PhD Program in Computational and Systems Biology

Preamble

Computational and systems biology (an interdisciplinary field that applies the techniques of computer science, applied mathematics and statistics to address biological problems) has changed the landscape of modern biology research. Universities and institutes in Singapore have been developing their strengths in different aspects of computational and systems biology. At this stage, it will be beneficial to integrate these efforts and develop a strong graduate program. This proposal aims to deal with this issue.

Rationale

Due to advances in high-throughput genomics and proteomics technology, bio-imaging, etc, the amount of experimental data generated is increasing exponentially. To analyze this data, Singapore-based companies such as Eli Lily and Novartis are expanding their research teams. Universities and A*STAR institutes (like GIS and BII) are also recruiting more computational and systems biology specialists. In addition to Singapore, other Asian countries like Japan and China are expanding their manpower in computational and systems biology. It is anticipated that the manpower requirement in computational and systems biology in Asia will increase steadily over the years.

The development of computational and systems biology is also relevant to the Government's push to develop bio-economy as the next pillar of growth where the potential of bio-prospecting, applied functional genomics, personalized medicine, clinical decision, and pharmacy information and management, etc is very significant. In view of these factors, it is important to move fast and establish an integrated PhD program to train the best talents who can serve Singapore and the regional needs.

A number of research groups in NUS, NTU, and A*STAR have already been established with their primary approach based on computational and systems biology. These groups are focused on genomic sequence analysis, proteomic data analysis, microarray data analysis, phylogenetic analysis, comparative genomic, imaging data analysis, population genetic, bio-pathways simulation, etc. The biological questions being targeted include virus transmission, vaccine development, cancer treatment and prevention, stem cell research, aging problem, etc. By linking up the various research groups in Singapore, we can develop an inter-disciplinary program that will produce a new generation of computational and systems biology specialists to tackle future challenges.

Objectives

Computational and systems biology is becoming an important stream in biomedical research. Currently, there is no PhD program specializing in computational and systems biology at NUS or other institutions. Students need to join the PhD program of either life science-related or computer science-related departments. As a result, the students mainly focus on either the life science or the computer science components and there is a lack of an integrated graduate program.

Potential participating Institutions

- ✓ National University of Singapore
  (Coordinator: Wing-Kin Sung)

- ✓ Duke-NUS Graduate Medical School
  (Coordinator: Steve Rozen)

- ✓ Temasek Life Sciences Laboratory
  (Coordinator: Laszlo Orban)

- ✓ A*STAR, Biopolis
  (Coordinator: Vladimir A. Kuznetsov (BII) and Guillaume Bourque (GIS))

- ✓ Nanyang Technological University
  (Coordinator: Xin Chen)

Besides the coordinators, there are many investigators and faculty members who can be outstanding supervisors and contributors to novel coursework. They include:

National University of Singapore:
FoS: Chen Yu Zong, Zhang Louxin, Christopher Hogue
SoM: Peter Little, Tan Tin Wee, Fu Xin-Yuan,
SoC: Wong Lim Soon, P S Thiagarajan, Wing-Kin Sung, David Hsu, Leong Hon Wai, Anthony Tung
NGS: Tom Fox, Li Baowen

Duke-NUS Graduate Medical School: Steve Rozen

Temasek Life Sciences Laboratory: Jose R. Dinneny, Greg Jedd, Snezhana Oliferenko, Laszlo Orban

A*STAR, Biopolis: Dong Yup Lee, Guillaume Bourque, Shyam Prabhakar, Vladimir A. KUZNETSOV, Frank Eisenhaber, Ng See Kiong, Li Xiaoli, B. Venkatesh

Nanyang Technological University: Xin Chen, Jagath Rajapakse, Jinyan Li

The postgraduate program

This program is structured to provide a strong and specific foundation for students to acquire sufficient skills and knowledge to further their research in computational and systems biology. Since a majority of the targeted candidates will be primarily trained in either (1) life sciences or (2) computing/mathematics, immigration modules in both disciplines are incorporated to bridge any deficiencies in these students. Students will acquire basic skills and knowledge through the core and foundation modules. For hands-on and more specific skills, students can acquire them through lab rotations.

In detail, the general structure will be as follows.

1. All students need to identify two supervisors from two different departments or institutes. (The main supervisor should guide the student to identify the second supervisor.)
2. All students need to take two core computational and systems biology modules (see (A) below) to acquire sufficient knowledge and skills.
3. All students need to take two modules from the foundation for computing/statistics (see (B) below) unless they pass the pre-screening test for computing/statistics.
4. Students without basic background in biology, computing, and statistics will be encouraged to read appropriate immigration modules before beginning the core and foundation modules (see (C)).
5. All students are required to do at least one lab rotation (see (D) below). (For students who do not have evidence that they have wet-lab experience, one of their lab rotations must have a web-lab component.)
6. The guideline for passing qualifier examination and final defense follows the NGS standard guideline.

(A) Core Computational and systems biology modules

- ✓ CS5238 Advanced Combinatorial Methods in Bioinformatics
- ✓ CS4220 Knowledge Discovery Methods in Bioinformatics
- ✓ CS6280 Special Topics in Computer Science on Computational Systems Biology
- ✓ CZ5225 Computational Biology: Modeling & Simulation
- ✓ CZ5226 Advanced Bioinformatics
- ✓ MA5264 Computational Molecular Biology
- ✓ ST5217 Statistical Methods for Genetic Analysis

(B) Foundation for computing/statistics

- ✓ CS5206 Foundation in Algorithms
- ✓ CS5228 Knowledge Discovery in Databases
- ✓ CS5233 Simulation and Modelling Techniques
- ✓ ST5201 Basic Statistical Theory
- ✓ PC5202 Advanced Statistical Mechanics

(C) Immigration modules

LS electives:

- ✓ LCM1101 Biochemistry of Biomolecules
- ✓ LSM2102 Molecular Biology
- ✓ LSM2103 Cell Biology
- ✓ LSM2202 Experimental Molecular and Cell Biology
- ✓ LSM4241 Functional Genomics

CS/Math electives:

- ✓ CS1020 Data Structures and Algorithms 1 or CS2020 Data Structures and Algorithms Accelerated
- ✓ ST1232 Probability and Statistics
- ✓ CS2102 Introduction to Database Systems
- ✓ MA3233 Graph Algorithms
- ✓ CS3230 Design and Analysis of Algorithms
- ✓ CS3244 Machine Learning
- ✓ CS3243 Introduction to Artificial Intelligence

Computational and systems biology electives:

- ✓ CS2220 Introduction to Bioinformatics
- ✓ ST2238 Introductory Biostatistics
- ✓ LSM3241 Bioinformatics and Biocomputing
- ✓ MA3259 Mathematical Methods in Genomics
- ✓ CS4220 Knowledge Discovery methods in Bioinformatics
- ✓ ST4243 Statistical Methods for DNA Microarray Analysis

(D) Lab rotation

The aim of lab rotation is to let the students to learn the state-of-the-art concept and the research skill through hand-on practice. Leveraging on the strengths of our universities and institutes, this is one of the important components in our graduate program.

With the help of the supervisor, the student will identify a mentor and participate in the lab for 1 semester. During the semester, the mentor will supervise the student to finish a small project. At the end of the lab rotation, the student needs

to write a report. The mentor and one internal examiner will evaluate the student and give a grade for the student.

Targeted number of students

Following the NGS model, we aim to recruit undergraduate students with good academic record and potential for research. The student should be a major in life science, mathematics, or computing. All the short-listed students will be interviewed.

Number of scholarships offered per year: 10 NGS-type scholarships

Targeted start-date of the program

August 2010
Length of scholarship: 4 year*