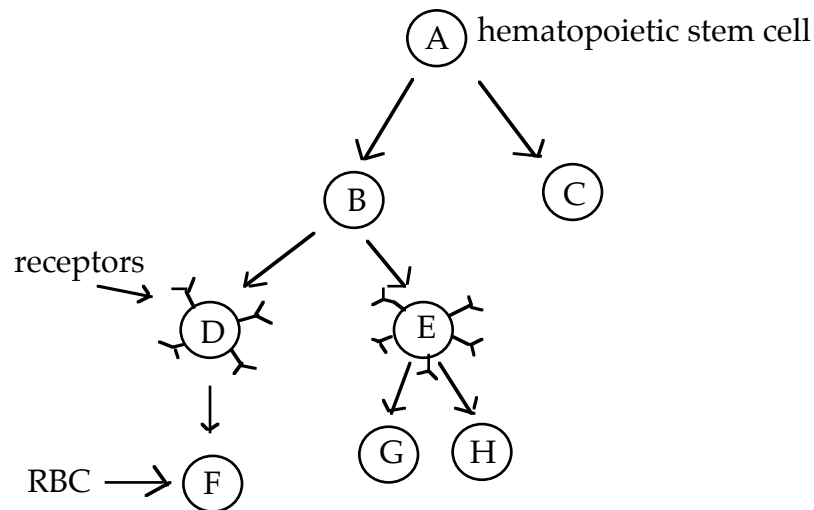


7.012 SECTION PROBLEM- STEM CELLS

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You are studying the differentiation of cells in the hematopoietic (blood-forming) system of humans. The hematopoietic stem cell gives rise to all the different blood cells in the circulatory system.

An abbreviated pathway of blood cell differentiation is shown below. Cells A, B, C, D, and E are stem cells. Cells F, G and H are terminally differentiated. "F" is a red blood cell.



a) What are two characteristics of a stem cell?

b) Is stem cell A a unipotent stem cell or a pluripotent stem cell? Explain briefly.

c) Cell differentiation can be in response to various external factors that stimulate cell differentiation. Red blood cell "F" has lost most of its cellular components, including its nucleus, during differentiation. Blood cell F is required for oxygen transport in humans.

The peptide hormone, erythropoietin (EPO), binds to a membrane receptor found on a cell that is a precursor to cell F.

i) Explain why F cannot divide to form more of itself.

ii) Which stem cell must EPO act on when production of cell F is required?

iii) What is the mechanism of action of EPO?

d) Is the cell that is a precursor to F a unipotent or a pluripotent stem cell?

e) If the precursor to F failed to produce membrane receptors for EPO, what would be the fate of cell D? Would this be a lethal mutation (lethal for the human being)?

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f) Some athletes train at high altitudes and then race or compete at low altitudes.

i) What happens to their blood composition at high altitudes?

ii) What is the advantage(s) of this strategy?

iii) What is the disadvantage(s) of this strategy?

7.012 Stem Cell Section

To determine the potency of several cell types (A, B, C, and D) that give rise to the kidney, adrenal glands ovaries or testes, you infect each cell type with a harmless retrovirus that incorporates itself randomly into the genome. This retrovirus can be used as a label to determine that future cells are derived from the original. You introduce these infected/labeled cells into embryos (one infected cell type per embryo), allow them to develop and then look for retroviral presence in the adult kidney, adrenal gland, and ovary or testes.

Embryos with the A cells --> in the animal you detect the virus only in the kidneys.

Embryos with the B cells--> in the animal you detect the virus only in the kidney.

Embryos with the C cells--> in the animal you detect the virus in all tissues tested
kidneys, ovary/testes, and the adrenal glands.

Embryos with the D cells --> in the animal you detect the virus only in the testes.

a) Based on this experiment, which of the four cell types have the characteristics of the most pluripotent cell and why?

b) Knowing that all four different cell types were types of stem cells, which ones could be described as unipotent stem cells and why?

c) Assuming the group of stem cells (A-D) could be assembled into a linear relationship in term of their origin, which one of the four types could be a precursor of the others?

d) Stem cells A and B give rise to kidneys. However, further testing has shown that these cells are not identical because they express different genes. What does it imply?

e) It has been found that inbred strains of mice with a certain mutation on the Y chromosome suffer infertility due to incomplete development of their D stem cells in the testes. However, a single injection of D stem cells seems to repopulate the testes and make mice at least partially fertile. Although human physiology and cell composition are almost identical to that of the mice, this form of therapy would not be easily replicated in humans. Explain briefly why.