Stem cells - Everything you need to know

Introduction

Purpose and objective

The purpose of this web site is to find out the awareness of the population on stem cells and to serve as a one-stop web site for anything related to stem cells. We hope that the survey finding will help to generate some buzzes among the audience and also help to dispel some misplaced hope or myths surrounding stem cells.

To reach a wider audience outside Asia, we have recruited a student from New Zealand to participate in interviews as well as to conduct some surveys. We also interviewed a few prominent scientists including Emeritus Professor Paul Berg, Nobel Prize Winner for Chemistry 1980 from Stanford University on his views on stem cell research.

Audience and aims

- The students/youths in the hope of generating more debates and hopefully interest in stem cells and stem cell research
- The working population and the married couples in the hope of promoting storage of cord blood or other sources of stem cells for future use. We aim to reach those especially outside the scientific community
- The middle age and above in the hope of offering some hope for them to look beyond a fragile and sickly old age in that stem cells may one day bring back their youth..

Background

What is stem cell?

- Stem cells - hail as one of the most important discoveries of the twenty first century have generated much hope as well as hype. What actually are stem cells?
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- Stem cells are the basic building blocks from which all other kinds of specialized cells in the living things are derived. There are potentially many sources of stem cells. Theoretically, stem cells also have the potential to have vast therapeutic uses in the foreseeable future.

A – Z of stem cells

A Adult stem cell: An undifferentiated cell found in a tissue or organ, that renew itself, and can differentiate to replenish dying cells and repaired damaged ones.

B Blastocyst: A ball of cells in early embryonic development with an inner cell mass enclosed by an outer layers of cells.

C Cryopreservation: a process where cells or whole tissues are preserved by cooling to low sub-zero temperatures, such as (typically) 77 K or −196 °C (the boiling point of liquid nitrogen) to save them for future use.

D DNA: Deoxyribonucleic acid is a chemical found primarily in the nucleus of cells. It contains the genetic instructions for carrying out life processes.

E Embryonic stem cells: Primitive cells from the embryo that have the potential to become a wide variety of specialized cell types.

Embryonic stem cell line: Embryonic stem cells that have been cultured under in vitro (in the lab) conditions. It is constantly-proliferating without differentiation. It can do so almost indefinitely.

F Fibroblast: A type of cell that synthesizes and maintains the extracellular matrix of many animal tissues. Fibroblasts provide a structural framework (stroma) for many tissues. Human ES cells are grown on a feeder layer of mouse embryonic fibroblasts (MEFs).

G Gene: A functional unit of inheritance located in a specific site on a chromosome. It directs the formation of an enzyme or other protein.

Genome: All the hereditary or genetic information of an organism which is encoded in its DNA.

H Hematopoietic stem cells (HSCs) are stem cells that form blood and immune cells such as myeloid and lymphoid cells. They have multipotent, oligopotent, and unipotent progenitors.

I Inner cell mass: The cluster of cells inside the blastocyst. These cells give rise to embryo and, ultimately, the fetus. They are commonly used to generate embryonic stem cells

J Jurisprudece: The study or application of the principles of law and justice as they relate to the practice of medicine and the relations of physicians to each other and to society in general especially in the case of stem cells research

K Karyotype : The chromosomal constitution of the nucleus of a cell.

L Long-term self-renewal: The ability of stem cells to renew themselves by dividing into the same non specialized cell type over long periods (many months to years) depending on the specific type of stem cell.

M Multipotent: Stem cells that can develop into more than one cell type in the body. They reproduce only limited cells and tissues and are found in the marrow of adult humans.

N Neural stem cell—A stem cell found in adult neural tissue that can give rise to neurons and glial (supporting) cells.

N Neurons: Nerve cells, the structural and functional unit of the nervous system. A neuron consists of a cell body and its processes, an axon, and one or more dendrites. Neurons function by the initiation and conduction of impulses and transmit impulses to other neurons or cells by releasing neurotransmitters at synapses.

O Oligodendrocyte:A supporting cell that provides insulation to nerve cells by forming a myelin sheath (a fatty layer) around axons.

P Pluripotent: Stem cells that are able to give rise to every cell types and hence tissue in the body, except the placenta. These are the cells of highest interest to stem cell researchers for they have the highest potential in medical research and therapeutics.

R Reproductive Cloning: It is the process of creating an animal that is identical to the animal that donated the somatic cell nucleus. The embryo is implanted in a uterus and develops into a live being. The first animal to be created by reproductive cloning was Dolly the sheep, born at the Roslin Institute in Scotland in 1996.

S Somatic cell nuclear transfer: A technique that combines an enucleated egg (nucleus removed) and the nucleus of a somatic cell (any body cells other than the gametes) to make an embryo. The cytoplasm within the egg then turns on the DNA in the nucleus so that cell division occurs resulting in the formation of totipotent stem cells that soon specialize into pluripotent, and then, within two weeks, multipotent stem cells.

Stem cell: Unspecialized cells with the ability to divide for long periods through cell division. Under certain optimal conditions, they can be induced to become specialised cells such as myocytes. They are the basis of every cell and tissue in the body.

T Totipotent: Stem cells that can give rise to every cell types and tissue in the body, including the placenta. The first four of five divisions of the cell after somatic cell nuclear transfer result in totipotent stem cells. Identical twinning occurs at this stage.

U Undifferentiated cell: A cell that has not yet generated structures or manufactured proteins characteristic of a specialized cell type.

V Virus One of the group of infectious agent not resolved in the light microscope, characterised by the lack of independent metabolism and are able to replicate only within the living host cells

W Wiskott-Aldrich Syndrome An immunodeficiency that is by eczema, thrombocytopenia (low platelet counts), immune deficiency, and bloody diarrhea (due to the low platelet counts). It can potentially be treated by stem cell therapy.

X X linked Lymphoproliferative Disease (XLP) One of the immunodeficiency diseases where patients can come down with severe glandular fever, lymphoma or severe frequent infections that can potentially be treated by stem cell therapy.

Y Yoke: The stored nutrient of the ovum.

Z Zygote: The cell resulting from union of a male and female gamete, until it divides.

The discoveries

1978

Hematopoietic stem cells (HSC) which are self-generating and can form multiple cell types are discovered in cord blood.

1981

Gail Martin at the University of California, San Francisco and researchers Martin Evans and M.H. Kaufman at the University of Cambridge successfully isolate and culture pluripotent ES cells from the inner cell masses of mouse blastocysts. Martin eventually coined the term "embryonic stem cells."

1988

• Biologist James Thomson of the University of Wisconsin-Madison reports in the journal *Science* the first successful isolation and culturing of human stem Cells..

Embryonic stem cells.

• The first successful cord blood stem cell transplant is done on a young boy with Fanconi's anaemia (a rare genetic disease). Since the boy's relatives are not a positive match for a bone marrow transplant, he receives cord blood from his healthy sister.

1990
Britain Human Fertilization and Embryology Act is passed. This allows creation of embryos for research limited to the study of infertility and to improve the techniques of in vitro fertilization.

1991
Natalie Curry, a young girl suffering from a rare blood disorder, has cord blood successfully transplanted to her from the umbilical cord of her infant sister Emily that contains stem cells.

1993
President Bill Clinton signs the NIH Revitalization Act of 1993 (fetal tissue transplant research). At the same time, he created the NIH Human Embryo Research Panel to study the ethics of fetal and embryonic research. The twenty-year moratorium on fetal tissue transplant was lifted.

1994
September: NIH Human Embryo Research Panel advises President Clinton that government-funded studies on human embryos should be allowed, and in some cases, embryos should be created specifically for research purposes.

1995
• For the first time, University of Wisconsin scientists successfully isolate embryonic stem cells from a non-human- a primate--rhesus monkeys.

• President Clinton signs the Dickey Amendment into law. The legislation prohibits all federal funding for research that results in the destruction of an embryo, regardless of the source of that embryo. It prohibits the creation of embryos for research purposes.

1996
Dolly the sheep the first mammal is cloned using somatic nuclear transfer technique by Ian Wilmut, Roslin Institute from a six year old ewe's udder.

1997
Scientists discover leukemia originates from a hematopoietic stem cell, the first direct evidence for cancer stem cells. Cumulina the first cloned mouse is cloned using a technique similar to the one that produced Dolly.

1998
• James Thomson isolates cells from the inner cell mass of the early embryo from "leftovers" of fertilization clinic, developing the first human embryonic stem cell lines.

• John Gearhart of Johns Hopkins University derives human embryonic germ cells from

cells in fetal gonadal tissue (primordial germ cells) from aborted fetuses.. They become the first scientists to succeed in deriving and maintaining these powerful pluripotent stem cells.

1999
• Researchers at Johns Hopkins University coax adult stem cells from bone marrow to develop into cartilage, fat and bone cells *in vitro*.

• The journal *Science* names stem cell research its breakthrough of the year.

2000
August: The National Institutes of Health (NIH) announces new guidelines paving the way for federal funding of stem cell research. The guidelines prohibit federal researchers from destroying embryos to obtain stem cells, but allow researchers to conduct research on cells taken from embryos previously destroyed by privately-funded sources.

September: A Colorado couple creates a genetically screened test-tube baby with the hope that the baby could save the life of his sister Molly. Molly Nash suffered from a rare genetic disease, Fanconi anemia, that prevented her body from creating bone marrow. The baby was born on August 29, and the transplant using umbilical cord blood cells took place on September 26.

2001
August 9: President Bush announces that federal funding for stem cell research will only be permitted using the existing 64 stem cell lines. Bush also creates a President's Council to evaluate and monitor stem cell research.

November: Scientists with Advanced Cell Technology claim to have cloned the first early human embryos for the sole purpose of generating embryonic stem cells. However, the evidence to support their claim is unsubstantiated.

2002
July 10: The President's Council on Bioethics recommends a permanent ban on reproductive cloning. The Council was split on the issue of therapeutic cloning. Ten members recommended a four-year moratorium on therapeutic cloning, which would allow for further review of the issue, while seven members were in favor of therapeutic cloning as long as regulations were in place.

December 11: Stanford University announces it will use somatic nuclear transfer technology to develop a new series of stem cell lines. Although this research is prohibited under federal funding, an anonymous donor will invest $12 million in the research program.

2003
• Dr. Songtao Shi of the National Institutes of Health discovers adult stem cells in children's baby teeth.

February: The U.S. House of Representatives passes the Human Cloning Prohibition Act banning both reproductive and therapeutic cloning.

April: The International Human Genome Sequencing Consortium announces the completion of the Human Genome Project--the sequencing of the human genome.

2004
February: Woo Suk Hwang, of Seoul National University in Korea, claimed to be the first to successfully clone a human embryo, and then harvest the stem cells for research. The research is later found to have been fabricated.

March: The President's Council on Bioethics recommends a ban on reproductive cloning but supports stem cell research on embryos 14 days old and younger.

May: Britain opens up the world's first government-financed stem cell bank containing embryonic and stem cell lines.

November 2: California passes legislation and become the first state in US to fund stem cell research.

2005
February: South Korean team headed by Woo Suk Hwang and Moon of report their creation of 11 new stem cell lines. This is also a fabricated research.

December: President Bush signs the Stem Cell and Therapeutic Research Act of 2005. The legislation creates a federal program to collect and store cord blood. It also created a national registry program to match cord blood for those in need.

2006
January: Experts from Seoul National University announce that Woo Suk Hwang's 2004 and 2005 research results are fraudulent. The journal *Science* withdraws both of Hwang's papers. Hwang resigns from the university and faces criminal investigation.

July 19: President Bush exercises his first presidential veto against legislation expanding federal funding for stem cell research.

August: The Advanced Cell Technology Company reports successfully removing a cell from a human embryo and extracting stem cell lines, without harming the embryo. However, their assertion of not harming the embryo is later disproved.

November 7: Voters in the state of Missouri pass Amendment 2 which allows any stem cell research and therapy allowed under federal law, but prohibits human reproductive cloning.

2007
Gene Targeting Garners Nobel Prize

January: Dr. Anthony Atala and other researchers at Wake Forest University discover stem cells in amniotic fluid. The discovery could provide an alternative to embryonic stem cells in research and therapy.

June 20: President Bush vetoes legislation lessening restrictions on federal funding for stem cell research.

October: Martin Evans, Mario Capecchi and Oliver Smithies win the 2007 Nobel Prize in Medicine and Physiology for their work that enabled the creation of genetically engineered mice. In using embryonic stem cells to introduce specific genetic modifications, their work changed the way scientists study human disease by allowing them to study the functions of individual genes and test new experimental therapies.

November: Shoukhrat Mitalipov of Oregon Health and Science University in Portland and his team create cloned primate embryos and uses them to make embryonic stem cells. The achievement leads to speculation that the breakthrough might allow the same to be done with human embryos.

November: Two teams of scientists announce they have genetically reprogrammed skin cells so that they take on the traits of embryonic stem cells. The discovery allows scientists to conduct stem cell research without the ethical implications of using embryonic cells.

2008
Researchers from Stemagen in United States claims to be the first to grow cloned embryonic cells using the skin cells of two men to the blastocyst stage, but fail to go to the next step of harvesting stem cells from it.

The Race Continues.....

Various sources of stem cells:

- Adult stem cells
- Early embryonic stem cells
- Fetal stem cells
- Umbilical cord stem cells
- Blastocyst embryonic stem cells

Harvesting of stem cells:

Stem cells are harvested mainly from haematopoietic tissues namely peripheral blood, bone marrow and umbilical cord. The last is one of the richish sources of stem cells.

The umbilical cord blood is harvested immediately after birth of the child and must be preserved immediately.

Storage of stem cells:

Stem cells are stored cryogenically and theoretically can be stored indefinitely. They have been successfully transplanted after 15 years of storage.

The oldest cord blood stored to date is around 20 years. It remains to be seen whether they will degenerate over time

Survey

The survey and its findings

The survey was conducted over a period of three weeks from 15th December 2007 to 7th January 2008 and from 25th January 2008 to 15th February 2008 in Singapore and New Zealand respectively. The sample size is larger in Singapore than that of New Zealand as the number of students involved in the project is mainly from Singapore.

The survey questionnaires

Early in December 2007, the group met and brainstormed for the survey questionnaires. There were all together three revisions before we finally agreed on the questions. We also tried to localise the questionnaires to Singapore and New Zealand.

Survey Questions

We are a group of Secondary 2 students from Raffles Institution. Conducting a survey regarding our topic is an essential part of our research education project. We hope that you will take just a few moments to answer the following survey questions about stem cell implantation. We appreciate your help very much.

Age: 10-2☐ 21-☐5 36☐0 50-☐der	**Sex:**
Involved in medical field:	Yes ☐ No ☐

	Questions	Strongly Agree	Agree	Disagree	Strongly Disagree
	Awareness/ Knowledge				
1	I know what stem cell is.	☐	☐	☐	☐
2	I read recent articles about breakthroughs in stem cell research.	☐	☐	☐	☐
3	I am familiar with the various impacts that will result from stem cell research.	☐	☐	☐	☐
4	I am aware of the potential benefits and uses of stem cell research.	☐	☐	☐	☐
5	I have heard of alternative sources of stem cell besides embryo/ cord blood.	☐	☐	☐	☐

	Questions	Strongly Agree	Agree	Disagree	Strongly Disagree
	Public opinion on stem cell research				
6	I support the idea of a stem cell research?	☐	☐	☐	☐
7	Singapore should be involved in the stem sell research from embryo	☐	☐	☐	☐

	Questions	Strongly Agree	Agree	Disagree	Strongly Disagree
	Controversy				
8	I am aware of the controversy regarding the topic of stem cell transplantation for the last few years	☐	☐	☐	☐
9	Stem cell research is ethical.	☐	☐	☐	☐
10	The future of mankind is bright if stem cell research conducted is successful.	☐	☐	☐	☐
11	I agree that scientist should harvest stem cell from embryo or aborted foetus.	☐	☐	☐	☐

	Questions	Strongly Agree	Agree	Disagree	Strongly Disagree
	Own opinion				
12	I will store cord blood of my future children.	☐	☐	☐	☐
13	I am willing to pay for	☐	☐	☐	☐

	cryopreservation of stem cell from cord blood.				

The survey population

We decided to survey the age group from 10 years and above. We targeted students, housewives, and working adults. Students attending secondary schools and Ngee Ann Polytechnic were targeted. Housewives and working adults attending a clinic were targeted randomly over the next three weeks

The survey analysis and findings

The survey results were analysed using SPSS, and Excel from 8th January 2008 to 28th February 2008. Linear co-relation and simple cross relational analysis were carried out. The group also tried to look at certain aspect of qualitative analysis and responses from those surveyed.

Survey population demographics for Singapore:

It is interesting to note that 84% of our respondents are female and 16% are male. The majority of the respondents is in the age group 0 - 20. The sample population is also large enough for the result to be useful. There is no drop-out from the respondents in that all of them answered all the 13 questions. This is because the target survey population is mainly students and working adults.

The survey demographics according to age:

Most of our survey population are teenagers under the category, between 0 – 20 years old. Their views are widely valued as they are the leaders of tomorrow.

The survey demographics according to sex:

In every age group, the females make up most of our survey population. This arises as the survey was conducted among families attending a general practitioner clinic and nursing students. These are mostly females. Females play an important part in the survey especially on the topics of the donation of embryos and the cryopreservation of embryos.

Involved in medical field or not:

Slightly more than 50% of our survey population is not in the medical related field. This is useful as we are able to gather the views of both medical related and non-medical related respondents. There is less bias and adds credibility and validity to our survey.

Knowledge of stem cell:

Only 10% of the survey audience totally knows about stem cells. 56% of the respondents have an idea of stem cells. 33% of the population does not know what stem cell is. 1% of the people does not have any idea of what stem cells is. This shows that there is a big knowledge gap, hence there is a need for educating the public about stem cell.

Read articles on stem cells:

Most of the survey population(approx. 75%) do not read articles on stem cells. The minority avidly reads articles on stem cells. This result shows that we should inculcate or encourage the public to read about stem cell. It may be good to find out why they do not want to read articles on stem cell.

Familiar with impacts of stem cell:

73% of the people are not familiar with the impacts of stem cell research. It is surprising that even though more than 50% of our respondents are in medical field, two-third claim to know

what is stem cell, yet three-quarter are not familiar with its impacts. Therefore, it is very important to tell people what stem cells can do for us.

Aware of stem cell benefits:

Most of our survey population (61%) are not aware about the benefits and uses of stem cells. This is because most of our survey population does not reading articles about stem cells. Even though 50% is in medical field, the level of ignorance is indeed alarming. Hence, it is vital to educate the public more about stem cells.

Know the sources of stem cell:

A large number of our survey population (58%) does not know where the stem cells come from. It will be difficult to make an informed decision when it comes to donating or obtaining stem cells for research or therapeutic purposes if they do not know the sources of stem cell.

Support stem cell research:

The majority of the survey population (69%) supports stem cell research. These people are most likely aware of what the future of stem cell can offer them. Hence, supporting stem cell research. The latter does not support stem cell research. This might be because they do not want to offer any financial support to fund stem cell research. They may also find stem cell transplantation not ethical and therefore, do not want to support stem cells research.

Support stem cell research in Singapore:

Even more people (78%) believes that Singapore should be involved in stem cell research. From the analysis, we can see that although more than half does not know enough about stem cell yet most support its research.

Aware of controversies in stem cell research:

50% of the survey population are not aware about the controversies in stem cell transplantation. When we look deeper, the people who are not aware come from those in medical related field as well. This is not unexpected as most respondent do not read widely on stem cell.

Stem cell research is ethical:

59% of our survey population agree that stem cell research is ethical. The minority believes that stem cell research is not ethical. Some might think it is ethical as it does not affect them in the short or long run. Others think that it is not ethical as this might need embryonic stem cells for their research and they do not want this to happen.

Future of mankind is bright with stem cell research:

Most of our survey population agree that the future is bright with stem cell research. They may think that in the future, diseases could be cured and that stem cell can be a solution to almost all the problems in the world.

Scientists should harvest stem cell from embryo:

60% support harvesting stem cell from embryo. This is surprising as there is a strong resistance among the scientific community against harvesting stem cell from embryo. This may be the result of ignorance.

Will store cord blood:

Close to 50% of the respondents want to store cord blood. This shows that more than half of our survey population is open minded and it is fine with them to store cord blood.

Will pay for cord blood storage:

More than 50% of the survey population do not want to pay for cryopreservation of cord blood. When we analyze deeper, people who want to store cord blood, refuse to pay for its preservation. Hence, a national world cord/stem cell blood bank may be the way forward.

New Zealand Survey Findings

We managed to interview 37 participants from New Zealand. The respondents' demographics are evenly distributed with females making up 51 % of the survey population. Most of the respondents are not involved in medical fields. The results are as followed:

More than 80% of the respondents are above 20 years old with the majority between 36-50 age ranges.

Awareness/Knowledge

1. 84% knows what is stem cell and up to 47% does not read articles on stem cell.
2. 46% is not familiar with the impact that will result from stem cell research and 27% is not aware of the potential benefits of stem cell research.
3. 47% of the respondents are not aware of alternative sources of stem cell besides embryo or cord blood.

Opinions on Stem Cell Research

1. 76% support stem cell research but only 56% supports it being carried out in New Zealand.
2. Only 19% are not aware of the controversies surrounding stem cell research while 53% thinks that stem cell research is ethical.
3. 60% agrees that the future of stem cell research is bright and 32% agrees that scientist should harvest stem cell from embryo or aborted foetus.

Opinion of Stem Cell Storage

- 35% will store cord blood of future children and 73% will not pay for its storage.

Comparative Analysis Between New Zealand and Singapore

Population Demographics

1. In Singapore the survey population is younger mostly between 10-20 yrs old while in N.Z. majority is between 36-50 yrs old.
2. A high proportion of the survey population is female (84%) in Singapore vs 51% in N.Z. About half of the respondents in Singapore is involved in medical field while only one respondent in N.Z. is.

Awareness/Knowledge

1. In Singapore, more respondents (34%) vs 16% do not know what stem cell is. A much higher proportion (75%) is not interest to read articles on stem cell compared to 49% in N.Z.
2. Similarly a much higher proportion of Singaporean respondent is not aware of the potential impacts (73% vs 46%), benefits, uses (61% vs 27%) and alternative sources of stem cell (58% vs 47%) compared to its N.Z counterparts.

Opinions on Stem Cell Research

1. Both countries offer strong support for stem cell research with 89% in Singapore and 76% in N.Z. However, there is a slight drop in support when it comes to supporting stem cell research in their own countries respectively (78% vs 51%).
2. Only a small percentage is not aware of the controversies surrounding stem cell research in N.Z. (19%) vs 50% in Singapore. 59% agrees that stem cell research is ethical in Singapore vs 53% in N.Z.
3. The survey population is more guarded and less optimistic in N.Z. when it comes to the future of stem cell research. A much smaller percentage (32%)agrees with harvesting stem cell form embryo or aborted foetus vs 60% in Singapore.

4. 50% of Singaporean surveyed will store and pay for cord blood storage whilde only 35% New Zealander will do so. Even more (73%) will not pay for its storage.

Survey Conclusions and Recommendations

1. It is most interesting to note that in Singapore although the survey population is much younger with a sizeable proportion in medical related field; there is a higher proportion of ignorance in the areas of knowledge and awareness of stem cell research as well as the controversies surrounding it.

2. However, though less knowledgeable, the support for stem cell research is much higher in Singapore than in N.Z. with a much higher proportion supporting harvesting stem cell from embryo or aborted foetus. This is perhaps being younger; they are more open to changes and acceptance of new challenges.

3. The younger Singaporean is also more willing to store and to pay for cord blood cryopreservation.

4. In both countries, almost the same proportion (more than 50%) is not aware of the alternative sources of stem cell. More than three quarters support stem cell research and a similar proportion (more than 50%) agrees that it is ethical. The level of interest in stem cell research is also alarming low in both countries.

RECOMMENDATIONS

1. Expose the young to stem cell through various innovative means of media to increase awareness.
2. Stem cell to be incorporated into mainstream education as part of science curriculum.
3. Education especially on the ethnics and alternative sources of stem cell targeting the young is vital.
4. Send a clear message to all that stem cell research is done with great care and the greatest respect for human lives.
5. More studies to be done to find out why the young and even those involved in medical field is not interested in stem cell research.
6. A World Stem Cell Bank may be the way forward for all to share and to accelerate research in stem cell.

Interview

Interview Questions

1. Tell us how you first got interested in stem cell research?

2. Where are your main sources of stem cell?

3. How long have you been researching on stem cells?

4. In general, tell us your findings.

5. How do you foresee the eventual applications of stem cell into our day to day lives? Are we very near to such breakthrough in the foreseeable future? (Or is it just in theories only).

6. What are the future possible applications of stem cells beside disease management and treatment?

7. What are the impacts of stem cells research on the various fronts:
    Economically-can it generate lots of jobs and wealth?
    Politically – global stand where are we heading to
    Ethically – will stem cell from aborted fetus or embryos ever be approved?
    Medicine and Human race.

8. Finally, tell us something about your journey into stem cell research. What are the obstacles you faced and any triumphs and joys along the way?

9. In the future, what do you think you will research on?

Interview with Dr Lim Sai Kiang

Dr Lim Sai Kiang is theGroup Leader,Biological Investigations, Genome Institute of Singapore . Her main interest is on the use of embryonic stem cells (ESCs) to repair tissue damage in diseases especially in the regeneration of damaged cartilage.

Her team has in the past researched into ESC with potential of differentiating into hepatocytes and insulin producing cells.

Interview with Dr Udolph Gerard

Dr Udolph Gerard is a principal investigator in Helios. Presently his main interest is in finding out the basic biology of adult stem cells and their potential use in regenerative medicine especially in neurodegenerative diseases like Parkinson's disease (PD).

The potential application of the studies have great implications for an aging society like Singapore.

Interview with Dr Ng Huck Hui

Dr Ng Huck Hui is working in A* Star 's Genome Institute of Singapore.

He and his team searches for the "targets of transcriptor factors proteins that control gene expression in embryonid stem cell

Interview with Dr Robert Zweigerdt

Dr Robert Zweigerdt is from A*Star Genome institute.

He works mainly on cardiomyocytes from embryonic stem cell and especially in the area of cardiac heart muscle repair.

Interview Extracts with Dr. Ng Huck Hui

1. Tell us how you got interested in stem cell research.
    - Previously working on budding yeast
    - Not many people working on ESCs at that time

2. What are your main sources of stem cells?
    - Mouse ESC
    - Some human ESCs from legal commercial sources
    - IVF treatment donations

3. How long have you been working on stem cells?
    - 5 years

4. In general, tell us your findings.
    - Cells use DNA as template to produce RNA which produces proteins
    - If a stem cell cannot undergo cell division, it will differentiate.
    - Mouse is a good for testing as the transcription factors are quite similar
    - Trying to understand what maintains the stem cells
    - Trying to convert a non-stem cell into a stem cell

5. Are we near to a breakthrough whereby stem cells can be used as a treatment method in hospitals?
    - Some have already made it
    - Others still many years, but possible

6. What are the future applications of stem cells besides disease management and treatment?
    - Cell replacement for skin loss, cartilage, some malfunction
    - 'Restore functions of damaged/lost cells

7. What are the economic/ethical impacts?
    - Intellectual product used as a money spinner
    - Stem cells acts like drugs
    - ESCs from embryos are unethical to many based on moral and religious grounds.
    - To Dr. Ng, it is ethical if it is not obtained by unorthodox means
    - Cloning humans and destroying embryos are unethical
    - Many people associate stem cells with destroying embryos and cloning humans when there are actually thousands of other stem cell methods

8. Share your journey as a stem cell researcher.
    - Obstacles
        - Understand nature of stem cells, how they are maintained, etc.
        - Have to start from scratch as Singapore does not have a long history of research
    - Dr. Ng had always been interested in science (Since Sec 2)
    - Failure rate = very high
    - Mostly see negative things, but occasionally see positive things
    - Discovery motivates and drives him
    - It can never be boring, and it can only be boring when creativity is not present

9. What will you research on next?
    - Reprogramming
        - Changing differentiated cells into ESCs which are more versatile

<u>Problems:</u>

- Immune Rejection
    - Solved by using your own cells
    - Solved by suppression
- Tumours
    - Differentiate the cells so they won't divide so much

<u>Extras:</u>

- Nobel prize last year awarded to the discovery of Mouse ESC

Meeting **Professor Alan Colman**

Professor Alan Colman -the "Dolly" creator, was the first in the world to clone a sheep. Even after cloning of Dolly, he still pursues research relentlessly. He is an inspiration to many stem cell scientists out there who are tirelessly researching on the many faces of stem cells. Interestingly, he is a fan of Manchester United. I guess the reasons being that he was born there and that team is always winning matches. Currently he is working in Singapore. We are indeed privileged to meet him. Although the meeting was brief, we are all deeply inspired by him. Though he is world renowned, he carries no air and is most willing to meet us.

Interview Reflections

1st interview with Dr. Lim on 10th January 2008

My first impression of a professor with a PhD degree under her belt was that she would be arrogant and snobbish. However, I was proven wrong. Dr. Lim welcomed us with open arms and invited us into the meeting room, where we took our seats and introduced ourselves.

Following that, she gave us a detailed tour of the entire office as well as the laboratories itself, which were actually prohibited areas. Dr. Lim then introduced us to her fellow colleagues who joined us in the interview. Among them, we were fortunate to meet the man who succeeded in cloning Dolly the sheep, Dr. Alan Colman in person. It was an extremely rare opportunity and I strongly believe that he is a inspiration to all those who are currently tirelessly researching in stem cells.

We proceeded with our interview, not only with Dr. Lim herself, but also two of her other colleagues. She always gave very insightful responses and often asked her colleagues to share their opinions with us. After an enriching two hour interview, we left with our minds crammed to the brim.

From the interview, I realized that these researchers all have a very determined nature as they would courageously pursue their interest, regardless of their challenges. When asked how they decided to enter the field of stem cells initially, Dr. Lim and her colleagues replied in similar ways. That is, they are just intrigued by the many mysteries and unknown boundaries surrounding stem cells. Besides being better informed about stem cells, our group managed to learn some values which are essential in our character development in the future.

In a nutshell, Dr. Lim has definitely changed my opinion of professors and certainly imparted to us knowledge which we could not possibly have access to through the internet. With all this said, I thank Dr. Lim, for her time and effort.

2nd interview with Dr. Ng on 17th January 2008

One week had passed since our first interview with Dr. Lim. I have to admit that my previous experienced boosted my confidence a great deal. Therefore, with much more poise, our group met Dr. Ng, also an expert in the field of stem cells.

Dr. Ng started by giving us a very brief tour of the research laboratories and led us into the meeting room. Without further ado, we bombarded him with numerous questions and he answered them brilliantly. Dr. Ng gave us an idea of his current research and their achievements.

Though Dr. Ng' explanations were not as detailed as Dr. Lim's, he nevertheless provided valuable information that we cherished. These two interviews worked hand-in-hand to give our group a well-rounded idea of stem cells research and have assisted us significantly in our research work.

After our interview ceased, I spotted a to-do list with the words "Win the Nobel Prize!" on my way out. I admire the fighting spirit of those who research relentlessly, in

order to reach a breakthrough in science. The journey ahead of them is filled with difficulties and no success is assured even after countless failures. Literally, they are wandering in absolute darkness and trying to find the cure of the century for the benefit of mankind.

These researchers get so excited when the younger generation are filled with curiosity and ask questions. I guess that they are relieved to acknowledge the fact that their research will be passed down to the next generation. After all, we should realize that the results will not be near in the future. It might take a few decades, if not, maybe even a century.

To end off, I sincerely thank Dr. Ng, for giving us a wondrous insight on stem cells!

Interview Mr Peter Slaney (New Zealand)

1. I was first interested because I like to keep track of technology, especially related to science. I am more interested in the ethical debate than scientific complexities.
2. I would only use umbilical cord. In New Zealand we are very against GE and other ways of tampering with nature, but support research.
3. 5 years.
4. No proper research done. *(by the way have you seen the latest findings that adult stem cells actually are as good as those from embryos after all??)*
5. Weaker genetic individuals would eventually be nonexistent. It would be possible to save people who are severely injured or suffering from debilitating or terminal diseases in many cases where they would die today.
6. Ultimately it will probably be used for pre-programmed populations- or at least superpeople: like superbacteria, immune to all the diseases that plague us. Eugenics. 'Survival of the fittest' but pre selected genes in a lab. They've done it with cows here in

NZ why not us?
7. Economically- Generate wealth for doctors. More and more are going into the scientific field and scientists will not be as much of a novelty, so they will not be paid as much.
Politically- As governments try to be politically correct it will be absolute morality versus relativistic pragmatism- and knowing today's politicians, the latter will win.
Ethically- Yes. See above.
Medicine- I think it will be of limited benefit but certainly help more than the bionic devices currently used- natural is always better.
8. See 4.
9. See 4.

Impacts of stem cell research:

Since Its discoveries, research in stem cells has grown leaps and bounds. It has impacted on human race in a way that is unprecedented. Its potential uses in science and medicine are tremendous. It has also generated many controversies along the way

Science and medicine

Stem cells research helps us to understand the genetic and cellular basis of disease. In the foreseeable future, it is likely to lead to new knowledge and better treatments and understandings for many diseases afflicting mankind. Without stem cells research, we are likely to remain stagnant in finding new cures and treatment for a lot of diseases.

Presently, adult stem cells from bone marrow are already being used to treat many blood disorders such as leukemia and lymphoma. The first experiment with embryonic stem cell only began in 1988. Research in stem cells gives us great insight in the following:

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1. Help us to understand the complicated processes that occur during human development
2. New modalities of therapies may be found for many diseases such as cancer and birth defects that involved abnormal cell division and differentiation.
3. Testing of new drugs. New cancer drugs can be used on cancer cell lines while specific new drugs can be tested for its safety on different cell types from pluripotent cell lines.
4. Generation of well differentiated cells and tissues for cell based therapies. It can potentially provide a renewable source of replacement cells and tissues to treat many diseases such as :
5. Parkinson's and Alzheimer's diseases, Cell replacement for skin loss and cartilage Spinal cord injury, stroke, heart disease, diabetes (insulin producing cells)
6. Osteoarthritis, and rheumatoid arthritis

In fact, the scientist Mr Robert Zweigerdt we interviewed have managed to derive heart muscle cells from embryonic stem cell

Economy

Stem cell research involved a huge amount of hardware and software. Singapore has poured in millions in setting up several specialised centers for carrying out stem cells research. It has also scouted the world for the best brains in stem cell research to come and do research here.

Stem cell research is potentially a multi-billions business. Many biotech companies and start-ups have been formed across the world to catch the potential financial rewards that will greet the successful teams. In USA the state of California borrowed three billions in 2005 for embryonic stem cells work.

Potential Benefits are:

1. Jobs creation for many from researchers to software engineers.
2. Companies may generate huge economic returns by selling well differentiated stem cells lines or types
3. Stem cells derived tissues can be sold and marketed for transplant and treatment of many diseases.
4. Hospitals and doctors can potentially carry out stem cells related treatment at huge financial benefits.

Politics and ethics

Stem cells research has generated much debates and controversies. Intense debates are still going on in many countries as to the potential benefits of stem cell research. Political powers have also muscle in the ethnical aspects of stem cell research. Everyone seems to want to have a say as to the extent where man should 'play God'.

Stem cells research is shrouded in clouds of varying viewpoints and ethical stands. These must be approached head-on. The main problems surround that of research on human embryonic stem cells. As science and technology advances, these ethical issues may be bypassed one day. The ends of embryonic stem cells research are good. The problems are the means. Is it alright to harvest ESS from donated eggs? Is an embryo a person or does it has a life? We have a duty not to kill.

Major mine field and Controversies:

- Intellectual products from stem cells research used as a money spinner
- Stem cells acts like drugs and can be sold like one
- ESCs from embryos are unethical to many based on moral and religious grounds.
- Cloning humans and destroying embryos are unethical
- Many people associate stem cells with destroying embryos and cloning humans when there are actually thousands of other stem cell methods

Hurdles to cross:

1. Many problems remain to be solved in stem cell research. . The road ahead is arduous and nit for the faint hearted. It will reward the brave and the persevering souls.

2. Political, moral, ethical barriers and hurdles must be crossed. Political wills must come in, religious debate must continue, and the world must be aware of the implications.

3. Hard to control: Embryonic stem cell may pass through several intermediate stages before becoming the cell type needed to treat a particular disease; this process is controlled by complex chemical cues.

Newspapers Articles

Stem cells research has been increasing in the news throughout the world especially in recent years. For example, in Singapore there is almost a weekly article on stem cell.

November 17 2007
Egging on research describes the harvesting of stem cells from cloned monkey embryo

January 15 2008
New local invention extracts stem cells with placental "juicer" which allows more stem cells to be extracted from placenta than current methods.

March 19 2008
Pain in the knee? Stem cell surgery can offer relief shows doctors growing cartilage in lab and implant it into the worn-down joints.

March 22 2008
Little Red Dot's big stem-cell drive shows how Singapore targets cell-based therapies for treating degenerative diseases featuring a key article by Dr Alan Colman

The obstacles and hurdles:

1. Scientists do not yet fully understand the signals that turn specific genes on and off to influence the differentiation of the stem cell.
2. Scientists are still not able to consistently produced identical cell types from embryonic stem cells. Also a limited cell types can be produced to date.
3. Immune rejection must be overcome.
4. The stem cells must overcome the hurdles of producing enough well differentiated cell types, transplantation and engraftment.
5. Immune rejection must be overcome
6. Risk of the not so well differentiated cells developing into tumours
7. Risk of viral contaminations

They must not differentiate into inappropriate cell types or generate tumors. It is clearly essential to guard against these risks in particular of tumorgenesis.

The promising future:

The future of stem cell is exciting and looks promising only if we allow ourselves in the words of Emeritus Professor Paul Berg to experiment till we find the answer.. The breakthrough may be near. It can also be very far away.

Each day news of new finding offers us more hope. In the future adult stem cells from the patients may be extracted and manipulated to be reintroduces into the same patient to cure debilitating diseases. We are not far to preclude the use of embryonic stem cells for cell therapy. The day where ethical objections and immunological rejections seems near. We are already able to get stem cells from skin cell.

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1. United Nations Educational, Scientific and Cultural Organisation (UNESCO): Bioethics http://portal.unesco.org/shs/en/ev.php-URL_ID=1372&URL_DO=DO_TOPIC&URL_SECTION=201.html

Print Resources

1. The Straits Times (Singapore)
2. TODAY Singapore
3. Time Magazines
4. New Zealand Press Agency
5. The Business Times (Singapore)
6. Reader's Digest
7. Newsweek Magazine
8. Innovation, The Magazine of Research & Technology.
   (Creating and Growing Body Parts, Vol 2, Number 3, Gwen Lee)

Useful Links

Singapore Stem Cell Consortium

This website was launched at its recently concluded Singapore Stem Cell symposium (17th March 2008). It acts as a repository for stem cell related news and activities both in Singapore and overseas. It has a detailed listing of stem cell researchers in Singapore, a stem cell bank, and a grant call information centre.

Genome Institute of Singapore (GIS)

This is the place where the team manage to interview Dr Ng Huck Hui. This website details the ambitious plan of Singapore push towards being the world leader in genomic sciences. It gives the latest updates of what goes on in this research being, Genome.

Institute of Medical Biology (IMB)

This is the place where the team interview Dr Lim Sai Kiang and her teams of scientists. This website gives an overview of what happens in this research building where discoveries made in laboratory are being translated to bed.

Stem Cell Club, Singapore

A Singapore website to serve the stem cell research community by providing a platform and forum for the researchers to interact and communicate with each other. It also acts as a bridge for scientists from other parts of the world to find out more about stem cell research in Singapore.

National Medical Ethics Committee (NMEC)

This Ministry of Health (MOH) website contains rich sources of information on ethical guidelines for medical practices in Singapore. .

Centre for Medical Ethics and Professionalism, Singapore Medical Association

This Singapore Medical Association website helps to promotes the practice of medical professionalism and ethics especially on professionalism, ethics, and health law and practice management.

World Health Organisation: Ethics and Health

This website serves as a platform to examine key issues on ethnics and health raised by activities throughout the world.