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Introduction

Stem Cell Bioethics, supported by a grant from the New York State STEM Cell Initiative (NYSTEM), provides information on a range of important and complex topics about stem cell science. Given the significant discoveries in stem cell science that have generated profound medical and social issues, we believe that the science, the ethics, and the applications of these discoveries all need careful consideration.

The fundamental science of **pluripotent** and **multipotent** stem cells will be the central theme of this Columbia University online course. Using a multidisciplinary approach, our aim is to provide a detailed exploration of the newest emerging scientific advancements and technologies in embryo and adult stem cell research, as well as an examination of actual and potential medical applications.

These modules were initially designed to accompany the Columbia University classroom course: "Stem Cells: Biology, Ethics, and Applications". We have now adapted the course to supplement any university course that focuses on stem cell research and potential medical and scientific applications. Undergraduate and graduate students as well as all others who have an interest in stem cell science, bioethical and social implications, and regulatory issues should find this course informative.

Within the eight Modules and Supplements of the online course, the reader will find:

- Presentation of advances in stem cell science and relevant ethical implications
- Historical and political perspectives
- Current and futuristic case studies
- References to seminal papers and reports
- Questions to promote thought and discussion
- Technical terms that are linked to a Glossary containing brief, easy to understand definitions
- Resources for further study
- “Expand Your Knowledge of Bioethics” examples that allow the reader to view opposing views on contentious bioethical issues

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Imagine

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Imagine...

- *Research that may lead to revolutionary new therapies to treat cancer, Parkinson's disease, Alzheimer's disease, diabetes, spinal cord injury, heart disease, and many other debilitating conditions. Do the promises of stem cell research offer a realistic treatment or cure for these diseases?*
- *A woman who does not want to, or who medically cannot, carry her fetus to term. Would she ever consider using a genetically modified cow possessing a human uterus as her surrogate? In the not too distant future, stem cell research may allow scientists to create such a human-animal chimera. What would be the risks of such a gestational scenario?*
- *When there is a need to obtain histocompatible stem cells to treat a child who is ill, is it ethical to obtain and develop compatible embryonic stem cells from a pre-implanted embryo, knowing that the blastocyst will be destroyed in the process of deriving the desired stem cells?*

While these scenarios may once have seemed like futuristic science fiction, advances in stem cell technology are bringing them closer to possibilities, if not to probabilities. In fact, desperate patients across the globe are traveling to countries such as China and the Caribbean to participate in unproven stem cell "therapies."

A good example is Yankee baseball pitcher Bartolo Colon, who underwent an as yet unproven procedure in the Dominican Republic in the spring of 2011. Doctors extracted stem cells from his bone marrow and fatty tissue and transplanted them into his elbow and shoulder. After his recovery, he signed a new one-year, $900,000, contract with the Yankees and is back throwing pitches at 95 miles an hour. His resurgence has increased the demand for the controversial procedure that utilizes stem cells to treat injured athletes.

Bartolo Colón

Follow-up: Bartolo Colón during the 2011 season has an 8 and 9 record with an Earned Run Average (ERA) of 3.63.

Recently, stem cell science has made rapid progress, revealing entirely new scientific opportunities that will enable the development of future treatments for a wide variety of medical conditions. Many of these experimental or medical breakthroughs will have an unprecedented societal impact. It is imperative to carefully evaluate these developments from diverse viewpoints including ethical, legal, religious, economic, cultural, political, as well as scientific perspectives. Together, these disciplines will shape both public policy and personal health decisions.

We believe that cell biologists, clinicians, and bio- and neuro-ethicists can work together to celebrate advances, while simultaneously helping to inform

and protect patients and the broader community concerning what might be considered inappropriate or premature applications of novel stem cell technologies. This will not be an easy process. We must engage in ongoing reasoned and informed discourse to ensure safe and appropriate innovations and applications of this new technology.

While the promise of stem cell therapies excites us, it also energizes YouTube creators to craft entertaining skits. You may enjoy this one that parodies the hype of stem cell research and disease.

A Musical Interlude

While the promise of stem cell therapies excites us, it also energizes YouTube creators to craft entertaining skits. You may enjoy this one that parodies the hype of stem cell research and disease.

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Course Outline

Introduction to Stem Cell Research: Description of the Modules and the Supplements

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Introduction

Module 1 - Biology and History of Stem Cell Science

This module will discuss the scientific evolution of stem cell research from the mouse to the human.

- Supplement 1. Brief Legal and Political History of Stem Cell Science
- Challenge: How will legal challenges relating to stem cell research funding and patenting of genes be resolved? Is federal oversight of embryonic research a probability?

Module 2 – Introduction to Stem Cell Bioethics

This module presents the evolving landscape of bioethical implications of deriving human stem cells from the embryo, to induced pluripotent stem (iPS) cell technology, to cloning, and beyond.

- Challenge: When does human life begin?
- Case Study: Can a couple use pre-implantation genetics to produce a child whose bone marrow stem cells will be used to save the life of a sibling with Fanconi Anemia?
- Supplement 2. Animal Rights and Welfare in the Context of Stem Cell Research
- Case Study: Chimeras cross the boundaries of species. Should governments restrict the use of non-human primates in research as we use stem cells and genetic engineering to enhance human-like behaviors in these animals?

Module 3 - Cellular Differentiation

This module presents the underlying genetic basis of cellular differentiation. We review the history of cell differentiation as it has been applied to stem cell research.

- Challenge: How do you transform a stem cell into a neuron?

Module 4 - Somatic Cell Nuclear Transfer (SCNT)

This module describes how the cloning of Dolly opened up new scientific and bioethical conundrums.

- Challenge: Under what circumstances is it ethical and scientifically sound to engage in therapeutic cloning?
- Supplement 3A. A Brief History of Vertebrate Cloning

- Supplement 3B. Ethical Considerations of Egg Donation
- Supplement 3C. The Cloning Scandal of Dr. Hwang Woo-Suk: A Cautionary Tale

Module 5 - Induced Pluripotent Stem (iPS) Cells

This model describes the history and basic principles of iPS that have dramatically changed the direction of stem cell research.

- Challenge: What innovative scientific principles emerged from iPS research?

Module 6 - Human Hematopoietic System: A View into Human Stem Cell Biology

This module describes how basic principles of immunology have been incorporated into stem cell biology.

- Challenge: What clinical advantage does using human hematopoietic stem cells have over using bone marrow-derived cells?

Module 7 - Applications of Stem Cell Science: In Medicine, Drug Screening, and Developing Animal Models of Human Disease.

This comprehensive module outlines the most compelling and emerging advances in applying stem cell technologies to health care.

- Challenge: Who should pay for the huge costs of engaging in clinical studies of stem cell technology?
- Supplement 4 Ethical Conduct of Research: Clinical Trials, Informed Consent, Addressing the Fallout from Premature Commercialization
- Case Study: Stem cell biology is constantly evolving. The public is finding it increasingly difficult to fully comprehend the risks and benefits of stem cell applications. How should physicians educate and advise desperate patients who want to participate in either long-range FDA approved clinical trials or immediate unproven foreign-based “therapies” in the hope to improve their paralysis?

Module 8 – Human-Animal Chimeras

This module describes the use of stem cells to create human-animal chimeras in studies that have had a dramatic scientific impact on organ transplantation and organ regeneration. In addition, generating human-animal chimeras have elicited heated debates on the definition of human species and what makes human beings a unique organism.

- Challenge: Is it ethical to reconstitute parts of an animal brain with human neurons or human reproductive organs?

Conclusion

Course Glossary

Links scientific terms in the text to a list of understandable definitions

References and Resources

Lists all cited references as well as full list of resources, published and media that are useful for further study.

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Conclusion

While holding out great promise for improvements in health, treatment of disease, and increased understanding of the brain and other organs, advancing stem cell technologies raise compelling ethical, legal, and social concerns which readers of the on-line course should carefully consider.

Emerging stem cell science reflects a dynamic and opposing balance between rapidly progressing and diverse scientific discoveries, and a range of bioethical and societal concerns. There are issues at every level and stage of research from manipulating a somatic cell into a stem cell, to enrolling a patient into a clinical stem cell trial, to educating legislators as well as the public. We believe this online course will help students and others experience and understand the balance between scientific discovery and societal concerns and thus better appreciate the myriad important ideas and ethical dilemmas that are generated by stem cell science.

We believe students, professors, health care professionals, and the public alike will find the online course informative and stimulating, and a unique entry into the future of stem cell research and its applications. The technologies are increasingly available and it is essential for us to use them responsibly and wisely.

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Additional Readings

Interl, J. (2010). "Getting It Right on Stem Cells." Scientific American Magazine 303(5): 27-27.

Zacharias, D. G., T. J. Nelson, et al. (2011). The Science and Ethics of Induced Pluripotency: What Will Become of Embryonic Stem Cells?, Mayo Clinic.