

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://exploreddegrees.stanford.edu/graduatedegrees>)s" 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
STEMREM 200	Stem Cell Intensive	1
BIOS 200	Foundations in Experimental Biology	6
STEMREM 201A	Stem Cells and Human Development: From Embryo to Cell Lineage Determination	1-2
STEMREM 201B	Stem Cells and Human Development Laboratory	3
STEMREM 202	Stem Cells and Translational Medicine	3-5
STEMREM 203	Stem Cells Immersion: Applications in Medicine, Business and Law	3
STEMREM 250	Regenerative Medicine Seminar Series	1
STEMREM 280	Stem Cell Biology and Regenerative Medicine Journal Club	2
BIOC 224/BIO 214/MCP 221	Advanced Cell Biology	4
GENE 205	Advanced Genetics	3

MED 255	The Responsible Conduct of Research	1
DBIO 210	Developmental Biology	4
STEMREM 399	Graduate Research	1-18
Total Units		33-53

- 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://exploreddegrees.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:

		Units
STEMREM 200	Stem Cell Intensive	1
BIOS 200	Foundations in Experimental Biology (Offered in Autumn and Spring)	6
STEMREM 201A	Stem Cells and Human Development: From Embryo to Cell Lineage Determination	1-2
STEMREM 201B	Stem Cells and Human Development Laboratory	3
STEMREM 202	Stem Cells and Translational Medicine	3-5
STEMREM 203	Stem Cells Immersion: Applications in Medicine, Business and Law	3

STEMREM 250	Regenerative Medicine Seminar Series	1
STEMREM 280	Stem Cell Biology and Regenerative Medicine Journal Club	2
BIOC 224/BIO 214/MCP 221	Advanced Cell Biology	4
GENE 205	Advanced Genetics	3
MED 255	The Responsible Conduct of Research	1
DBIO 210	Developmental Biology	4
STEMREM 399	Graduate Research	1-18
Total Units		33-53

- Students are also required to take 2 electives, totaling a minimum of 6 units.
- 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.
- 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 Fuller, Irving L. Weissman, Joanna Wysocka,

Teaching Faculty:

- Philip A. Beachy (Professor, Institute for Stem Cell Biology and Regenerative Medicine, Department of Biochemistry and Developmental Biology)
- 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)
- Maximilian Diehn (Assistant Professor, Institute for Stem Cell Biology and Regenerative Medicine and Department of Radiation Oncology/Radiation Therapy and Member of the Stanford Cancer Institute)
- Margaret Fuller (Reed-Hodgson Professor in Human Biology and Professor of Genetics, Member of the Stanford Cancer Institute)
- Sarah C. Heilshorn (Assistant Professor, Materials Science and Engineering, Professor (by courtesy), Chemical Engineering and Bioengineering and Member of Bio-X)
- Michael T. Longaker (Professor, Institute for Stem Cell Biology and Regenerative Medicine and Department of Surgery/Plastic and Reconstructive Surgery, Professor (by courtesy), Bioengineering and Materials Science and Engineering/Engineering Materials and Science and Member of Bio-X and Stanford Cancer Institute)
- Ravindra Majeti (Assistant Professor, Institute for Stem Cell Biology and Regenerative Medicine and Department of Medicine/Hematology and Member of Bio-X and Stanford Cancer Institute)
- Michelle Monje-Deisseroth (Assistant Professor, Institute for Stem Cell Biology and Regenerative Medicine and Neurology and Neurological Sciences and Member of Bio-X and Child Health Research Institute)
- Hiroimitsu Nakauchi (Professor, Institute for Stem Cell Biology and Regenerative Medicine and Department of Genetics)
- Roeland Nusse (Professor, Institute for Stem Cell Biology and Regenerative Medicine and Department of Developmental Biology and Member of Bio-X and Stanford Cancer Institute)
- Theo D. Palmer (Associate Professor, Institute for Stem Cell Biology and Regenerative Medicine and Department of Neurosurgery and Member of Bio-X and Stanford Cancer Institute)
- Maria-Grazia Roncarolo (George D. Smith Professor, Institute for Stem Cell Biology and Regenerative Medicine and Department of Medicine)
- Vittorio Sebastiano (Assistant Professor, Institute for Stem Cell Biology and Regenerative Medicine and Department of OBGYN and Member of the Stanford Cancer Institute)
- Irving L. Weissman (Professor, Institute for Stem Cell Biology and Regenerative Medicine, Department of Pathology and Developmental Biology, Professor (By courtesy) Department of Biology and Member of Bio-X and Stanford Cancer Institute)
- Marius Wernig (Assistant Professor, Institute for Stem Cell Biology and Regenerative Medicine and Department of Pathology and Member of Bio-X)
- Joseph Wu (Stanford Cardiovascular Institute and Professor in the Department of Medicine (Cardiology) and Department of Radiology (Molecular Imaging Program))
- Joanna Wysocka (Assistant Professor, Institute for Stem Cell Biology and Regenerative Medicine, Department of Chemical and Systems Biology and Developmental Biology and Member of the 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. 1-2 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. 3 Units.

Limited enrollment restricted to first year majors. Lab fee may apply. Focus is on human development from embryo to cell lineage determination. Emphasis is on human developmental biology, derivation of pluripotent stem cells, cell sorting, genomics, bioinformatics, imaging and other related topics. Comprehensive laboratory-based instruction focused on human developmental biology, derivation of pluripotent stem cells, cell sorting, genomics, bioinformatics, imaging and other related topics. Provides hands-on skills development within each first-year class of STEMREM graduate students. Must be taken 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.

STEMREM 280. Stem Cell Biology and Regenerative Medicine Journal Club. 2 Units.

For graduate, medical and undergraduate students. Review of current literature in both basic and translational medicine as it relates to stem cell biology and/or regenerative medicine in a seminar format consisting of both faculty and student presentations. Includes discussions led by faculty experts in the area covered for that particular session. Topics may range widely, depending on the available literature and students' interests. Students are expected to review the chosen article before class presentations and participate in discussion. Discussion includes methodology and statistical analysis of each study and its relevance to stem cell biology and/or regenerative medicine.

STEMREM 281. Landmark Papers in Immunology and Stem Cell Biology: How to Pose Experimental Questions. 2 Units.

Focus on deciphering article titles to accurately assess the biological question being asked, and what experiment design might best approach the question, encouraging students to become experimentalists, not memorizers, of information presented by authors. Topics include implications of paper questions for the field, deciphering paper titles, hypothesizing research questions.

STEMREM 299. Directed Reading in Stem Cell Biology and Regenerative Medicine. 1-18 Unit.

Prerequisite: consent of instructor.

STEMREM 370. Medical Scholars Research. 4-18 Units.

Provides an opportunity for student and faculty interaction, as well as academic credit and financial support, to medical students who undertake original research. Enrollment is limited to students with approved projects.

STEMREM 399. Graduate Research. 1-18 Unit.

Students undertake investigations sponsored by individual faculty members. Prerequisite: consent of instructor.

STEMREM 801. TGR Project. 0 Units.

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STEMREM 802. TGR Dissertation. 0 Units.

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