gene therapy – the therapeutic or medical application of somatic genetic transfer.

genetic—pertaining to transmission of traits or defects by genes.

genetic engineering—intentionally altering the genetic composition of an organism.

genome—the full complement of genetic information possessed by the chromosomes of an individual organism or species.

genotype—the genetic composition of an individual; compare phenotype.

germ cell—a gamete (sperm or oocyte) or a primordial cell that can mature into a gamete.

germ layer—any of the three primitive layers (endoderm, mesoderm, and ectoderm) into which the inner cell mass of an early embryo (blastocyst) divides as a preliminary to further development.

germ line—the line of primordial cells, identifiable in the late embryonic stage of development, that will eventually differentiate into gametes (sperm or oocytes, depending on the sex of the embryo).

gonad—an organ (testis or ovary) that produces sex cells (sperm or oocytes).

gonadal ridge—embryonic structure from which the gonads develop.

hematopoietic stem cell—a stem cell from which all red and white blood cells develop; found in adult bone marrow, umbilical cord blood, peripheral blood, and fetal liver. Adult hematopoietic stem cells can replace bone marrow that has been destroyed by disease or radiation therapy and can continue to produce mature blood cells.

human embryonic stem cell—a pluripotent stem cell derived from the inner cell mass of the blastocyst stage of a human embryo.

hybrid cell—a cell resulting from the junction of two cells of different origins, whose nuclei have fused into one.

hybridization—pairing of an RNA strand and a DNA strand, or of two different DNA strands.

hybridoma—a cell line formed in the laboratory by the fusion of normal immune cells (e.g., lymphocytes) and tumor cells (e.g., myeloma). Such cells retain the ability of their immune ancestors to produce monoclonal antibody and the capacity of their neoplastic ancestors to replicate indefinitely in culture.

immortal—referring to a cell line that is capable of indefinite propagation; see telomerase.

implantation—the attachment of a blastocyst to the uterine lining.

in situ hybridization—laboratory technique in which a single-stranded DNA probe of known sequence, radioactively or fluorescently labeled, is made to seek out and fuse with a corresponding nucleic acid sequence in a specimen.

in vitro fertilization—an assisted reproductive technique for infertile couples in which fusion of a sperm

and an oocyte is carried out in a laboratory rather than within the female reproductive tract. After the resulting zygote has developed to the blastocyst stage it is implanted in the uterus of the mother for further development.

inheritable genetic modification (IGM) (germline genetic modification, germline engineering)—a technique of altering the genetic composition of gametes (oocytes and sperm) in which viral vectors are used to insert new genes. Since these changes are inheritable, they are passed on to offspring and become part of the human gene pool.

inherited—genetically transmitted.

inner cell mass (ICM)—a small group of cells within the cavity of a blastocyst (a very early embryo), which will give rise to the embryonic disk, then the three germ layers, and finally to all the cells and tissues of the fetus except the placenta and fetal membranes. Embryonic stem cell lines are derived from cells isolated from the inner cell mass.

knockout—referring to a cell line or experimental animal from whose genome a gene has been deliberately deleted by homologous recombination.

large-offspring syndrome—a disorder of cloned cattle and sheep in which a fetus grows abnormally large; associated with dystocia, stillbirth, and birth defects.

leukemia inhibitory factor—a naturally occurring protein (so named because it suppresses development of mouse leukemia cells) that has been used to inhibit differentiation in a stem cell line.

lineage—the descendants of a common ancestor.

long-term self-renewal—the persistence of a stem cell line for months or years due to repeated divisions forming the same undifferentiated cell types.

mesenchymal stem cell—a multipotent cell found in embryonic connective tissue and, much more rarely, in adult bone marrow and connective tissue; capable of differentiating into bone, cartilage, and fat cells.

mesoderm—the middle one of the three germ layers of the early embryo, derived from the inner cell mass of the blastocyst. As fetal development progresses it gives rise to muscle, connective tissues including bone and fat, and blood cells.

mitochondria—organelles that synthesize ATP (adenosine triphosphate) and are the principal site of cellular energy metabolism through the oxidation of foodstuffs (carbohydrates, fats, and proteins).

mitochondrial DNA—genetic material in mitochondria that codes for synthesis of mitochondrial proteins and enzymes independently of nuclear DNA. Virtually all of the mitochondrial DNA in a cell is derived from the cytoplasm of the oocyte (maternal gamete).

monoclonal antibody—an antibody produced by a hybridoma (a clone of cells derived from the fusion of an immune cell and a tumor cell).

morula—a stage of embryonic development preceding the blastocyst stage; the morula is a spherical mass of undifferentiated cells.

multipotent – referring to stem cells that can develop into at least two types of mature, more differentiated cell, but not into a wide range of cell types.

multipotent adult progenitor cells (MAPC)—cells derived from adult bone marrow that can be differentiate into various connective tissue cells.

neural stem cell—a stem cell occurring sparsely in the adult brain that can differentiate into neurons and neuroglial cells.

oligopotent progenitor cells—progenitor cells that can differentiate into a limited number of mature cell types.

oocyte—a female gamete (sex cell); this term is now preferred to ovum.

ooplasm—the cytoplasm of an oocyte; its mitochondria possess genetic material (mitochondrial DNA) that functions independently of nuclear (chromosomal) DNA and is the principal source of mitochondrial source in a zygote.

ooplasmic transfer (cytoplasmic transfer)—an experimental technique of injecting cytoplasm from an oocyte of a woman known to be fertile into an oocyte of an infertile woman. The oocyte thus modified is then fertilized in vitro and implanted into the uterus of the infertile woman.

parthenogenesis—the maturation of an unfertilized oocyte to form a new individual; occurs naturally in some insects and has been artificially induced in experimental animals. A possible means of producing embryonic stem cells without fertilization.

phenotype—the sum of observable or measurable physical, biochemical, and physiologic traits or features of an individual; determined in large measure by the genotype, but distinct from it.

plasticity—the ability of stem cells from one adult tissue to differentiate into mature cell types of another tissue.

pluripotent stem cell—a stem cell with the capacity to differentiate into cells of all germ layers (endoderm, ectoderm, and mesoderm) and into most or all cell types found in the adult body. Pluripotent cells used in stem cell research are derived from the inner cell mass of a very early embryo (blastocyst) or from the gonadal ridge of a slightly more mature embryo. Pluripotent cells cannot differentiate into placenta or fetal membranes.

population doubling—the doubling of the number of cells in a line of cells growing in vitro; in non-immortal lines, differentiation potential and life expectancy decline as the number of doubling increases, while the

Update

likelihood of genetic mutations increases.

preimplantation genetic diagnosis and screening (PGD)—testing of embryos that have been created by in vitro fertilization for certain genetic traits, including gender, so as to direct the choice of which one to implant.

primitive streak—a band of cells appearing in the third week of embryonic development, marking the longitudinal axis of the body and the site of the future spinal cord.

primordial germ cell—an embryonic cell that can mature and differentiate into a gamete (oocyte or sperm).

progenitor cell—a cell occurring in fetal or adult tissue that can differentiate into a more specialized cell but, unlike a stem cell, cannot renew itself indefinitely by repeated cell division.

proliferation—expansion of a cell population by repeated cell division.

regenerative (or reparative) medicine—a mode of treatment in which stem cells are induced to differentiate into the specific cell type required to repair damaged or depleted adult cell populations or tissues.

reproductive cloning—a process by which an entire new organism is created by somatic cell nuclear transfer from a single body cell of another organism, to which it is genetically identical; cloning of an embryo for transplantation into a uterus in order to produce a mature organism that is genetically identical to the nuclear donor.

research cloning—see *therapeutic cloning*.

somatic cell—all cells of a developing or mature organism except germline cells.

somatic cell genetics—the study of the genetics of somatic cells cultured in vitro.

somatic cell nuclear transfer (SCNT)—transplantation of the diploid nucleus of a somatic cell into an unfertilized oocyte from which the haploid nucleus has been removed. The resulting chimera has the genetic makeup of the donor cell but the developmental potential of a primitive germ cell. Cell division of the chimera yields a clone of totipotent stem cells that are genetically identical with the donor of the nucleus.

somatic genetic transfer (also called somatic genetic modification)—a process in which desired genes are introduced into the somatic cells of the body by means of a viral vector.

somatic mutation—any mutation occurring in a somatic cell rather than in the germ line.

somatic stem cell – see *adult stem cell*.

sperm—a male gamete; this abridged term is now preferred to spermatozoon.

stem cell—an undifferentiated multipotent precursor cell that is capable both of perpetuating itself as a continuing line of stem cells and of undergoing differentiation into one or more specialized types of cells.

sunset legislation—a type of legislation that incorporates an expiration date so that it must be reevaluated at a later time; this allows for changes in policy as public opinion and perceived needs change.

telomerase—an enzyme produced by germ cells, bone marrow stem cells, and tumor cells. It helps to prevent the attrition of telomeres (terminal sequences of chromosomes) during mitosis and confers immortality on a cell line.

telomere—a repeating sequence of double-stranded DNA at either end of a chromosome. As cells divide and differentiate throughout the lifespan of an organism or cell line, the occasional failure of a telomere sequence to be replicated during mitosis leads to gradual shortening of chromosomes. This genetic erosion plays an important part in normal aging and sets a natural limit on the number of times that such cells can undergo mitosis.

teratogen—any agent or factor that causes, or increases the likelihood, of congenital malformations.

teratoma—a tumor containing tissues from all three embryonic germ layers, usually arising in a gonad (ovary or testis). Can be artificially induced by injection of stem cells into immunodeficient laboratory animals, in order to assess the pluripotency of the cells.

therapeutic cloning—creation by somatic cell nuclear transfer of a clonal embryo, which is induced to divide until the blastocyst stage, during which embryonic stem cells are harvested from the inner cell mass.

totipotent stem cell—a zygote or any cell of the very early (3-4-day) embryo, which has the capacity to differentiate into all cell types that are found in an embryo, fetus, newborn, or adult, including the embryonic components of the trophoblast and placenta required to support development and birth. No artificially created stem cell line to date has been shown to have these properties.

trophectoderm—the outer cellular envelope of the blastocyst, which will develop into the placenta and fetal membranes.

trophoblast—the outer envelope of the blastocyst, containing cells that will differentiate to form the placenta and fetal membranes.

umbilical cord stem cell—a hematopoietic stem cell that is present in umbilical cord blood during the immediate postpartum period; similar to bone marrow stem cells.

unipotent stem cell—a stem cell that is capable of sustaining a self-renewing line or of differentiating into a single mature cell type.

vector—in cloning, the plasmid or phage used to carry the cloned DNA segment.

zygote—the diploid cell that results from the fertilization of an oocyte (ovum, egg) by a sperm cell.