

# SYSTEMS, SYNTHETIC AND PHYSICAL BIOLOGY

## Contact Information

**Systems, Synthetic and Physical Biology**

<https://sspb.rice.edu/>

170 BioScience Research Collaborative

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**Jonathan J. (Joff) Silberg**

Program Director

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Systems, Synthetic and Physical Biology (SSPB) is a new discipline that draws upon principles from physics, chemistry, engineering, and mathematics and integrates experimental biochemical, cell biological, and molecular genetics approaches with computational design, simulation, and modeling to anticipate the properties of complex and multiscale biological systems. As a unique graduate program, SSPB represents a cooperative effort by faculty in the Schools of Natural Sciences and Engineering to provide training in this highly interdisciplinary field. This program is overseen by the Synthetic Biology Institute and a steering committee composed of members from any of the participating departments.

The interdisciplinary nature of the SSPB program allows students to achieve their graduate degree requirements by taking select classes from any of the participating departments and performing their thesis research under the supervision of any faculty associated with the program.

Systems, Synthetic and Physical Biology does not currently offer an academic program at the undergraduate level.

## Master's Program

- Master of Science (MS) Degree in the field of Systems, Synthetic and Physical Biology\*

## Doctoral Program

- Doctor of Philosophy (PhD) Degree in the field of Systems, Synthetic and Physical Biology. (<https://ga.rice.edu/programs-study/departments-programs/engineering/systems-synthetic-physical-biology/systems-synthetic-physical-biology-phd/>)

\* Although students are not normally admitted to a Master of Science (MS) degree program, graduate students may earn the MS as they work towards the PhD.

## Director

Jonathan J. Silberg, *BioSciences*

## Professors

Caroline Ajo-Franklin, *BioSciences*

Pedro J.J. Alvarez, *Civil and Environmental Engineering*

Gang Bao, *Bioengineering*

Matthew Bennett, *BioSciences*

Oleg A. Igoshin, *Bioengineering*

Lydia Kavraki, *Computer Science*

Marek Kimmel, *Statistics*

Anatoly B. Kolomeisky, *Chemistry*

Frederick C. MacKintosh, *Chemical and Biomolecular Engineering*

Caroline A. Masiello, *Earth, Environmental and Planetary Sciences*

Luay K. Nakhleh, *Computer Science*

Edward P. Nikonowicz, *BioSciences*

Jose Nelson Onuchic, *Physics and Astronomy*

George Phillips, *BioSciences*

Jacob Robinson, *Electrical and Computer Engineering*

Ka-Yiu San, *Bioengineering*

Laura Segatori, *Bioengineering*

Yousif Shamoo, *BioSciences*

Jonathan J. Silberg, *BioSciences*

Jeffrey J. Tabor, *Bioengineering*

Yizhi Jane Tao, *BioSciences*

Peter G. Wolynes, *Chemistry*

## Associate Professors

Michael Diehl, *Bioengineering*

Ching-Hwa Kiang, *Physics and Astronomy*

Natasha Kirienko, *BioSciences*

Robert M. Raphael, *Bioengineering*

Hans Renata, *Chemistry*

Jacob Robinson, *Electrical and Computer Engineering*

Todd Treangen, *Computer Science*

Omid Veisheh, *Bioengineering*

Aryeh Warmflash, *BioSciences*

Han Xiao, *Chemistry*

Chong Xie, *Electrical and Computer Engineering*

## Assistant Professors

Caleb Bashor, *Bioengineering*

James Chappell, *BioSciences*

Mingjie Dai, *Bioengineering*

Marcos H. de Moraes, *BioSciences*

Yang Gao, *BioSciences*

Anna-Karin Gustavsson, *Chemistry*

Isaac Hilton, *Bioengineering*

Laura Lavery, *BioSciences*

Lei Li, *Electrical and Computer Engineering*

Theresa Loveless, *BioSciences*

George Lu, *Bioengineering*

Lan Luan, *Electrical and Computer Engineering*

Lauren Stadler, *Civil and Environmental Engineering*

Jerzy Szablowski, *Bioengineering*

Evelyn Tang, *Physics and Astronomy*

Ross Thyer, *Chemical and Biomolecular Engineering*

Todd Treangen, *Computer Science*

Rosa Uribe, *BioSciences*

Omid Veisheh, *Bioengineering*

Julea Vlassakis, *Bioengineering*

Han Xiao, *Chemistry*

Vicky Yao, *Computer Science*

## Adjunct Professors

Bryn Adams, *Institute of Biosciences and Bioengineering*

Jimmy Gollihar, *BioSciences*

Herbert Levine, *Bioengineering*

Jianpeng Ma, *Bioengineering*  
 Susan M. Rosenberg, *BioSciences*  
 François St-Pierre, *Electrical and Computer Engineering*  
 Junghae Suh, *Bioengineering*

*For Rice University degree-granting programs:*

To view the list of official course offerings, please see [Rice's Course Catalog](https://courses.rice.edu/admweb/!SWKSCAT.cat?p_action=cata) ([https://courses.rice.edu/admweb/!SWKSCAT.cat?p\\_action=cata](https://courses.rice.edu/admweb/!SWKSCAT.cat?p_action=cata)).

To view the most recent semester's course schedule, please see [Rice's Course Schedule](https://courses.rice.edu/admweb/!SWKSCAT.cat) (<https://courses.rice.edu/admweb/!SWKSCAT.cat>).

## Systems/Synthetic/Phys Biology (SSPB)

### SSPB 501 - PHYSICAL BIOLOGY

**Short Title:** PHYSICAL BIOLOGY

**Department:** Systems/Synthetic/Phys Biology

**Grade Mode:** Standard Letter

**Course Type:** Lecture

**Credit Hours:** 3

**Restrictions:** Enrollment is limited to Graduate level students.

**Course Level:** Graduate

**Description:** Basic introduction to a biophysical view of living systems, from the subcellular to the multicellular scales. Topics include: biomolecular dynamics, cellular biomechanics, cell motility and cell division, calcium signaling, action potential propagation, and tissue organization. Cross-list: BIOE 502, BIOS 505.

### SSPB 502 - INTRO COMPUTATIONAL SYSTEMS BIOLOGY: MODELING & DESIGN PRINCIPLES OF BIOCHEM NETWORKS

**Short Title:** INTRO SYSTEMS BIOLOGY MODELING

**Department:** Systems/Synthetic/Phys Biology

**Grade Mode:** Standard Letter

**Course Type:** Lecture

**Credit Hours:** 3

**Restrictions:** Enrollment is limited to Graduate level students.

**Course Level:** Graduate

**Description:** The course summarizes techniques for quantitative analysis and simulations of basic circuits in genetic regulation, signal transduction, and metabolism. The class is based on MATLAB, with a brief refresher provided at the beginning. We discuss engineering approaches adapted to computational systems biology and aim to formulate evolutionary design principles explaining the organization of networks in terms of their physiological demands. Topics include end-product inhibition in biosynthesis, optimality and robustness of the signaling networks, and kinetic proofreading. The topics covered include modeling of enzyme kinetics, biochemical reaction networks, gene regulation, stochasticity of gene expression, and evolutionary and epidemiological population dynamics. The final project focuses on modeling synthetic biology circuits. Instructor Permission Required. Cross-list: BIOE 552. Recommended Prerequisite(s): Basic knowledge of biochemistry, cell biology, linear algebra, and ordinary differential equations is expected. Experience with MATLAB or Python programming is highly recommended.

### SSPB 503 - SYNTHETIC BIOLOGY

**Short Title:** SYNTHETIC BIOLOGY

**Department:** Systems/Synthetic/Phys Biology

**Grade Mode:** Standard Letter

**Course Type:** Lecture

**Credit Hours:** 3

**Restrictions:** Enrollment is limited to Graduate level students.

**Course Level:** Graduate

**Description:** Design of biology at scales from molecules to multicellular organisms will be covered by lecture, primary literature, and student presentations. Students will write a research proposal at the end of the course. Cross-list: BIOE 508.

### SSPB 550 - GRADUATE SEMINAR

**Short Title:** GRADUATE SEMINAR

**Department:** Systems/Synthetic/Phys Biology

**Grade Mode:** Satisfactory/Unsatisfactory

**Course Type:** Seminar

**Credit Hour:** 1

**Restrictions:** Enrollment is limited to students with a major in Systems/Synthetic/Phys Biology. Enrollment is limited to Graduate level students.

**Course Level:** Graduate

**Description:** Seminar course to introduce SSPB students to current research topics and activities in the systems, synthetic, and physical biology fields. Repeatable for Credit.

### SSPB 575 - INTRODUCTION TO RESEARCH

**Short Title:** INTRODUCTION TO RESEARCH

**Department:** Systems/Synthetic/Phys Biology

**Grade Mode:** Satisfactory/Unsatisfactory

**Course Type:** Research

**Credit Hours:** 3

**Restrictions:** Enrollment is limited to students with a major in Systems/Synthetic/Phys Biology. Enrollment is limited to Graduate level students.

**Course Level:** Graduate

**Description:** Introduction of first-year graduate students to the research programs and laboratories of individual faculty members. Repeatable for Credit.

### SSPB 599 - GRADUATE TEACHING IN SSPB

**Short Title:** GRADUATE TEACHING IN SSPB

**Department:** Systems/Synthetic/Phys Biology

**Grade Mode:** Satisfactory/Unsatisfactory

**Course Type:** Internship/Practicum

**Credit Hour:** 1

**Restrictions:** Enrollment is limited to Graduate level students.

**Course Level:** Graduate

**Description:** Supervised instruction in teaching systems, synthetic, and physical biology. Repeatable for Credit.

### SSPB 601 - NAVIGATING INTERDISCIPLINARY TEAMS IN SCIENCE AND ENGINEERING

**Short Title:** INTERDISCIPLINARITY I

**Department:** Systems/Synthetic/Phys Biology

**Grade Mode:** Standard Letter

**Course Type:** Seminar

**Credit Hour:** 1

**Restrictions:** Enrollment is limited to Graduate level students.

**Course Level:** Graduate

**Description:** Covers team science literature on the assumptions that guide scientific practice, communication, and group integration. Instructor Permission Required.

**SSPB 602 - INNOVATIONS AND CHALLENGES IN BIOELECTRONICS RESEARCH****Short Title:** INTERDISCIPLINARITY II**Department:** Systems/Synthetic/Phys Biology**Grade Mode:** Standard Letter**Course Type:** Seminar**Credit Hour:** 1**Restrictions:** Enrollment is limited to Graduate level students.**Course Level:** Graduate**Prerequisite(s):** SSPB 601**Description:** Covers literature on past biotechnological innovations that required interdisciplinary collaboration for success. Instructor Permission Required.**SSPB 610 - INTERDISCIPLINARY BIOELECTRONICS RESEARCH COLLOQUIUM****Short Title:** BIOELECTRONICS COLLOQUIUM**Department:** Systems/Synthetic/Phys Biology**Grade Mode:** Satisfactory/Unsatisfactory**Course Type:** Seminar**Credit Hour:** 1**Restrictions:** Enrollment is limited to Graduate level students.**Course Level:** Graduate**Description:** Covers effective oral communication in the interdisciplinary field of bioelectronics. Repeatable for Credit.**SSPB 620 - INTERDISCIPLINARY BIOELECTRONICS PEER WRITING GROUPS****Short Title:** BIOELECTRONICS WRITING**Department:** Systems/Synthetic/Phys Biology**Grade Mode:** Satisfactory/Unsatisfactory**Course Type:** Seminar**Credit Hour:** 1**Restrictions:** Enrollment is limited to Graduate level students.**Course Level:** Graduate**Description:** Covers effective written communication in the interdisciplinary field of bioelectronics. Repeatable for Credit.**SSPB 677 - SPECIAL TOPICS****Short Title:** SPECIAL TOPICS**Department:** Systems/Synthetic/Phys Biology**Grade Mode:** Standard Letter**Course Type:** Lecture/Laboratory, Independent Study, Internship/Practicum, Laboratory, Lecture, Seminar**Credit Hours:** 1-4**Restrictions:** Enrollment is limited to Graduate or Visiting Graduate level students.**Course Level:** Graduate**Description:** Topics and credit hours vary each semester. Contact department for current semester's topic(s). Repeatable for Credit.**SSPB 700 - INTERDISCIPLINARY BIOELECTRONICS RESEARCH****Short Title:** BIOELECTRONICS RESEARCH**Department:** Systems/Synthetic/Phys Biology**Grade Mode:** Satisfactory/Unsatisfactory**Course Type:** Research**Credit Hours:** 1-3**Restrictions:** Enrollment is limited to Graduate level students.**Course Level:** Graduate**Description:** Covers research in the interdisciplinary field of bioelectronics. Repeatable for Credit.**SSPB 800 - GRADUATE RESEARCH****Short Title:** GRADUATE RESEARCH**Department:** Systems/Synthetic/Phys Biology**Grade Mode:** Satisfactory/Unsatisfactory**Course Type:** Research**Credit Hours:** 1-15**Restrictions:** Enrollment is limited to students with a major in Systems/Synthetic/Phys Biology. Enrollment is limited to Graduate level students.**Course Level:** Graduate**Description:** Graduate students will conduct independent research/thesis project under the direction of their advisor. Repeatable for Credit.

## Description and Code Legend

**Note:** Internally, the university uses the following descriptions, codes, and abbreviations for this academic program. The following is a quick reference:

### Course Catalog/Schedule

- Course offerings/subject codes: Courses from various subjects may apply towards this program

### Department (or Program) Description and Code

- Systems, Synthetic and Physical Biology: SSPB

### Graduate Degree Descriptions and Codes

- Master of Science degree: MS
- Doctor of Philosophy degree: PhD

### Graduate Degree Program Description and Code

- Degree Program in Systems, Synthetic and Physical Biology: SSPB

### CIP Code and Description <sup>1</sup>

- **SSPB Major/Program:** CIP Code/Title: 30.0101 - Biological and Physical Sciences

<sup>1</sup> Classification of Instructional Programs (CIP) 2020 Codes and Descriptions from the National Center for Education Statistics: <https://nces.ed.gov/ipeds/cipcode/>