CHAPTER 2

THE SCIENCE OF STEM CELLS

1 Stem cells are unspecialised cells. They are able to renew, proliferate or reproduce themselves. They are also able to specialise and differentiate into other types of cells with specialised functions.

2 The three widely recognised types of human stem cells are embryonic stem cells ('ES cells'), embryonic germ cells ('EG cells') and adult stem cells ('AS cells').

3 ES cells originate from early human embryos. The potential sources of ES cells are:

(a) human embryos created by *in vitro* fertilisation ('IVF') for assisted reproduction or fertility treatments and subsequently not used or needed for treatment which are donated for research. These are commonly referred to as 'surplus' or 'spare' embryos;

(b) ES cell lines which are propagated serially from ES cells derived from human embryos;

(c) human embryos that are created by IVF with gametes donated for the sole purpose of providing research material. These are commonly referred to as 'research embryos'; and

(d) human embryos[1] created for research by the application of cloning technology[2], such as somatic cell nuclear transfer ('SCNT')[3]. These are also commonly referred to as 'research embryos'.

[1] The use of the word "embryo" in this case is a further extension of the use of the word which now encompasses post-fertilisation products prior to differentiation of placental from foetal products: later products of development where the early foetal structures are already visible, and this new class of cells derived from cloning technology which are not products of gametic fusion.

[2] The process is also commonly known as 'therapeutic cloning'. See also Chapter 3.

[3] In SCNT, the nucleus of an adult human cell is introduced into an enucleated human ovum.

4 EG cells originate from the primordial reproductive cells of the developing foetuses and may be sourced from cadaveric foetuses.

5 AS cells are found in certain adult tissues, including the bone marrow, brain, skin, intestine and from blood cells of the umbilical cord at time of birth.

6 The ability to specialise into other types of cells differ among ES cells, EG cells and AS cells. ES cells appear to be widely pluripotent, retaining the best potential to develop into nearly any cell type, followed in descending order by EG cells and AS cells. Moreover, ES cells appear highly proliferative, both in the embryo as well as in culture, while AS cells appear nearly quiescent and may be more difficult to maintain and expand in culture. These are important biological differences between ES cells, EG cells and AS cells which impact research. ES cells appear to be the most fundamental and extraordinary of the human stem cells, with the highest research potential.

7 Human stem cell research, especially with ES cells, holds the promise for tremendous benefits to mankind in the major areas of treatment and therapy, and in the study of human developmental biology. In treatment and therapy, there is potential for ES cells to be used to generate specialised cells, tissues and organs, and to treat injury or disease including burns, muscular degeneration, cancer, immunodeficiencies, inherited blood diseases, osteoarthritis, spinal cord injury, diabetes, heart failure, liver failure, kidney failure, Alzheimer's disease, Parkinson's disease, multiple sclerosis, and other neurodegenerative diseases.

8 A five day old embryo, more properly called a blastocyst, consists of a mass of cells. Any particular cell is as likely to become part of the placenta, which is discarded at birth, as to become part of the new life. In the first 14 days, the cells of the embryo have not yet differentiated into tissues. The 'primitive streak' appears around the fourteenth day and develops into the nervous system. From the fourteenth day onwards, the embryo develops other tissues and organs and has the potential to develop into a foetus.

9 As stated above, ES cell lines originate from ES cells drawn from early human embryos. In collaboration with researchers from Australia and Israel, Singapore has successfully developed six ES cell lines for research. These originate from ES cells from five-day old frozen embryos, in excess of clinical application, and donated with informed consent of the donors for research. These original ES cells have been serially propagated, to date, at least 200 times. However, there appear to be concerns that cells from ES cell lines alone may not be adequate when it comes to clinical application, in view of problems such as immunological rejection.

10 Research into human stem cells is in its early stage. Nonetheless, its potential is well acknowledged locally and internationally.