Perspective

Science and Society: A Stem Cell Technology Model

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Stem cell technology has been recognized as an emerging technology that could transform current supportive approach toward curing many chronic disorders and degenerative conditions. Regenerative medicine is the promising area of medical practice in the coming decade. However, stem cell technology also brings up controversial issues from the bioethical perspective such as the destruction of human embryos to derive embryonic stem cells or putting the egg donors at risk when retrieving oocytes used in somatic cell nuclear transfer technique. Recently, scientists have discovered a novel method to derive human embryonic stem cell-like cells (iPS; induced pluripotent stem cells) from human skin cells. This innovative approach would not only be a breakthrough discovery to advance the knowledge of stem cell research and the landmark for future stem cell-based therapy but will also provide viable solutions for social concerns on bioethical issues.

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Stem cell technology has been recognized as an emerging technology that could transform the current approach toward curing many chronic disorders and degenerative conditions. Regenerative medicine is the promising area of medical practice for the coming decade. Cell and tissue replacement therapy could be the final answer for many incurable diseases. Stem cell technology would also be a very helpful tool for understanding early human developmental process and screening potential candidates for new drug discovery. However, stem cell technology also brings up many controversial issues from the bioethical perspective. For example, there are many arguments on the justification to destroy one life (human embryo) to save another life (potential candidate for stem cell therapy).

This is a good case scenario of the situation when science intersects with society's morale. The appropriate solution would be an approach that would support the advancement of science for the benefit of human, while maintaining the moral and integrity of the society. Hopefully, this "balance" approach would be a key success for sustainable science and society development.

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Background[1]

Conventional approach to derive new human embryonic stem cell line involves the harvest of the inner cell mass from a human embryo (Fig. 1a). It would inevitably destroy that embryo and raise the critical issue of the moral status of human embryos. It would also re-address the issue of when life begins and the dignity of human embryos.

The other approach to derive a new human embryonic stem cell line is from somatic cell nuclear transfer (SCNT) technique or widely recognized as "cloning" technique used previously in creating Dolly the sheep (Fig. 1b). This method would be a good potential candidate for providing patient-specific stem cell line that would be used for transplantation without creating immune rejection. To date, this approach has

not been proved successful yet in human. In addition, a lot of human eggs would be needed and play a key limiting step as an essential resource for this approach. Then, even this has been proved to be a viable option for creating human embryonic stem cell in the future, there would undoubtedly be a significant concern on the supply side of the equation. This would involve the medical risk and the risk for coercion. There is also the issue of the appropriate compensation that the egg donor should obtain.

Following up the somatic cell nuclear transfer technique, a research group proposed that if the donor "nucleus" to be used for nuclear transfer has been modified to prevent the implantation potential of the embryo created (Fig. 1c), they should be able to use that embryo for making a cell line without ethical conflict. This actually brought up many arguments and concerns. Since this method artificially and intentionally modifies the potential and capability of the embryo to claim the right to destroy it, this would consequently not be a justified approach. In addition, there is a concern that the modification being made to the donor nucleus may have long-term adverse effects to the stem cells that would finally be used for therapeutic purposes.

Evolution of stem cell technology

With the limitations and ethical concerns on both the classical derivation method and somatic cell nuclear transfer technique, scientists have further made the effort to propose and prove other ethically sound techniques. These included the parthenogenesis method and derivation of new cell lines from dead or chromosomally abnormal human embryos (Fig. 1d-f). However, all these approaches still require plenty of human "eggs" and "embryos" and seem to be overwhelmed with social concerns and criticism.

The other potential method proposed to overcome these ethical controversies is the "single blastomere" approach that adopts the blastomere biopsy technique (Fig. 1g) used in preimplantation genetic diagnosis (PGD). After a single blastomere has been removed from the eight-cell stage embryo, the biopsied embryo still has a potential to implant and develop into a human being. The new human embryonic stem cell line can be derived from a "single blastomere". However, there are still other concerns related to this approach. Since the embryo may not have a direct benefit from the new cell line established, this would be not justified for the embryo to take "unnecessary" risk and harm. In addition, this PGD method would inevitably link with the "selection" of embryos to be implanted and to be discarded. Some still see this as an unnatural and unethical way to select the ones to live or to die.

Recent breakthrough as a promising solution

The novel approach is a new platform of stem cell technology and is a breakthrough discovery for stem cell research advancement. This approach uses retroviruses to insert four genes into somatic differentiated cells (skin cells) and can derive cells with the properties almost identical to human embryonic stem cells[3,4] (Fig. 1h). These cells have been named iPS cells or induced pluripotent stem cells.

This method may not be a perfect and ethical concern-free approach. However, this recent breakthrough can produce patient-specific pluripotent stem cell line without using human embryos or eggs that have created significant ethical concerns in the past. This is a promising approach that scientists can provide a reasonable solution to society's concerns.

Forging ahead

There is a concern on the potential of cancer formation from the iPS cells since proto-oncogene has been used to transform somatic differentiated cells into pluripotent cells. Moreover, the use of viruses to transport the reprogramming genes into the adult cells could cause mutations that predispose these cells to cancer, a technical problem that will have to be solved before the iPS cells can be used in the clinical practice.

It may be too early and currently there is not enough evidence to suggest that iPS cells can replace the classical derivation of embryonic stem cells from embryos or by somatic cell nuclear transfer. Research on human embryonic stem cells, somatic cell nuclear transfer and adult or tissue-specific stem cells still needs to be performed[5]. All are part of a research effort to understand how cells function, what happens in the disease processes, and how the early stages of human development occur. This important knowledge and advancement would finally establish the "safe" and "effective" stem cell therapies.

Conclusion

The evolution and milestone of stem cell technology is a good model to study and to demonstrate the intersection and interaction between science and society. Without the advancement of science, there would be no innovation in health care and no improvement in quality of life with emerging technologies.

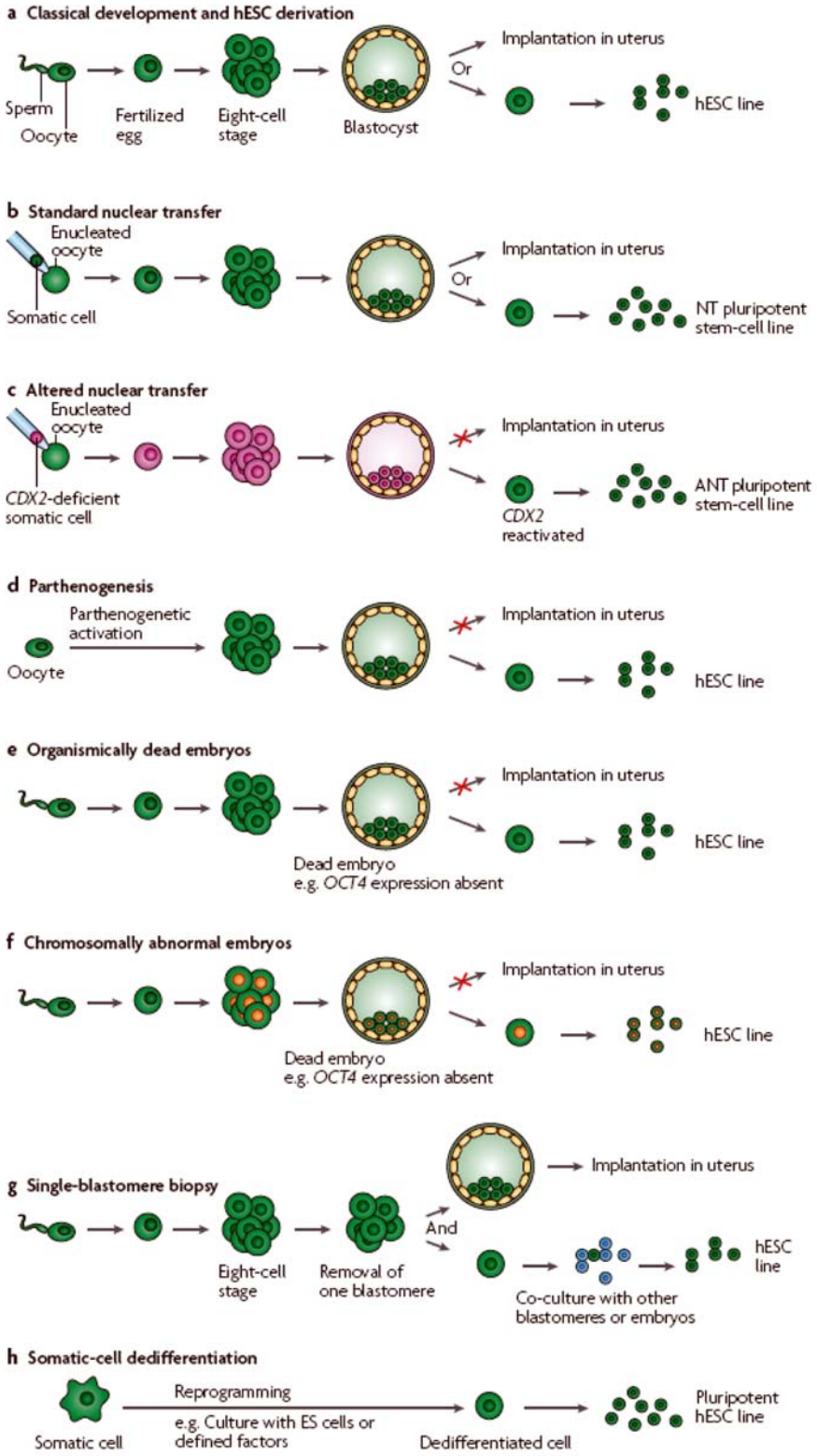

Fig. 1 Overview of conventional and novel approaches to derive human embryonic stem cells (hESCs)[2]

However, without agreement and engagement with the society, the advancement of science would not be able to deliver sustainable development.

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วิทยาศาสตร์และสังคม: กรณีศึกษาจากเทคโนโลยีเซลล์ต้นกำเนิด

สรภพ เกียรติพงษ์สาร

เทคโนโลยีเซลล์ต้นกำเนิดนับเป็นเทคโนโลยีใหม่ที่มีศักยภาพนำไปสู่การรักษาโรคเรื้อรังและภาวะที่เกิดจากความเสื่อมสภาพจำนวนมากให้หายขาดได้ เวชศาสตร์การซ่อมสร้างจึงเป็นสาขาวิชาสำคัญสำหรับเวชปฏิบัติในทศวรรษหน้า หากแต่เทคโนโลยีเซลล์ต้นกำเนิดยังได้ก่อให้เกิดการวิพากษ์ทางชีวจริยธรรมในหลากหลายประเด็น เช่น การทำลายตัวอ่อนของมนุษย์เพื่อสร้างเซลล์ต้นกำเนิด ความเสี่ยงของการบริจาคเซลล์ไข่เพื่อนำไปใช้ในการย้ายเปลี่ยนนิวเคลียสระหว่างเซลล์ ปัจจุบันนักวิทยาศาสตร์ได้ค้นพบวิธีการใหม่ที่จะสามารถสร้างเซลล์ที่มีคุณสมบัติเสมือนเซลล์ต้นกำเนิดตัวอ่อนของมนุษย์จากเซลล์ผิวหนังได้ การค้นพบครั้งนี้มิได้เป็นแต่เพียงความก้าวหน้าครั้งสำคัญของวงการวิจัยเซลล์ต้นกำเนิด และเป็นแนวทางหลักในการนำเซลล์ต้นกำเนิดไปใช้ในการรักษาในอนาคต หากแต่ยังได้นำเสนอวิธีการใหม่ที่สามารถหลีกเลี่ยงปัญหาทางชีวจริยธรรม และสามารถตอบโจทย์ที่สังคมตระหนัก และให้ความสำคัญได้