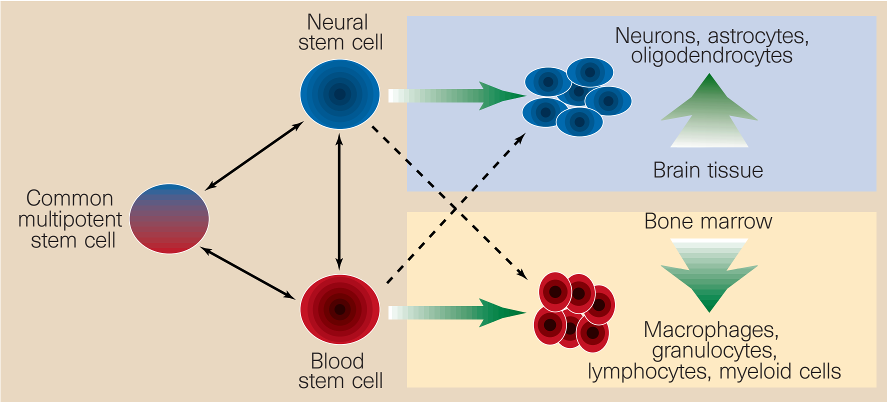

Figure 2 **Possible ways in which neural and blood stem cells could interact. Bjornson *et al.*[2] have found that neural stem cells may differentiate into blood tissues under the influence of environmental signals from the bone marrow (dotted line). Alternatively, they may transform into a blood stem cell, or even de-differentiate into a more primitive neural/blood stem cell first (double-headed arrows). Contact with the bone marrow is important because neural stem cells differentiated *in vitro* can only make neural tissue (even when given growth factors that induce differentiation of blood cells). Although not as well characterized, blood stem cells may also give rise to neural cells (astrocytes) when exposed to the brain environment.**

is, a full complement of cells with the appropriate architecture) after injury[8]. For this reason, their stem-cell status has been questioned[4].

One system in which stem cells are well established is the blood. Here, haematopoietic stem cells can regenerate all cellular components in irradiated animals[8]. Although the relationship between brain and blood is complex, it has long been recognized that the brain contains a phagocytic cell type called microglia, which arise either from the neuroepithelium or from the bone marrow[9]. During the life of an animal, many cells from the adult bone marrow may enter the brain and, although most of them make microglia, a small percentage may develop into astrocytes[10].

Now there is evidence of travel in the opposite direction. Bjornson *et al.*[2] generated neural stem cells from adult ROSA26 mice (which carry a specific cell marker), and isolated clones that gave rise to neurons, astrocytes and oligodendrocytes. Importantly, no blood cells were seen to arise from these cells *in vitro*. The authors then injected the clonal cultures into the tail veins of irradiated mice from another strain. Amazingly, 20 weeks later, both the blood and bone marrow from the grafted mice contained a range of blood cells derived from the transplanted neural stem-cell pool. How were these cells from the brain transformed into blood cells? The precursors from the central nervous system must have been able to respond to environmental cues in the irradiated marrow — they may either have reverted to a pluripotent phenotype, or have been induced to form blood cells directly (Fig. 2).

The findings of Johansson *et al.*[1] and Bjornson *et al.*[2] indicate that neural stem cells are much more plastic, and more widely spread throughout the adult central nervous system, than previously thought. The exact biological function of these cells remains to be clarified, but the old dogma that the adult brain cannot produce new neurons can now safely be rejected. Most of the neural stem cells lie dormant, waiting for an activating stimulus. Yet their ability to generate neurons and glia, and their presence in the central nervous system throughout life, suggests new, intriguing possibilities for recovery and repair after damage to the central nervous system — and, unexpectedly, the regeneration of blood tissues. We do not know whether human neural stem cells also arise from the ependymal layer, or whether they have the capacity to turn into blood. However, similar embryonic human cells can be cloned[11], grown for extended periods[12] and continue to reside in the adult brain[13], so it may not be long before we find out. □

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Daedalus

Space aeronautics

Any spacecraft has to propel itself by firing something in the opposite direction — combustion gases for a conventional rocket, a plasma stream for an ion engine, reflected sunlight for a solar sail. Daedalus likes the idea of a motor which acts on the tenuous gas in space itself. A conventional propeller, of course, could never be made big enough. But Daedalus recalls the Crookes radiometer, the little 'light mill' in a glass bulb, which spins in sunlight. The gas in its bulb has to be so rarefied that the mean free path exceeds the thickness of its vanes, making it an ideal engine for a low-pressure environment. In such attenuated conditions, a temperature difference across a vane, set up by sunlight shining on one side of it, drives the surrounding gas past it. Each molecule that hits the edge of a vane recoils with increased thermal energy, propelling the vane.

Even at normal orbital altitudes the mean free path is many metres. So any large object with a temperature difference from front to back should be propelled through space, cold end first, by the radiometer effect. The obvious design is a modified solar sail. Daedalus proposes a long plastic sheet, perhaps many square kilometres in area but only a few micrometres thick, with a surface coating graded continuously from dead black at the 'rear' to fully metallic at the 'front'. The blacker the surface, the more it would be heated by sunlight. A temperature gradient would be established along the length of the sheet, propelling it cold-end first by thrust from its whole vast area. Radiation-pressure would also act on the sheet, making it a combined radiometer craft and solar sail. Unlike a pure solar sail, it could be oriented (by a system of giant adjustable veins or rudders) to steer towards the Sun, the ideal direction for a solar-powered spacecraft.

For journeys away from the Sun, Daedalus will impregnate his radiometer craft with a graded distribution of radioactive material, to keep the rear always hotter than the front. As it slowly climbs away from the Sun in an outward spiral orbit, its solar propulsion will fade but its radioactive drive will keep going. In a mission lasting centuries, it could journey far into interstellar space. Its transmitters, powered by thermoelectric radioactive heating and aimed at the Earth by a huge parabolic section of its metallized film construction, would keep us informed of its findings.

David Jones