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Embryonic Development of Stem Cells, its Evolution and Differentiation

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Abstract

Stem cells have been identified as a source of virtually all highly differentiated cells that are replenished during the lifetime of an animal. The critical balance between stem and differentiated cell populations is crucial for the long-term maintenance of functional tissue types. Stem cells maintain this balance by choosing one of several alternate fates: self-renewal, commitment to differentiate, and senescence or cell death. These characteristics comprise the core criteria by which these cells are usually defined. The self-renewal property is important, as it allows for extended production of the corresponding differentiated cells throughout the life span of the animal.

Key-Words: Differentiation, Embryonic, Stem cells Target

Introduction

Stem cells are generally defined as clonogenic cells capable of both self-renewal and multilineage differentiation (Metcalf and Moore, 1971). Stem cells can be divided into a long-term subset, capable of indefinite self-renewal, as well as a short-term subset that self-renews for a defined interval. The earliest stem cells in ontogeny are totipotent, extending from the zygote to the inner cell mass of the blastocyst; soon thereafter, totipotent stem cells give rise to somatic stem/progenitor cells and primitive germ line stem cell. Stem cells are not only units of biological organization, responsible for the development and the regeneration of tissue and organ systems, but also are units in evolution by natural selection. Stem cells give rise to non–self renewing oligolineage progenitors, which in turn give rise to progeny that are more restricted in their differentiating potential, and finally to functionally mature cells.

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Hematopoietic stem cell

Blood cell production is sustained throughout the lifetime of an individual by hematopoietic stem cells (HSCs). HSCs are defined by their ability to engraft bone marrow (BM) of irradiated hosts, self-renew, and differentiate into all types of mature blood cells (Akashi and Weissman, 2001). During postnatal life, the bone marrow supports both self-renewal and differentiation of HSCs in specialized microenvironmental niches (Arai *et al.*, 2004, Avecilla *et al.*, 2004) , whereas embryonic hematopoiesis is compartmentalized into anatomical sites where specific stages of hematopoietic development and different lineage outputs are manifest. The hematopoietic system originates from the mesodermal germ layer, which gives rise to the hemangioblast, a bipotential precursor for blood and endothelium (Choi *et al.*, 1998, Huber *et al.*, 2004). In murine embryos, commitment to the hematopoietic lineage is evident at embryonic days in the yolk sac, which first produces a transient population of primitive erythrocytes that express embryonic globins (Palis *et al.*, 1999). Shortly thereafter, the yolk sac gives rise to a second wave of progenitors that consists of single- and multilineage myeloerythroid progenitor cells. However, the yolk sac microenvironment does not support differentiation of definitive progenitors, which instead exit via the vitelline veins to the fetal liver rudiment, where definitive erythroid differentiation is initiated.

In avian embryos, de novo hematopoiesis occurs in an additional mesodermal appendage, the allantois (Caprioli *et al*., 1998 and Caprioli *et al*., 2001). In mice, the allantois forms the umbilical cord and the mesodermal components of the fetal placenta upon fusion with the chorion. The allantois develops from the epiblast during gastrulation and grows into the exocoelomic cavity as a mesodermal extension of the posterior primitive streak.

Conclusion & Summary

Hematopoietic stem cells (HSCs) develop during embryogenesis in a complex process that involves multiple anatomical sites. Once HSC precursors have been specified from mesoderm, they have to mature into functional HSCs and undergo self-renewing divisions to generate a pool of HSCs. During this process, developing HSCs migrate through various embryonic niches, which provide signals for their establishment and the conservation of their self-renewal ability. These processes have to be recapitulated to generate HSCs from embryonic stem cells. Elucidating the interactions between developing HSCs and their niches should facilitate the generation and expansion of HSCs in vitro to exploit their clinical potential.

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