

The topmaster

BioMolecular Integration / Systems Biology *(BMISB)*

Free University Amsterdam (VUA)

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Embedding

The scientific area

With the sequences of entire genomes having become available, and with the possibility to measure changes in the amounts of all messenger RNA's, proteins, and metabolites, we all of sudden envisage the possibility to really understand the functioning of living cells and organisms. This understanding will lead to a much improved combat against and treatment of diseases, to a much better, cheaper, and safer production of many food and chemical substances by living organisms, as well as to decreased challenges of the environment by those production processes. The all-time aim of Biology, i.e. understanding the phenomenon of life itself comes within reach and so does an important aim of physics and chemistry to understand the molecular processes that are at the basis of life. The coming scientific generation will be able to meet these challenges.

How the tens of thousands types of molecules determine the functioning of the living cell through their interactions is the topic of a new area of scientific research that is internationally becoming famous as Systems Biology. The complexity of the interactions requires the application of mathematical techniques and bioinformatics. The subtleties of these interactions necessitate the application of the most modern biophysical and biochemical techniques if possible inside the living cell. The insight one aims for in the functioning of the living cell, demands quantitative cell physiological methodology, whilst the basis in functional genomics makes modern molecular biology and cell biology of great interest. At the moment both in fundamental and applied top research there is a shortage of excellent scientists that cover all these aspects at the same time, understanding, commanding and improving the corresponding techniques and concepts.

The scientific basis: the top research center CRBCS

This master is organized by the Center for Research on BioComplex Systems of the Free University Amsterdam (CRBCS), in collaboration with the Center for Integrative BioInformatics of the Free University (IBIVU). These two institutes emerge from the Faculties (Schools) of Exact Sciences (FEW) and Earth and Life Sciences (FALW) of the Free University Amsterdam (VUA). The CRBCS focuses on the biological complexity that connects the molecular to the cellular level of living systems, with extensions to the multicellular levels of quantitative ecology and human physiology on the one hand, and to the complexity in dead matter on the other hand. It is an institute of scientific research groups that have been selected on the basis of proven excellence and of relevance of their scientific areas for the focus of the CRBCS. The IBIVU is special because of its incorporation of the subarea of bioinformatics that integrates flows of data from various molecular levels and disciplines. The topmaster Biomolecular Integration / Systems Biology is offered by five core professors of the CRBCS and one core professor from the IBIVU, under the directorship of the scientific director of the CRBCS.

International affiliated ('sister') institutes

The topmaster Biomolecular Integration / Systems Biology (BMISB) of the Free University Amsterdam is organized in collaboration with five international scientific academic centers (so-called 'sister institutes') that have been selected on the basis of their excellence in the area of Biomolecular Integration and Systems Biology. From each of these five sister institutes one top scientist will be appointed as international special professor within the CRBCS. Her/his duties will include the teaching in the topmaster, and the functioning as external

examiner, as member of the International Advisory Board, and of the Examination Committee (see below).

The five sister institutes will be selected by the International Advisory Committee on the basis of proven scientific excellence in the areas that are most relevant for the topmaster curriculum, and on the basis of their willingness to operate on a reciprocal basis, guaranteeing the quality of their teaching to students of the Free University Amsterdam.

Research school

This topmaster will be organized from the CRBCS, but in conjunction with the research school BioCentrum Amsterdam (BCA). The students of the topmaster will interact with the Ph.D. students of the BCA during various activities, including seminar days. The masterstudents will also be treated as preferred candidates for the fulfillment of Ph.D. studentships in that school.

Relationships to other Master's programs

The master BMI/SB is the top variant of the accredited FALW-VUA Master's program *Biomolecular Sciences*. As such it parallels the basic variant of the latter. It aims for the more ambitious students who wish to focus more explicitly on Biomolecular Integration, on Systems Biology, and on the interface between the Exact Sciences and the Life Sciences. Students who experience the top variant as too intensive will be able to switch gears and enter the basic variant. Under special conditions the reverse cross over will be possible for ambitious students enrolled in the basic variant. The top variant selects at the entry level (see below).

After the first two months there will be an additional exam (see also below). Those who pass with honors can proceed with the topvariant. Those that just pass can further enroll in the basic variant. The students who fail may wish to reconsider.

The diploma of the curriculum will state:

Master of Biomolecular Sciences (*cum laude*) and Topmaster Molecular Integration/Systems Biology.

The topmaster BMI/SB also aims for the more ambitious students in Master's programs in the Exact Sciences, who are attracted to in-depth applications in the Life Sciences and in Systems Biology. Interfaces between those Master's programs and the topmaster are under investigation.

The Program

Curriculum

The 2 years' (120 ECTS) curriculum looks as follows:

Portal course

Two months' (10 ECTS) entry course for the acquisition of the basic knowledge that the student does not yet avail of: The aim is to make the physics bachelor student sufficiently knowledgeable about Biology and to make the Biology bachelor sufficiently current with physics, chemistry and mathematics. During the course there will be a short introduction to the research groups within the CRBCS and it will be checked whether the expertise of the student may develop to a sound basis for the BMI/SB program. Passing the exam of this portal course with honors is a requirement for following the rest of the topmaster BMI/SB. In case this exam is just passed, the student may want to switch to the basic variant

of Biomolecular Sciences or to a different Master's program offered by the Free University Amsterdam.

Central course (30 ECTS)

A. 6 x 3 weeks (6 x 4 ECTS) intensive course of which each of the core professors teaches 4 ECTS:

- a. **Biomolecular dynamics** (Van Grondelle *et al.*)
- b. **Single molecule biophysics and biochemistry** (nanobiology) (Schmidt *et al.*)
- c. **Chemistry of complex biomolecules** (Van der Vies, Vermeulen *et al.*)
- d. **Molecular genetics in living cells** (Lill *et al.*)
- e. **Intracellular networks** (Westerhoff *et al.*)
- f. **Integrative bioinformatics** (Heringa, Snoep *et al.*)

Each part will be concluded by an exam.

B. One month (6 ECTS) intensive lecture plus tutorial course taught by the five international special professors. Also this will be concluded by an exam. Topics include: silicon cell, mathematical modelling of cellular networks, single molecule fluorescence, essential molecular dynamics.

Science communication (5 ECTS)

A 5 ECTS course in which the following is taught at an advanced international level:

- Maintaining a lab book according to international standards
- Writing scientific articles in perfect English
- Preparation of scientific posters
- Preparation of scientific webpages
- Oral presentations
- Use of databases

International research project (61 ECTS)

A. two months' (11 ECTS) orientation on possible scientific research. Here the student searches for and then defines the research project that she or he will execute subsequently (see below). This will be coached on an individual basis by the student's coach and by the core professor who may become responsible for the research project. The student should interview the other Professors of the institute, consult the literature and visit the sister institutes electronically (3 ECTS). These activities will result in two written reports, both of which will be defended orally. One of these is a literature overview in the form of a mini review (5 ECTS). The other is a short research proposal to be formulated in the format of a 'grant proposal' for the Dutch national science foundation (3 ECTS). Both of these will be judged in terms of quality. The research proposal should be at least bi-disciplinary and aim for a single research project to be executed in two laboratories, *i.e.* one in the CRBCS and one in a sister institution abroad (or in another high quality research group where the research and teaching capabilities have been verified).

B. Half a month (2 ECTS) phase of evaluating and criticizing the research proposals and mini-reviews of the other students.

C. 8 months (41 ECTS) for executing the research project in the two laboratories.

D. 1 month (5 ECTS) reporting on the research project in the form of a scientific article and an oral presentation.

E. The student will be confronted with international conferences, prepares a poster presentation, attends a conference and is involved in organizing a conference (2 ECTS).

Scientific Seminars (3 ECTS)

The student should attend scientific seminars in the host institutes. Of ten seminars a brief, critical report must be made in which a number of questions are being raised which the students should attempt to get answered by the speaker.

Reflection (6 ECTS)

One month course on the backgrounds of modern Biomolecular Sciences and Systems Biology (including philosophy of science, sociology of science, and ethics, on Systems Biology, emergence-reductionism-holism, collaboration between different disciplines, transgenetics, and the role of scientific discovery and of objective experimentation in modern society and politics, the role of industry; with international lecturers).

Exam (5 ECTS)

One month for preparing and executing a comprehensive final exam. The student will be subjected to examination by one of core professors and one of the international professors. The exam will not repeat the examinations of the individual components of the curriculum, but will test the ability of the student to connect the various parts of the curriculum with each other. An example is the connection of the course parts of the program with the research project the student has carried out.

Further aspects of the curriculum

The lecturers

The key components of this curriculum will be taught by a small number of professors (and their direct staff) selected on the basis of their involvement in top research in the Biomolecular Sciences and Systems Biology: there is a preference for intensive personal interactions with a limited number of top researchers over short interactions with many lecturers.

Seminar program

Every two months a renowned scientist will lecture for up to one and a half hour after which he or she will intensively discuss the lecture with the topmaster students. Each student must ask the international scientist at least one scientific question. The student must summarize the seminar critically and report on the answers to the questions in writing. The students that are abroad when the seminar takes place may participate through the broad-band internet connection. The renowned scientist will visit the institute for three days and during two of these he or she will discuss intensively with all second year topmaster students their research projects.

Study group

During the entire curriculum the student will be part of a so-called study group. This study group consists of all students that have started in the same academic year and of students of comparable curricula at the international sister schools. The students will discuss each other's plans for research, the research itself and will also consult each other on scientific and other matters. It is the intention that after the completion of the topmaster this study group will become an international network of young scientists in Systems Biology.

Work discussions

During his research project the student will participate in the regular work discussions of the hosting group. In addition he will participate in monthly work discussions with all the other students of his study group. Each student will use 15 minutes to report on his work. On the same day three scientific articles will be discussed by all students of the study group. These discussion sessions will be attended by at least two professors. The latter have the task of activating the discussions and challenging the students into being critical.

Timing

Depending on the student's financial abilities, the curriculum of 120 ECTS will extend over 2.0 or 2.5 years. In the latter case the student can be involved as a teaching assistant to bachelor students and thus obtain some additional income. The curriculum begins each year on the first Monday of September. Extremely well pretrained students can start two months later. In special cases the student can start at other times in the year. In both cases, formal permission should be obtained from the Examination committee.

Virtual and actual presence

Students will execute research projects at two locations, one in the CRBCS and one in a sister institute abroad. The coaching by the CRBCS professors when the student is abroad and by the foreign professor when the student is at the CRBCS, will be facilitated by frequent discussions through a broadband internet connection. In case the student comes from afar, parts of the standard courses can be followed long distance through the same connection. Lectures and seminars given at the CRBCS will be broadcast over broad-band internet.

Language

The language of the course is American English

Industry

Industry tours will be organized for each student, halfway the second year of the curriculum. The students will give short presentations on their work in the company and will be challenged by questions of company people. Each student will be in contact with at least two companies in this manner.

Organisation of the Master's program

Target student group, entry requirements, selection

The science area of this Master's program is explicitly trans- and interdisciplinary. Students will come from various bachelor curricula from inside and outside the European Union. Influx from mathematics, informatics, physics, chemistry, biochemistry, biophysics, biology, medical biology, and biomedical sciences is aimed for. The diversity of the influx of students will be cultivated in order to come to a scientific melting pot from which the students learn to help each other by intensive collaboration. The entry criteria are tripartite; (i) proven excellence in the bachelor phase in one of the above disciplines, (ii) potential excellence at the level of the other disciplines, to be proven in the first two months of the master's program (*i.e.* in its portal phase), and (iii) proven profound motivation for scientific top research.

(i) will be verified on the basis of a diploma of (a) the Free University Amsterdam bachelors of Biology, Medical Biology, Medical Natural Sciences, Chemistry, Physics and Astronomy, Mathematics or Pharmaceutical sciences with an average grade exceeding 7, (b) a bachelor program of one of the five international sister schools with comparable grades, (c) a bachelor

of the University of Amsterdam, or Hogeschool Windesheim in Biology, Biomedical sciences, Chemistry or Mathematics and Natural sciences with an average grade of 7 or higher, (d) a comparable bachelor from another European institution for higher education (University or Higher Technical School [HBO]), in any of the above disciplines with an average grade of 7.5 or higher or equivalent, (e) any education that is demonstrably equivalent to any of the above, (f) a successful entry exam. The entry exam will be facilitated through an individual preparatory phase, in which the capabilities of the prospective student will be assessed and necessary study material will be suggested. Long distance exams will be offered, which will be finalized by local exams when the student arrives at the CRBCS.

Verification of criterion (ii) will be accomplished by the exam at the end of the portal phase of the Master's program, in which potential excellence in all mentioned basic disciplines should be demonstrated by the student. Failing this second criterion the student may switch to one of the basic master curricula of the Free University Amsterdam, in particular to that of the basic variant of the Master's Biomolecular Sciences, Biomedical sciences, or Medical natural sciences.

The third criterion will be assessed through an interview/exam after the portal phase in which two top scientist plus a psychological/didactic expert will be present.

Volume of the curriculum

In 2004 the top master curriculum will be limited to a maximum of fifteen students. These are students that (i) have applied for a position in the topmaster curriculum, (ii) meet the above criteria and (iii) are among the fifteen best.

Part-time and combination variants

The curriculum has been set up for full-time study. It will take two full years of intensive personal activity for its completion. If there are convincing reasons to spread the program for an individual student over more than two years, then these should be discussed with the Director. Depending on approval by the examination committee an individual curriculum can then be drawn up. Proposals for hybrid curricula with topmasters at the sister institutes will be met positively. In this way the student could obtain a combined master at two universities. Also here a plan needs to be approved by the examination committee.

End qualifications of the student

The end qualifications of this topmaster curriculum are those of the basic variant of the master biomolecular sciences, with on top of those:

- proven excellence as researcher in the quantitative life sciences and systems biology
- proven understanding of physical chemical and organizational principles of life
- proven expertise with the modern experimental, conceptual and modeling methods for the Biomolecular sciences and Systems Biology
- insight in the most important biomathematical, biophysical, biochemical, biological, and biomedical topics of the moment, and in how these can be approached
- a unique and excellent profile at the interface between the exact sciences and the life sciences
- participation in a local and international network of young life scientists with an interest in BioMolecular Integration or Systems Biology

Personal coaching

Each student will be appointed one of the six core professors as a coach. This coach interacts with the student at least once a month and addresses personal problems as well as lack of

motivation or quality. The group of students also has a general coach (*i.e.* the master coordinator) who will attempt to solve common problems such as housing, visa problems, conflicts, homesickness and conflicts with the personal coach.

Career Planning

In November, February and May of the second year of the curriculum, career planning discussions will take place between the individual student, his coach and the master coordinator. The career wishes of the student for after the master program will be determined, and it will be discussed in which ways these wishes might be realized. Contact will be established with various research groups to examine whether they might welcome the student as a future Ph.D. student. Applications for fellowships will be facilitated when necessary.

Cost of the Master's program to the student

For students who enter the course on the basis of a bachelor's diploma obtained in the European Union and who have not yet obtained the Master's diploma, the standard registration costs for Free University Amsterdam master program apply, *i.e.* about 1445 Euro per year. To other students a fee of 10 kEURO per year applies. A limited number of fellowships is available specifically for students of this topmaster. For applications the Director should be contacted. In addition there is the possibility that the student generates income by working as a batchelor assistant. The latter option will lengthen the time it takes to complete the curriculum.

Administration and quality control

Embedding

The topmasterprogram BioMolecular Integration/Systems Biology is an interfaculties program of the Faculties (Schools) of Earth and Life Sciences (FELS/FALW) and Exact Sciences (FES/FEW) of the Free University Amsterdam (vrije Universiteit Amsterdam). The program is the topvariant of the MSc-program Biomolecular Science. This MSc program also has the basal variant Biomolecular and Cell Science. The MSc-program Biomolecular Science fall within the School of Life Sciences of FELS (FALW), the Faculty that is formally in charge of the program.

Director and mastercoördinator

The Head of the School of Life Sciences is, for the Board of FALW, responsible for the quality of the MSc program Biomolecular Sciences. For the topvariant Biomolecular Integration/Systems Biology this responsibility has been relegated to the Director of the CRBCS, who therewith is effective director of the program. The director is assisted by a master coordinator who is appointed following the advice of the CRBCS director. The CRBCS director is responsible to the board of the Free University Amsterdam for the 'top' aspects of the master program. With respect to the more general quality requirements he is responsible to the director of the school of Life Sciences of FALW (Dr. Kits) and to the equivalent of FEW. Prof. Dr. H.V. Westerhoff and Dr. K. Krab [klaas@bio.vu.nl] presently function as Director and Master coordinator of the topmaster Biomolecular Integration / Systems Biology.

The core professors

Because this curriculum aims at the top amongst students, six excellent professors will be appointed as core professors of the curriculum. Each core professor can have himself assisted

by other teachers that are involved in his research program. For the first three years of the topmaster (*i.e.* starting September 2004, and 2005, and 2006) the core professors are: Prof. dr. S. van der Vies, Prof. Dr. H.Lill, Prof. dr. C. Schmidt, Prof. dr. R. van Grondelle, Prof. dr. J. Heringa, and Prof. dr. H.V. Westerhoff.

The international professors

Special part-time professors will be appointed at the advice of the international advisory committee in order to teach expertise that is not available at high level within the CRBCS. These professors will also function as examiners, and as members of the International Advisory Board and of the Examination Committee. They should execute more than 90 % of their normal function in one of the collaborating sister institutions.

International advisory board

The quality of the curriculum at the international level will be guaranteed by following the advice of the international advisory board. This board will consist of the members of the international advisory board of the CRBCS plus the part-time special international professors. The six core professors of the topmaster are selected on the basis of scientific excellence amongst the CRBCS and IBIVU professors. Both this selection and that of the international special professors will take place at the suggestion of the international advisory board. The excellence will be determined on the basis of reports of visitation committees and of international indicators of quality. Every fifth year the international advisory board will have the quality of the curriculum evaluated by a site visit by independent international stop scientists who teach at universities. The international scientific committee focuses primarily at the top-quality aspects of the curriculum.

Curriculum committee

The curriculum committee is responsible for the practical execution and quality of the curriculum. It consists of four of the core professors of the program and four students. The mastercoordinator functions as secretary of the committee and as its permanent adviser. The other core professors also serve as advisory members. The curriculum committee meets at least once every semester with the directors of the schools of the participating Faculties (FES and FELS). The curriculum is evaluated every year by the curriculum committee, following and exceeding the standards of the School of Life Sciences of FELS. When evaluating the program, the opinions and careers of ex-students will play an important role. These careers will be tracked, and peer groups of ex-students will be formed.

Each fifth year the program will be proposed for affirmation to the VNAO. In preparation of this request the international advisory committee will be asked for an explicit advice supported by a site visit of excellent international lecturing and researching scientists

Examination committee

The examination committee consists of the six core professors and of the part time special international professors and of the directors of the schools of FALW and FEW. It is chaired by the director of the CRBCS. The examination committee meets once each semester with the Head of the school of Life Sciences of FELS and with his FES colleague. The committee is responsible for the quality of all exams of the curriculum and for determining whether a spectacular student has past or failed any of the exams. The CRBCS director hands the diplomas to the students.

Further Information

Websites: www.systembiology.net/topmaster (up-to-date) en www.falw.vu.nl (general, formal)

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