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Commentary

Controlling and Modulation of Stem Cell Niche Regulations and their Involved in Interactions

Sehab Zakaria*

Department of Oncology, University of North Carolina at Chapel Hill, Chapel Hill, NC, USA

DESCRIPTION

Stem cell niches are specialized microenvironments that regulate the behavior and fate of stem cells in various tissues and organs. Stem cells are undifferentiated cells that can self-renew and differentiate into multiple cell types, depending on the signals they receive from their surroundings. Stem cell niches provide these signals, which can include cell-cell interactions, extracellular matrix components, growth factors, cytokines, oxygen tension, and physicochemical properties. Stem cell niches are essential for maintaining stem cell identity, quiescence, proliferation, differentiation, and survival. They also play a role in tissue homeostasis, regeneration, and aging. Stem cell niches have been identified and characterized in many systems, such as the hematopoietic system, the skin, the intestine, the brain, the testis, the ovary, the mammary gland, and the hair follicle. Each niche has its own specific features and mechanisms, but some common principles can be derived from comparative studies. For example, stem cell niches often consist of a core population of niche cells that directly contact and support stem cells, as well as a peripheral population of accessory cells that modulate the niche microenvironment. Niche cells can be derived from different lineages than stem cells, or from stem cell progeny. Niche cells can also secrete or present soluble or membrane-bound factors that activate or inhibit specific signaling pathways in stem cells. Some of the most important signaling pathways involved in stem cell niche regulation are Notch, Wnt, FGF, EGF, TGF-β, SCF, and chemokine.

Stem cell niches are dynamic and responsive to various stimuli, such as tissue injury, inflammation, infection, stress, hormones, and aging. These stimuli can alter the composition and function of the niche microenvironment, leading to changes in stem cell behavior and fate. For instance, tissue damage can induce niche cells to produce factors that stimulate stem cell activation and differentiation to repair the tissue. Inflammation can affect the balance between pro- and anti-inflammatory cytokines in the niche, influencing stem cell survival and function. Hormones can modulate the activity of niche cells and stem cells in a tissue-specific manner. Aging can impair the function and integrity of the niche microenvironment, resulting in reduced stem cell maintenance and regeneration capacity.

Stem cell niches are also involved in pathological conditions, such as cancer and degenerative diseases. Cancer stem cells are a subset of malignant cells that have stem-like properties and are responsible for tumor initiation, progression, metastasis, and resistance to therapy. Cancer stem cells can arise from normal stem cells or differentiated cells that acquire mutations that confer self-renewal and unlimited proliferation potential. Cancer stem cells can also hijack normal stem cell niches or create their own niches by recruiting or reprogramming other cells in the tumor microenvironment. These niches provide cancer stem cells with signals that promote their survival, growth, invasion, and evasion from immune surveillance and drug treatment. Degenerative diseases are characterized by progressive loss of tissue function due to impaired or exhausted stem cell activity. Degenerative diseases can be caused by genetic mutations or environmental factors that affect stem cell function or niche quality. For example, Alzheimer's disease is associated with reduced neurogenesis due to impaired neural stem cell function and niche factors in the brain. Stem cell niches are important targets for regenerative medicine and therapeutic interventions. Understanding the molecular and cellular mechanisms of stem cell niche regulation can provide insights into the biology of stem cells and their potential applications. Manipulating the niche microenvironment can enhance or inhibit stem cell function for therapeutic purposes. For example, stimulating niche factors can improve stem cell expansion and differentiation for transplantation or tissue engineering. Inhibiting niche factors can reduce cancer stem cell survival and resistance for anti-cancer therapy. Engineering artificial niches can mimic or recreate natural niches for studying or controlling stem cell behavior *in vitro* or *in vivo* . Stem cell niches are complex and diverse structures that orchestrate the fate and function of stem cells in various tissues and organs. Stem cell niches are essential for tissue development, maintenance, regeneration, and aging. Stem cell niches are also involved in

Correspondence to: Sehab Zakaria, Department of Oncology, University of North Carolina at Chapel Hill, Chapel Hill, NC, USA, E-mail: zakaria.seha@gmail.com

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disease pathogenesis and therapy. Stem cell niches pose many challenges and opportunities for research and application in the field of stem cell biology.