STEM CELL BIOLOGY AND REGENERATIVE MEDICINE

Courses offered by the Program in Stem Cell Biology and Regenerative Medicine are listed under the subject code STEMREM on the Stanford Bulletin’s Explore Courses web site.

Graduate Program in Stem Cell Biology and Regenerative Medicine

The Stanford Stem Cell Biology and Regenerative Medicine (SCBRM) program is dedicated to doctoral education that translates basic science to clinical applications, typically referred to as Translational Science, and of intense interest internationally in medical schools and universities. Our doctoral program provides exceptional didactic education and research experience in the basic sciences underlying stem cell biology. In addition, program participants will receive specialized training in the development and clinical application of discoveries in the basic sciences to achieve regenerative therapies. Thus, our graduates will be uniquely positioned to develop successful translational careers in Stem Cell Biology and Regenerative Medicine, and will emerge prepared to deliver on their passion to improve the human condition. The core curriculum is combined with unique research and clinical/professional immersion rotations to provide opportunities for doctoral students to specialize in the broad subject of translational medicine and yet focus specifically on fundamentals of SCBRM. The curriculum combines education in genetics and developmental biology with an introductory laboratory-based stem cell course, an advanced course in stem cell biology and regenerative medicine, and a clinical rotation with alternative opportunities in law, business and/or engineering.

The mission of the SCBRM graduate program is to produce future leaders in translational science through a combination of basic science and clinical/professional immersion. The program aims to be innovative and to change the landscape for graduate education in the biomedical sciences by having the immersion tailored to each student’s translational goals. The program accommodates students who wish to focus primarily at the basic science level alongside those who wish to focus specifically on innovation such as a new device to solve a clinical problem. In the former case, the student might seek out a primary mentor affiliated with the basic sciences and take electives that reflect the more basic interest. In the latter case, the student might select an elective with an engineering focus and seek out primary mentorship with a more clinically or engineering focused mentor. In this way, graduates from our doctoral program receive exceptional didactic education and research experience and are well positioned to develop successful translational careers in SCBRM by applying their knowledge and passion to improve human health.

Master of Science in Stem Cell Biology and Regenerative Medicine

University requirements for the M.S. degree are described in the “Graduate Degree (http://exploredegrees.stanford.edu/graduatedegrees)” section of this bulletin.

Students in the Ph.D. program in SCBRM may apply for an M.S. degree in SCBRM, assuming completion of appropriate requirements. The program does not accept applications for a standalone M.S. degree.

To receive an M.S. in Stem Cell Biology and Regenerative Medicine, Students must complete the following:

1. Four full-tuition quarters of residency as a graduate student at Stanford.
2. At least 45 units of academic work, all of which must be in courses at or above the 100 level, 16 units of which must be at or above the 200 level.
3. Four quarters of graduate research, consisting of rotations in the labs of at least three SCBRM faculty members.
4. Course work in Stem Cell Biology and Regenerative Medicine as well as other core requirements:
   a. STEMREM 200 Stem Cell Intensive hands-on immersion to learn basic methods of tissue culture, mouse embryo fibroblast (MEF) preparation, embryonic stem and induced pluripotent stem (ES/IPS) cell culture, differentiation, DNA isolation, polymerase chain reaction (PCR), sequencing, and basic microscopy.
   b. BIOS 200 Foundations in Experimental Biology focuses on the broad themes of Evolution, Energy and Information.
   c. STEMREM 201A Stem Cells and Human Development: From Embryo to Cell Lineage Determination and STEMREM 201B Stem Cells and Human Development Laboratory develop a fundamental understanding of introductory stem cell principles in human development, aging, and disease accompanied by a laboratory-based module with immersion in stem cell-based methods (embryology, embryonic stem cells, reprogramming, adult stem cells).
   d. STEMREM 202 Stem Cells and Translational Medicine, advanced topics related to individual organ systems, cancer stem cells, translational principles of medicine and immunology as related to regenerative medicine, as well as bioengineering and bioinformatics as related to stem cell biology.
   e. STEMREM 203 Stem Cells Immersion: Applications in Medicine, Business and Law, students specialize and choose a clinical immersion, rotation in a biotechnology company or venture firm, or further delve into cutting edge technologies, bioinformatics, materials and/or engineering approaches for stem cell applications in industry, diagnostics and medicine.
   f. STEMREM 250 Regenerative Medicine Seminar Series, a forum for researchers to meet and discuss Stem Cell Biology and Regenerative Medicine and to spark collaborations. 6 units of this course is required.
   g. STEMREM 280 Stem Cell Biology and Regenerative Medicine Journal Club, review and discussion of current literature in both basic and translational medicine as it relates to stem cell biology and/or regenerative medicine.

Units

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<th>Course Code</th>
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<tr>
<td>STEMREM 200</td>
<td>Stem Cell Intensive</td>
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<td>Foundations in Experimental Biology</td>
<td>6</td>
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<td>STEMREM 201A</td>
<td>Stem Cells and Human Development: From Embryo to Cell Lineage Determination</td>
<td>1-2</td>
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<td>STEMREM 202</td>
<td>Stem Cells and Translational Medicine</td>
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<td>STEMREM 203</td>
<td>Stem Cells Immersion: Applications in Medicine, Business and Law</td>
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<td>STEMREM 250</td>
<td>Regenerative Medicine Seminar Series</td>
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<td>STEMREM 280</td>
<td>Stem Cell Biology and Regenerative Medicine Journal Club</td>
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<tr>
<td>BIOC 224/</td>
<td>Advanced Cell Biology</td>
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<td>BIO 214/</td>
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<td>MED 255</td>
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<td>DBIO 210</td>
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<td>STEMREM 399</td>
<td>Graduate Research</td>
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<td>Total Units</td>
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h. Students are also required to take 2 electives, totaling a minimum of 6 units.

i. Biochemistry proficiency is required by the end of the second year, as well as a total of 80 units and completed qualifying examinations. Students who do not pass the qualifying examination may retake a full qualifying exam, be retested in a few areas, or be asked to redo their presentation.

5. Participation and attendance at the annual SCBRM Retreat.

6. The qualifying examination process in SCBRM before admission to Ph.D. candidacy has two parts:
   • Part I: a comprehensive written exam in the form of a 5-page NIH grant proposal
   • Part II: a 15-minute oral presentation of the proposal to the thesis committee followed by open questions from the qualifying exam committee on the proposal or encompassing areas of research/academic scholarship that are deemed relevant to the proposal.

Students who do not pass the qualifying exam may retake the full qualifying exam, be retested in a sub-area, or be asked to redo their presentation. Those students who fail the qualifying exam twice may be awarded a master’s degree based on completion of course work and rotations. In addition, students who choose to voluntarily leave the program are also awarded a master's degree based on completion of the qualifying exam.

**Doctor of Philosophy in Stem Cell Biology and Regenerative Medicine**

University requirements for the Ph.D. are discussed in the “Graduate Degrees (http://exploredegrees.stanford.edu/graduatedegrees)” section of this bulletin.

The Stem Cell Biology and Regenerative Medicine curriculum, combined with the research and rotation opportunities, provides a flexible educational opportunity for doctoral students to specialize in the broad subject of translational medicine while being focused more specifically on the fundamentals of Stem Cell Biology and Regenerative Medicine while training in the laboratories of participating SCBRM faculty. The goal of the SCBRM program is to provide an avenue for graduate education to translate the best of basic research into a clinical setting.

**Application and Admission**

Applications are made through the Graduate Admissions (http://gradadmissions.stanford.edu) web site.

Applicants will be assessed based on their undergraduate transcripts, test scores, research experience, statement of purpose and letters of recommendation that document exceptional potential, ability, or achievements.

Students admitted to the program are offered financial support covering tuition, a living stipend, and insurance coverage. Applicants are urged to apply for independent fellowships such as from the National Science Foundation. Fellowship applications are due in November of the year prior to matriculation in the graduate program, but SCBRM graduate students may continue to apply for outside fellowships after matriculation. Because of the small number of department-funded slots, students who have been awarded an outside fellowship have an improved chance of acceptance into the program. Upon matriculation, each student is assisted in selecting courses and lab rotations in the first year and in choosing a lab for the dissertation research. Once a dissertation adviser has been selected, a dissertation committee is composed to include the dissertation adviser and two additional SCBRM faculty, to guide the student during their dissertation research. The student must meet with the dissertation committee at least once a year.

**Degree Requirements**

Candidates for Ph.D. degrees at Stanford must satisfactorily complete a program of study that includes 135 units of graduate course work and research.

Requirements for the Ph.D. degree in SCBRM include:

1. Completion of at least 3 research rotations in the labs of SCBRM faculty members.

2. Completion of the following courses:
   a. STEMREM 200 Stem Cell Intensive hands-on immersion to learn basic methods of tissue culture, mouse embryo fibroblast (MEF) preparation, embryonic stem and induced pluripotent stem (ES/iPS) cell culture, differentiation, DNA isolation, polymerase chain reaction (PCR), sequencing, and basic microscopy.
   b. BIOS 200 Foundations in Experimental Biology focuses on the broad themes of Evolution, Energy and Information.
   c. STEMREM 201A Stem Cells and Human Development: From Embryo to Cell Lineage Determination and STEMREM 201B Stem Cells and Human Development Laboratory develop a fundamental understanding of introductory stem cell principles in human development, aging, and disease accompanied by a laboratory-based module with immersion in stem cell-based methods (embryology, embryonic stem cells, reprogramming, adult stem cells).
   d. STEMREM 202 Stem Cells and Translational Medicine advanced topics related to individual organ systems, cancer stem cells, translational principles of medicine and immunology as related to regenerative medicine, as well as bioengineering and bioinformatics as related to stem cell biology.
   e. STEMREM 203 Stem Cells Immersion: Applications in Medicine, Business and Law students specialize and choose a clinical immersion, rotation in a biotechnology company or venture firm, or further delve into cutting edge technologies, bioinformatics, materials and/or engineering approaches for stem cell applications in industry, diagnostics and medicine.
   f. STEMREM 250 Regenerative Medicine Seminar Series a forum for researchers to meet and discuss Stem Cell Biology and Regenerative Medicine and to spark collaborations. 6 units of this course is required.
   g. STEMREM 280 Stem Cell Biology and Regenerative Medicine Journal Club review and discussion of current literature in both basic and translational medicine as it relates to stem cell biology and/or regenerative medicine.

3. Students have the option to select from the following courses in the first year:

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<td>BIOS 200</td>
<td>Foundations in Experimental Biology (Offered in</td>
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<td>STEMREM 201A</td>
<td>Stem Cells and Human Development: From Embryo to</td>
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<td>Cell Lineage Determination</td>
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<td>STEMREM 201B</td>
<td>Stem Cells and Human Development Laboratory</td>
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<td>STEMREM 202</td>
<td>Stem Cells and Translational Medicine</td>
<td>3-5</td>
</tr>
<tr>
<td>STEMREM 203</td>
<td>Stem Cells Immersion: Applications in Medicine,</td>
<td>3</td>
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<td>Business and Law</td>
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<tr>
<td>STEMREM 250</td>
<td>Regenerative Medicine Seminar Series</td>
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4. Students are also required to take 2 electives, totaling a minimum of 6 units.
5. Biochemistry proficiency is required by the end of the second year, as well as a total of 80 units and completed qualifying examinations. Students who do not pass the qualifying examination may retake a full qualifying exam, be retested in a few areas, or be asked to redo their presentation.
6. STEMREM 802 TGR Dissertation.

Students unable to meet Ph.D. milestones after remediation are offered a M.S. degree if they have completed all requirements.

Program Director: Theo D. Palmer

Program Co-Directors: Margaret T. Fuller, Irving L. Weissman and Joanna Wysocka

Teaching Faculty:

- Arash A. Alizadeh (Assistant Professor, Medicine/Oncology and Member of Bio-X, Child Health Research Institute and Stanford Cancer Institute)
- Philip A. Beachy (Professor, Institute for Stem Cell Biology and Regenerative Medicine, Department of Biochemistry and Developmental Biology and Member of Bio-X and Stanford Cancer Institute)
- Samuel Cheshier (Assistant Professor, Neurosurgery and (by courtesy) Neurology & Neurological Sciences and Member of Bio-X, Child Health Research Institute and Stanford Cancer Institute)
- Michael F. Clarke (Professor, Institute for Stem Cell Biology and Regenerative Medicine and Department of Medicine/Oncology and Member of Bio-X and Stanford Cancer Institute)
- Tushar Desai (Assistant Professor, Medicine/Pulmonary & Critical Care Medicine and Member of Bio-X, Child Health Research Institute and Stanford Cancer Institute)
- Maximilian Diehn (Assistant Professor, Radiation Oncology/Radiation Therapy and Member of Bio-X and Stanford Cancer Institute)
- Margaret T. Fuller (Professor, Developmental Biology, Genetics and Obstetrics & Gynecology/Reproductive Biology and Member of Bio-X, Child Health Research Institute and Stanford Cancer Institute)
- Sarah C. Heilshorn (Associate Professor, Materials Science and Engineering and (by courtesy) Chemical Engineering and Member of Bio-X, Child Health Research Institute and Stanford University)
- Stefan Heller (Professor, Otolaryngology/Head and Neck Surgery and Member of Bio-X, Stanford Cancer Institute and Stanford Neurosciences Institute)
- Michael T. Longaker (Professor, Surgery/Plastic and Reconstructive Surgery, and (by courtesy) Bioengineering and Materials Science and Engineering and Member of Bio-X, Child Health Research Institute and Stanford Cancer Institute)
- Ravindra Majeti (Associate Professor, Medicine/Hematology and Member of Bio-X and Stanford Cancer Institute)
- Michelle Monje-Deisseroth (Assistant Professor, Neurology & Neurological Sciences and Member of Bio-X, Child Health Research Institute, Stanford Cancer Institute and Stanford Neurosciences Institute)
- Hiromitsu Nakauchi (Professor, Institute for Stem Cell Biology and Regenerative Medicine and Department of Genetics and Member of Bio-X)
- Roeland Nusse (Professor, Developmental Biology and Member of Bio-X and Stanford Cancer Institute)
- Anthony Oro (Professor, Dermatology and Member of Bio-X, Child Health Research Institute and Stanford Cancer Institute)
- Theo D. Palmer (Associate Professor, Neurosurgery and Member of Bio-X, Child Health Research Institute, Stanford Cancer Institute and Stanford Neurosciences Institute)
- Sergiu Pasca (Assistant Professor, Psychiatry & Behavioral Sciences/Stanford Center for Sleep Sciences & Medicine and Member of Bio-X, Child Health Research Institute and Stanford Neurosciences Institute)
- Matthew Porteus (Associate Professor, Pediatrics/Stem Cell Transplantation and Member of Bio-X, Cardiovascular Institute, Child Health Research Institute and Stanford Cancer Institute)
- Maria Grazia Roncarolo (Professor, Pediatrics/Stem Cell Transplantation and Medicine/Blood & Marrow Transplantation and Member of Bio-X, Child Health Research Institute and Stanford Cancer Institute)
- Vittorio Sebastiano (Assistant Professor, Obstetrics & Gynecology/Reproductive Biology and Member of Bio-X and Child Health Research Institute)
- Judith Shizuru (Professor, Medicine/Blood & Marrow Transplantation and Member Stanford Cancer Institute)
- Irving L. Weissman (Professor, Institute for Stem Cell Biology and Regenerative Medicine, Department of Pathology and Developmental Biology and (by courtesy) Department of Biology and Member of Bio-X and Stanford Cancer Institute)
- Marius Wernig (Associate Professor, Institute for Stem Cell Biology and Regenerative Medicine and Department of Pathology and (by courtesy) Chemical & Systems Biology and Member of Bio-X, Child Health Research Institute, Stanford Cancer Institute and Stanford Neurosciences Institute)
- Joseph C. Wu (Professor, Medicine/Cardiovascular Medicine and Radiology and Director, Cardiovascular Institute and Member of Bio-X, Child Health Research Institute and Stanford Cancer Institute)
- Sean M. Wu (Associate Professor, Medicine/Cardiovascular Medicine and (by courtesy) Pediatrics and Member of Bio-X, Cardiovascular Institute and Child Health Research Institute)
- Joanna Wysocka (Professor, Chemical & Systems Biology and Developmental Biology and Member Bio-X and Stanford Cancer Institute)

Courses

STEMREM 83Q. The Stem Cell: Biological, Social, and Practical Aspects of Stem Cell Research. 3 Units.
Preference to sophomores. Ethical, legal, social, and economic dimensions of stem cell research such as the discovery of human embryonic stem cells and the international landscape of public policy. How stem cells work, their role in the upkeep of the human body, and current and future uses in medicine. Issues at the intersection of science and society such as human-animal hybrids, notions of justice in intellectual property law, distribution of health care, and the major ethical frameworks defining the debate. Prerequisite: AP Biology.

STEMREM 199. Undergraduate Research. 1-18 Unit.
Students undertake investigations sponsored by individual faculty members. Prerequisite: consent of instructor.

STEMREM 200. Stem Cell Intensive. 1 Unit.
Open to first year Stem Cell Biology and Regenerative Medicine graduate students or consent of Instructor. Hands-on, five-day immersion to learn basic methods of tissue culture, mouse embryo fibroblast (MEF) preparation, embryonic stem and induced pluripotent stem (ES/iPS) cell culture, differentiation, DNA isolation, polymerase chain reaction (PCR), sequencing, and basic microscopy.
STEMREM 201A. Stem Cells and Human Development: From Embryo to Cell Lineage Determination. 1-3 Unit.
For graduate, undergraduate and medical students. Offers didactic lectures focused on human developmental biology, derivation of pluripotent stem cells, cell sorting, genomics, bioinformatics, imaging and other related topics. Provides the educational foundation and social group building within each first-year class of STEMREM graduate students. Students enrolling for 1 unit attend all lectures; students enrolling for 2 units attend all lectures and discussion sections.

STEMREM 201B. Stem Cells and Human Development Laboratory. 1 Unit.
Targeted enrollment to first year graduate students or any other student who wishes to improve their ability to design, perform, analyze, and communicate results from laboratory based experiments. Content early in the quarter is focused on how to design an experimental aim and approach. Practical examples are drawn from the participating students' fall-quarter research rotations (or current research projects). In mid-quarter, the focus shifts from how to design the experiment to how to update the PI on this week's experimental progress and the weekly meeting emulates a typical lab meeting with brief presentations of experimental progress from each student. Focus shifts at the end of the quarter to strategies for concise presentation of data and conclusions drawn from experimental results. Provides hands-on skills to maximize both the student's experience during a research rotation and improve communication skills between student and mentor (skills that are valuable to any student at any stage of their research career). SCBRM students must take concurrently with STEMREM 201A.

STEMREM 202. Stem Cells and Translational Medicine. 3-5 Units.
For graduate, undergraduate and medical students. Focus is on fundamentals of stem cell biology and regenerative Medicine. Topics include exploration of the well-studied system of hematopoiesis, molecular pathways of pluripotency and tissue-specific stem cells and ends with coverage of aging as related to stem cell dynamics. Features include lectures on the basic science of each topic, followed by clinical applications in order to show the mechanisms and methods to translate findings to therapeutic applications, culminated with construction of a research proposal or business plan in an area of interest, to be further explored in STEMREM 203. Students enrolling for 3 units submit four of seven problem-sets; students enrolling for 4 units submit five of seven problem-sets; students enrolling for 5 units turn in seven of seven problem-sets.

STEMREM 203. Stem Cells Immersion: Applications in Medicine, Business and Law. 3 Units.
For graduate and medical students. Provides the clinical, pharmaceutical, biotechnology or business immersion necessary to allow insight into the world of medicine from multiple vantage points, setting the stage for students to translate research successfully beyond the academic sphere and gain the necessary knowledge to move their research proposal/business plan forward (from STEMREM 202). Prerequisites: STEMREM 201A and STEMREM 202.

STEMREM 250. Regenerative Medicine Seminar Series. 1 Unit.
For graduate, medical and undergraduate students. A forum for Stanford researchers to meet, hear about what is going on in Stem Cell Biology and Regenerative Medicine at Stanford, and spark collaborations. Topics include all areas of regenerative medicine, broadly defined, ranging from fundamental biological principles and basic science advances to novel applications in biotechnology, stem cell biology, and human disease.