What is a stem cell?

Where from?
What’s for?
Definition?
Molecular markers?
Methods for identification?
Intrinsic or extrinsic clues?
STEM CELLS

Embryonic stem cells

Adult stem cells

The promise of Stem Cell Research

Figure 3. Stem Cells Self-Renew and Differentiate to Give Rise to Transit Amplifying and Fully Differentiated Cells

Drug Development and Toxicity Tests
Cultured Pluripotent Stem Cells
Tissues/Cells for Therapy

Experiments to Study Development and Gene Control

Bone Marrow  Nerve Cells  Heart Muscle Cells  Pancreatic Islet Cells
**Embryonic stem cells** can be indefinitely grown in vitro and can give rise to many differentiated cell types, mainly neurons, endothelium, cardiomyocytes and blood.

Selection to nearly homogeneity of the desired cell type is still needed.

**Adult stem cells**

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Figure 9. Three Pathways to Possibly Reprogram Multipotent Stem Cells for Treatment of Human Disorders.
and, how really society should interfer with research?

"We're here to help with your stem cell research. I'm a philosopher and he's a politician."

The simplest concept of stem cells

Stem cell

Progenitor
The simplest concept of stem cells

- **Stem cells** are low proliferating cells
- **Progenitors** are highly proliferating cells

- Stem cells are relatively uncommon, with frequencies varying from roughly 0.0001% to roughly 5% of the total cells in a tissue—accordingly, tissue-specific stem cells may be difficult to isolate;

- Stem cells cycle relatively slowly, and often we see transit amplifying (TA) cells dividing more often than stem cells;

- Stem cell activity is governed by the cells’ microenvironment or *niche*, comprising cell-adhesion molecules, cell–cell signals and growth factors; and

- More controversially, stem cell populations are self-maintaining, in that each stem cell division, on average, generates one stem cell and one TA cell, or each two stem cell divisions, on average, generate two stem cells and two TA cells.
Stem cells at different developmental stages appear to have different capacities for self-renewal and differentiation

- The only totipotent cells are those removed at the pre-blastocyst stage of embryo development;
- Totipotent stem cells can generate any cell type;
- After the third cell division, cells begin to specialize.
- Cells removed from the inner cell mass are pluripotent, having less but nonetheless impressive, capacity for differentiation into various cell types.
- Embryonic stem cells (ES) are pluripotent
Some tissue-specific stem cells that are already differentiated retain multipotent capacity to generate cells of a still more restricted class of cell lineages;

Some stem cell biologists contend that putatively tissue-specific stem cells may 'dedifferentiate' and 'transdifferentiate' into other cell types.

Stem cells are generally characterized as cells with the potential for self-renewal and the capacity to generate more specialized cells.
Summary
Stem cell scientists and ethicists have focused intently on questions relevant to the developmental stage and developmental capacities of stem cells. Comparably less attention has been paid to an equally important set of questions about the nature of stem cells, their common characteristics, their non-negligible differences and their possible developmental species specificity. Answers to these questions are essential to the project of justly inferring anything about human stem cell biology from studies in non-human model systems—and so to the possibility of eventually developing human therapies based on stem cell biology. After introducing and discussing these questions, I conclude with a brief discussion of the creation of novel model systems in stem cell biology: human-to-animal embryonic chimeras. Such novel model systems may help to overcome obstacles to extrapolation, but they are also scientifically and ethically contentious. BioEssays 26:1005–1012, 2004. © 2004 Wiley Periodicals, Inc.

Figure 1. Two concepts of stem cells. On the left is the traditional view of stem cells, showing an irreversible loss of potency in maturing stem cells. On the right is an evolving view postulated by Blau et al. whereby stemness is a biological function that progressively degenerates over time but remains potentially recruitable within even differentiated cells in particular contexts. Redrawn with substantial modification from Fig. 7 in Blau HM, Brazelton TR, Weimann JM. 2001. The evolving concept of a stem cell: Entity or function? Cell 105:829–841, with permission of Elsevier.
The definition of ‘stem cell’ is essentially functional: “rather than referring to a discrete cellular entity, a stem cell most accurately refers to a biological function that can be induced in many distinct types of cells, even differentiated cells”
The simplest concept of stem cells

No specific marker for Stem cells

More molecular markers for progenitors
The simplest concept of stem cells

No specific marker for Stem cells

More molecular markers for progenitors
Cell lineage

The potency of stem cells

orthodox

Non-orthodox
Non-orthodox Cell lineage

ADULT STEM CELLS:
what did change in the last years?

1. Stem cells from tissues where cells do not usually divide, such as brain and heart, grown in vitro

2. Stem cells from one tissue, e.g., the bone marrow, have been shown to also produce differentiated cell types of embryologically unrelated tissues (skeletal & cardiac muscle, neurons & glia, liver, epithelia etc.)... But the story is quite controversial...
Figure 1. Schematic representation of the differentiation pathway of a committed hematopoietic stem cell that transdifferentiates to unexpected, nonhematopoietic tissues. This diagram depicts true stem cell plasticity.