Title

ISSCR Education Committee syllabus and learning guide for enhancing stem cell literacy

Journal

Stem Cell Reports, 18(2)

ISSN

2213-6711

Authors

Perlin, Julie R

Anderson, William J

Bartfeld, Sina

et al.

Publication Date

2023-02-01

DOI

10.1016/j.stemcr.2022.12.004

Peer reviewed

Stem Cell Reports
Forum
ISSCR
OPEN ACCESS

ISSCR Education Committee syllabus and learning guide for enhancing stem cell literacy

Julie R. Perlin,[1,*] William J. Anderson,[2] Sina Bartfeld,[3] Anna Couturier,[4] Yvanka de Soysa,[5] R. Scott Hawley,[6] Ping Hu,[7] Yuin-Han Loh,[8] Lolitika Mandal,[9] Zubin Master,[10] Alysson R. Muotri,[11] Eugenia Piddini,[12] Jose M. Polo,[13] and Esteban O. Mazzoni[14,*]

[1]International Society for Stem Cell Research, Skokie, IL, USA
[2]Harvard University, Cambridge, MA, USA
[3]Technische Universität Berlin, Berlin, Germany
[4]University of Edinburgh, Edinburgh, UK
[5]Boston Children's Hospital, Boston, MA, USA
[6]Stowers Institute for Medical Research, Kansas City, MO, USA
[7]Guangzhou Laboratory, Guangzhou, China
[8]Institute of Molecular and Cell Biology, Singapore, Singapore
[9]Indian Institute of Science Education and Research Mohali (IISERMohali), Punjab, India
[10]Mayo Clinic, Rochester, MN, USA
[11]University of California, San Diego, San Diego, CA, USA
[12]University of Bristol, Bristol, UK
[13]Monash University, Melbourne, VIC, Australia
[14]New York University, New York, NY, USA
*Correspondence: jrperlin@gmail.com (J.R.P.), eom204@nyu.edu (E.O.M.)
https://doi.org/10.1016/j.stemcr.2022.12.004

The rapidly evolving stem cell field puts much stress on developing educational resources. The ISSCR Education Committee has created a flexible stem cell syllabus rooted in core concepts to facilitate stem cell literacy. The free syllabus will be updated regularly to maintain accuracy and relevance.

A RESOURCE TO FACILITATE STEM CELL EDUCATION

Stem cell science, along with related clinical, ethical, legal, policy, and social implications, is a rapidly evolving and dynamic field. Misconceptions surrounding stem cell science and resulting treatments are rampant, and scientifically accurate stem cell education is critical for informed decisions by researchers, students, clinicians, regulators, policymakers, patients, and the public. Even though the field has experienced considerable growth, resources to help educators teach stem cell science and regenerative medicine are limited. Recognizing this deficit, the International Society for Stem Cell Research (ISSCR) established the Education Committee, which is committed to improving stem cell education by promoting evidence-based science communication and correcting misinformation about stem cells and their therapeutic applications.

The ISSCR Education Committee has created free and versatile materials rooted in foundational discoveries to help instructors cultivate an appreciation for, and understanding of, stem cell research. The Core Concepts in Stem Cell Biology: Syllabus and Learning Guide is an open-source resource designed to facilitate the creation of stem cell classes and courses for undergraduate, graduate, and medical students.[1] The guide is built around eight core concepts in stem cell science, each bolstered with learning objectives and an annotated bibliography. This flexible resource can be used as a guide to teach an entire stem cell biology course or be adapted for use in existing curricula.

FILLING AN UNMET NEED IN STEM CELL EDUCATION

In contrast to similar disciplines, stem cell science lacks a well-established textbook that can serve as the backbone of an introductory level course, leaving new instructors, or instructors new to stem cell science, with no recognized consolidated resource on stem cell biology. Furthermore, stem cell science includes not only the biological principles of the discipline but also clinical applications and associated ethical, legal, policy, and social issues. The ISSCR Education Committee created a resource for instructors that covers the essential areas of stem cell science and is endorsed by the ISSCR, the largest society in the world dedicated to the advancement of responsible stem cell research.

This guide helps instructors assemble a clear, cohesive, and comprehensive syllabus that identifies the critical topics and salient literature from embryos to ethics and all stem cells in between. This resource is intended to provide our community with a template for designing curricula, enable institutions and instructors to offer more classes on stem cell science and thereby reach additional students, and help curtail the spread of misinformation surrounding stem cell science and unproven clinical treatments. The fourteen Education Committee members

Table 1. Overview of the eight modules that make up the *Core Concepts in Stem Cell Biology* syllabus

Eight modules in stem cell science	Overview
Module 1: Introduction to Stem Cell Biology	fundamentals of stem cell biology, which provide students with the building blocks necessary for understanding, examining, and dissecting the dynamic field of stem cell research
Module 2: Introduction to Development	from fertilization to gastrulation and cell-fate determination, students learn how cells in the early embryo gain unique identities and functions
Module 3: Pluripotency and Reprogramming *In Vitro*	an overview of how to characterize and establish different types of pluripotent cells and their potential clinical applications
Module 4: Adult Stem Cells and Regeneration	how adult stem cells develop and maintain tissues during homeostasis and in response to injury, and their application in regenerative medicine
Module 5: Directed Differentiation and Transdifferentiation	understanding differentiation, both *in vivo* (during embryonic development and in the adult) and *in vitro*, transdifferentiation, and directed differentiation, and how these concepts can be applied clinically
Module 6: Leveraging Tools to Study Stem Cell Biology	cutting-edge technologies that are used to interrogate stem cells to further their experimental use and clinical potential
Module 7: Clinical Applications of Stem Cell Biology	how stem cell technologies are being translated for clinical applications
Module 8: Ethical Issues in Stem Cell Research	ethical and policy issues surrounding human embryos, egg donation, gene editing, unproven stem cell interventions, fetal tissue, and science communication

are based in seven countries and have strong expertise in developmental and stem cell biology, cellular and molecular biology, stem cell ethics and policy, education, and science communication. We used our diverse scientific and educational backgrounds to create a syllabus and learning guide to address a previously unmet need in the field.

FLEXIBLE TOPIC-FOCUSED MODULES

The syllabus and learning guide are grounded in eight core concepts that span basic biology, clinical application, and ethical and policy considerations (see Table 1).[2] These topic-focused modules can be taught independently or as a series to provide students with a cohesive introduction to stem cell science. Through these modules, students will learn about the unique features of stem cells; how stem cells regulate development and regeneration in various organisms; the fundamental biology underlying *in vivo* and *in vitro* pluripotency, self-renewal, differentiation, and cellular reprogramming; the latest advances in technology and clinical applications; and the ethical, legal, and social implications of stem-cell- and regenerative-based technologies.

Each of the eight topics is broken down into its core concepts and supported by key peer-reviewed primary and secondary literature. A curated and annotated bibliography of foundational discoveries in the field highlights major discoveries and provides scientific context and significance. The eight modules also contain learning objectives that progress from knowledge and comprehension to analysis and synthesis, which can be modified based on the course level.

While advanced biomedical undergraduate, graduate, and medical students are the main target audiences for the educational content of this guide, the resource is flexible and can be adapted and used in a variety of courses to instruct students from diverse backgrounds. Advanced students can explore optional topics and upper-level learning objectives and learn how to generate hypotheses, design experiments, and interpret and analyze results through classical studies found in the annotated bibliography.

HOW THE LEARNING GUIDE IS BEING PUT INTO PRACTICE

Since its creation in November 2020, the open-source *Core Concepts in Stem Cell Biology* syllabus and learning guide have been well received by the stem cell community. The syllabus was downloaded directly from the ISSCR website more than 1,800 times by individuals from more than 1,000 institutions globally, underscoring the need for this type of resource and its popularity. A survey was sent to the downloaders who agreed to be contacted to find out how they have used the guide and how it can be enhanced.

We conducted a pilot feedback study. Although the feedback response rate was low (2.5%), it was very positive. We obtained responses from users

from eleven countries, most of whom identified as academic professors. Overall, the majority of respondents indicated that the syllabus was highly effective at helping them identify key principles of stem cell science; teach stem cell science to a greater number of people; design or improve a course on stem cell science; incorporate stem cell science into other courses; and identify key papers and achievements in stem cell science. Over half of the respondents used the learning guide to design a new syllabus, and nearly half used it to teach a new course dedicated to stem cell science. Cumulatively, instructors used these tools to teach hundreds of students, with an almost even split between undergraduate and graduate students.

Qualitative feedback echoed these sentiments. One user commented on the learning guide, "It had provided a conceptual framework and a guide to organize the main issues and select the crucial problems in stem cell research, to be addressed with the most updated literature references," and another user reported that "[a]s a long-time stem cell scientist it has given me new angles on what all to include in stem cell courses." Furthermore, over half of respondents reported sharing the syllabus, one of whom said that they "share[d] [it] with students and trainees as an essential resource," underscoring the value of the guide.

The committee plans to collect further data on how educators use and adapt the syllabus to their needs, as well as suggestions on enhancing the resource through periodic interviews and questionnaires. Further, the syllabus will serve as the backbone of the São Paulo School of Advanced Science on Stem Cell Biology course,[3] which is to be held in São Paulo Brazil in September 2023 for undergraduate and graduate students and postdoctoral fellows. This experience will inform future revisions, and recordings of these lectures by leaders in the field will complement the online syllabus, further enriching the resource.

BUILDING ON TO THE LEARNING GUIDE

The ISSCR Education Committee intends to augment the syllabus with additional resources in the future. Additions will include video interviews with the lead and corresponding authors of highlighted works. These conversations will provide a behind-the-scenes look into the lives and experiences of a diverse group of international researchers and insights into the genesis of landmark discoveries and the process of overcoming obstacles. These personal encounters will provide a deeper understanding of the reasoning and the journey behind scientific discoveries—something rarely conveyed in textbooks or manuscripts. Based on survey feedback, future updates could also include laboratory exercises that complement the core concepts, more in-depth discussions of specific topics, and additional resources to explore key primary literature. Additionally, we intend to expand the resources for other audiences that may benefit from further stem cell education, for example middle and high school educators, medical professionals, patients, and policymakers.

Stem cell science is an incredibly vibrant and impactful field that is constantly evolving. The learning guide is meant to be a living document, which the Education Committee is committed to periodically expanding and updating with new advances in stem cell science and their clinical applications. While the syllabus and learning guide provide instructors with a roadmap to teach students, educators are responsible for ensuring they are teaching up-to-date material and presenting it properly. We encourage instructors and students to participate in updating the syllabus and invite you to send feedback to info@isscr.org and share additional content needs, suggested topics, and essential references. We are committed to working collaboratively with other ISSCR committees and the larger scientific community to enhance stem cell education further. We hope this resource will make stem cell education more accessible around the globe and reduce misinformation about stem cells and their potential applications.

REFERENCES

1. Core concepts in stem cell biology: syllabus and learning guide: https://www.isscr.org/learning-guide.
2. Syllabus on the ISSCR website: https://www.isscr.org/learning-guide.
3. São Paulo school of advanced science on stem cell biology course: https://espca.fapesp.br/school/sao_paulo_school_of_advanced_science_on_stem_cell_biology/105/.