Curriculum for the award of the Degree of

Master of Science in Molecular Life and Health Sciences

options:
• Developmental Biology and Regeneration
• Neurobiology
• Biochemistry and Cell Biology
• Marine Biology
• Teaching

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1 Introduction
Molecular mechanisms govern the fate and the function of every cell, from archaea living in the remotest trench in the ocean, to the highly connected cells of our brain. Interestingly, cells of various origins share common genes, and therefore use similar proteins and molecular pathways. These can be explored in a variety of model organisms and cultured cells, which you will discover in this exciting Master programme that bridges fundamental molecular science and its potential application to understanding human health and disease.

The Department of Biology of the Faculty of Science and Medicine offers a multidisciplinary study programme leading to the degree of Master of Science in Molecular Life and Health Sciences, with the four research options Developmental Biology and Regeneration, Neurobiology, Biochemistry and Cell Biology, and Marine Biology. The programme consists of 120 ECTS\(^1\) credits and corresponds to 24 months of full-time study. Students aiming at becoming high school teachers and having to acquire 30 additional ECTS credits in a different study domain, can choose the option Teaching consisting of 90 ECTS (18 months). English is the official language for all activities. However, students may choose the language of the examinations (English, French or German).

A special emphasis is placed on the development of the student’s scientific capabilities (independent thinking, problem-solving skills, critical evaluation of data, oral and written communication skills, ability to work in a team). The student will deepen her/his theoretical, conceptual and practical knowledge of a selected area of molecular biological sciences and acquire techniques needed in basic research as well as in practical applications such as biomedical and pharmacological research, biotechnology, public health, and teaching at secondary level II. Courses are accompanied by discussions, seminars, oral presentations by students and writing exercises in order to stimulate active participation. Students are integrated in one of the research teams and have the opportunity to experience all aspects of the daily life of a research scientist. They will obtain extensive experience with academic research in biology and learn to plan, carry out, analyse and present research. The Master also paves the way to a potential PhD and an academic career in biology and related fields. Other MSc graduates also find job opportunities as laboratory manager in the academic or private sectors.

2 Overview
The MSc in Molecular Life and Health Sciences programme allows to choose between 5 options:
- Developmental Biology and Regeneration (DBR), 120 ECTS
- Neurobiology (NEU), 120 ECTS
- Biochemistry and Cell Biology (BCB), 120 ECTS
- Marine Biology (MAR), 120 ECTS
- Teaching (TE), 90 ECTS

The four first options are oriented toward research, while the latter is suited for students who aim at becoming teachers at the secondary level II (DEEM/LDM/KLD).

Developmental Biology and Regeneration
This option is centred on the molecular mechanisms that govern animal development in various model systems including the fruit fly *Drosophila melanogaster*, the nematode *Caenorhabditis elegans*, the zebrafish *Danio rerio*, and marine chordates. Research groups investigate molecular aspects of regeneration, cell differentiation, epigenetics, gamete formation and aging. Research

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\(^1\) ECTS: European Credit Transfer System. One ECTS corresponds to 30 hours of effective work of the student.
focuses on fundamental aspects of molecular genetics and cell biology, and often correlates with perspectives on understanding human diseases. The tools employed are among others, molecular genetics, molecular biology, protein analysis, microscopy and imaging, and morphology.

Biochemistry and Cell Biology
This option puts special emphasis on molecular mechanisms regulating health and their dysregulation in disease. Biomolecules regulating the internal clock, nutrient sensing and growth control, lipid metabolism and membrane biogenesis, ribosome biogenesis, and stress responses are analysed by classical biochemical, “omics”, and computational biology approaches. In addition to mammals, especially human cell culture lines, the organisms studied are the mouse and the unicellular eukaryotic fungus *Saccharomyces cerevisiae* (Baker's yeast). The combination of model systems and approaches allows fascinating and detailed studies of gene functions, regulation of cell homeostasis and its dysregulation in human diseases.

Neurobiology
The brain remains one of the biggest unresolved mysteries in life sciences. This orientation focuses on the nervous system, exploring how it functions on different conceptual levels, ranging from genes and genetics, over behaviour and circuits to neurodegeneration. The animal models used include the fruit fly *Drosophila melanogaster*, the nematode *Caenorhabditis elegans*, the cnidarian *Nematostella vectensis* and the mouse. Research groups engage integrative approaches to investigate neural stem cells and cancer, cell differentiation and connectivity, sensory systems, behaviour, learning & memory and neurodegeneration. The tools employed are molecular genetics, molecular biology, protein analysis, microscopy and imaging, behavioural analysis and many more.

Marine Biology
Oceans harbour the largest diversity of animals, are the core ecosystem impacting climate and are of large economic importance for food production. However, much remains unknown on the biodiversity of marine animals and particularly about the genomes, physiological and molecular adaptions in diverse environments. This option focuses on animals in the marine environment, their biodiversity, and investigates how relevant features emerged in evolution. It provides an overview on behavioural, molecular, physiological, neuronal and developmental mechanisms in Xenocoelomorpha, Cnidarians, Cephalopods and Tunicates. The curriculum includes several hands-on courses and workshops at leading Marine Stations in Europe.

Teaching
This option combines core courses from the 4 research options and aims at giving a general overview of the MLHS Master programme. It is strictly reserved for students who need to acquire 30 additional ECTS credits in another domain to apply for the education as teachers at secondary level II (DEEM/LDM). These students can also choose one of the 120 ECTS options, or change from the 90 ECTS to a 120 ECTS option while still in their 1st or 2nd semester of Master studies. While the option Teaching also gives access to PhD studies, a complement consisting of approximatively 30 ECTS might be required, depending on the laboratory and University.

3 Acquired skills
The aim of the studies leading to the award of an MSc in Biology is to deepen knowledge and perfect competence in the chosen field and at the same time develop skills in scientific English. Thus, once the MSc programme completed, students will have shown that they can apply their knowledge to accomplish a project by working independently in a research team. The award of the degree requires creative and self-critical talents as well as the ability to communicate ideas and work both in English and in the student’s native language.
4  Master courses

For each option, the MSc programme offers a number of obligatory and recommended courses. If prerequisites are met, credits for recommended courses can be replaced by elective\(^2\) Master courses offered in both the MSc in Molecular Life and Health Sciences and the MSc in Environmental Biology programmes (see the appropriate study plan: https://www3.unifr.ch/scimed/en/plans/master). Teaching units are described in section 12.

Elective courses can also be chosen among Master level courses at the Universities of Berne and Neuchâtel (BeNeFri convention). An individual programme of elective courses according to the study programme is established by each student. In this case, the student must consult the study advisor before taking the course. Completing a Master programme requires minimal amounts of ECTS credits as follows:

- Master courses: 49 ECTS for DBR, NEU, BCB, MAR and 36.5 ECTS for TE.
- Master thesis related activities: 11 ECTS for DBR, NEU, BCB, MAR and 8.5 ECTS for TE.
- Master thesis: 60 ECTS for DBR, NEU, BCB, MAR and 45 ECTS for TE.

The mode of assessment of the courses is described in separate documents (codes SBL and SBC; see http://www3.unifr.ch/scimed/plans).

Courses are evaluated with a grade between 6 (best mark) and 1 (worst mark) or with passed/failed, based on an oral or a written examination, or some other performance of the student. Students who are close to completing their Bachelor can ask for an anticipated Master (via MyUniFr). If admitted to an anticipated Master, such students are allowed to attend Master courses, but cannot acquire any ECTS credits.

All Master courses offered in the five options are summarized as a table in section 13.

5  Master’s thesis-related activities

As members of a research team the Master students take part in various activities such as research group meetings, seminars, literature study/Journal club etc. Students are expected to participate in those activities throughout the duration of the study. The credits for these activities amount to 11 or 8.5 ECTS points, respectively. A detailed list of the activities required from students following a given option is given in section 11 (see below).

6  Master thesis description and assessment

The *Master thesis* (SBL.05001; SBL.05002) is a scientific project carried out by a student under the supervision of a group leader within a research group of the Department of Biology. The details vary with the option and research group, but in general the student is expected to establish a research strategy, plan the project, carry out the research, analyse the results, present them in a formal seminar, and write them up in the form of a scientific paper. The written report in the form of a scientific paper, the oral presentation of the work and the practical work will be the objects of the final assessment of the Master thesis. A Master thesis is evaluated with a grade in an independent validation package, and corresponds to 60 ECTS credits (SBL.05001, 3 semesters) or 45 ECTS credits (SBL.05002, 2 semesters). The duration of the Master thesis work is counted according to the calendar year, not the academic year: SBL.05001 takes 18 months and SBL.05002

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\(^2\) elective: student’s choice
takes 12 months full time, including 5 weeks of vacation per year, and the time that students spend to take lectures and seminars of the corresponding study plan.

Each student must choose a research group and be accepted at latest at the start of the second semester of her/his Master studies. The group leader will be his/her supervisor for the Master thesis.

For the options DBR, NEU, BCB, and TE, students have the possibility to carry out their Master thesis within a research group of the Medicine section of the Faculty of Science and Medicine, University of Fribourg. This requires however the approval of the hosting group, the study advisors of Biology and Biomedical Sciences, and furthermore needs a summary describing the prospective project and the techniques that will be used.

To facilitate this choice, students are encouraged to familiarise themselves with the research carried out in the different research groups either before starting their studies or during the first months of their Master study, e.g., by taking part in their research group meetings. The beginning of the second semester is the latest deadline for the choice of a research group. Students inform the department secretary of their choice.

If a thesis is evaluated as insufficient (less than 4.0), the student has the option to begin a new Master thesis in another research group. In this case, the student has to continue to attend and participate to the Master thesis-related activities. The limitation of the duration of studies described in section 10 still applies and refers to the beginning of the first attempt.

7 Validation

The teaching units of the Master programme can only be examined after the student has completed all requirements for her/his Bachelor degree.

The **Validation Package MScBL1** comprises the Master courses and the Master’s thesis-related activities. **Validation Package MScBL2** comprises the Master thesis.

With the validation of the **MScBL1 and MScBL2** packages the student obtains the degree of Master of Science in Molecular Life and Health Sciences, option Developmental Biology and Regeneration, Neurobiology, Biochemistry and Cell Biology, Marine Biology, or Teaching.

8 Conditions of admission

The acceptance to a Master programme in Molecular Life and Health Sciences may be granted provided the following two conditions have been met by the applicant:

- Satisfying the University admission requirements as defined in the [Règlement concernant l’admission à l’Université de Fribourg](https://www3.unifr.ch/apps/legal/fr/document/274904),
- The student possesses a Bachelor of Science in Biology or in Biochemistry from the University of Fribourg or an academic degree judged equivalent by the Faculty of Science and Medicine.

The Commission for Students’ Requests will decide on the eligibility of candidates with degrees that are not judged equivalent by the Faculty of Science and Medicine ([Commission des requêtes des étudiants·e·s](Chemin. du Musée 8, CH-1700 Fribourg, Switzerland)). The decision is based on practical, theoretical and communication skills of the candidate and the option that she/he has applied for.

Based on the candidate’s academic qualification for the specific option of the MSc in Molecular Life and Health Sciences, the Commission for Students’ Requests can accept the application on the condition that additional requirements are fulfilled, provided they are of a minor scope and can be completed simultaneously with the Master studies. Otherwise, access is denied or applicants can be admitted to a “pre-master programme” and begin the actual Master programme only after
having fulfilled the requirements initially set for the pre-master. Final acceptance to the Master programme for a qualifying student depends on the successful completion of the additional requirements.

9 Ethics and science
Ethical principles are an integral part of a scientific education. Accepted international conventions must be respected during research and while documenting all scientific work whether it be a project, a lecture, a thesis, or a report. In particular, every external source of information (articles, lectures, web pages, etc.) must be correctly cited. Every student of the Faculty of Science and Medicine has signed a formal commitment to restrain herself/himself from doing “plagiarism”.

10 Regulations and Additional Information
The Regulation of 6 April 2020 for the award of the Bachelor of Science and Master of Science degrees establishes a limit on the duration of Bachelor's and Master's studies, as well as of the minor study programmes (see articles 10, 11a, 12a, 13 and 31) (https://www3.unifr.ch/scimed/fr/rules/regulations).

Detailed information about studying Biology can be found in the documents referenced on the web page http://www3.unifr.ch/scimed/en/plans which can also be obtained from the Office of the Department of Biology, chemin du Musée 10, CH-1700 Fribourg.
### 11 Detailed programmes of the options

#### 11.1 Option Developmental Biology and Regeneration

[Version 2021, validation packages: PV-SBL.xxx, PV-SBL.yyy]

11.1.1 Study programme

<table>
<thead>
<tr>
<th>Code</th>
<th>Study programme</th>
<th>Semester</th>
<th>tot. h.</th>
<th>ECTS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>General skills (obligatory)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SBL.00501</td>
<td>Introduction to data analysis</td>
<td>AS</td>
<td>10</td>
<td>1</td>
</tr>
<tr>
<td>SBL.30001</td>
<td>Introduction to R</td>
<td>AS</td>
<td>3 days</td>
<td>2</td>
</tr>
<tr>
<td>SBL.00427</td>
<td>Visual communication of data</td>
<td>SS</td>
<td>8</td>
<td>1</td>
</tr>
<tr>
<td><strong>Obligatory courses</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SBL.00114</td>
<td>Experimental genetics</td>
<td>AS</td>
<td>8</td>
<td>1</td>
</tr>
<tr>
<td>SBL.00115</td>
<td>The RNA world</td>
<td>AS</td>
<td>12</td>
<td>1.5</td>
</tr>
<tr>
<td>SBL.00117</td>
<td>Neurogenetics (BeFri lecture)</td>
<td>AS</td>
<td>28</td>
<td>3</td>
</tr>
<tr>
<td>SBL.00119</td>
<td>Molecular genetics of model organism development (BeFri lecture)</td>
<td>AS</td>
<td>28</td>
<td>3</td>
</tr>
<tr>
<td>SBL.00125</td>
<td>Light and fluorescence microscopy for life sciences</td>
<td>AS</td>
<td>28</td>
<td>3</td>
</tr>
<tr>
<td>SBL.00127</td>
<td>BeFri research colloquium in cell and developmental biology I</td>
<td>SS</td>
<td>12</td>
<td>1.5</td>
</tr>
<tr>
<td>SBL.00129</td>
<td>BeFri research retreat in cell and developmental biology</td>
<td>SS</td>
<td>2 days</td>
<td>1</td>
</tr>
<tr>
<td>SBL.00130</td>
<td>Nuclear organization and chromosome dynamics</td>
<td>AS</td>
<td>8</td>
<td>1</td>
</tr>
<tr>
<td>SBL.10001</td>
<td>Modelling human disease in experimental genetic systems</td>
<td>SS</td>
<td>20</td>
<td>2</td>
</tr>
<tr>
<td>SBL.10002</td>
<td>From bench to bedside</td>
<td>SS</td>
<td>5</td>
<td>0.5</td>
</tr>
<tr>
<td>SBL.10003</td>
<td>Health-related topics in developmental biology</td>
<td>SS</td>
<td>20</td>
<td>2</td>
</tr>
<tr>
<td>SBL.10004</td>
<td>Ethics in stem cell research</td>
<td>SS</td>
<td>8</td>
<td>1</td>
</tr>
<tr>
<td>SBL.10006</td>
<td>Developmental biology of marine animal models</td>
<td>AS</td>
<td>8</td>
<td>1</td>
</tr>
<tr>
<td>SBL.00414</td>
<td>Cell fate and tissue regeneration</td>
<td>AS</td>
<td>8</td>
<td>1</td>
</tr>
<tr>
<td>SBL.00415</td>
<td>Cell proliferation</td>
<td>SS</td>
<td>8</td>
<td>1</td>
</tr>
<tr>
<td>SBL.00429</td>
<td>Animal models of regeneration</td>
<td>SS</td>
<td>20</td>
<td>2</td>
</tr>
<tr>
<td><strong>Total ECTS credits in obligatory courses</strong></td>
<td></td>
<td></td>
<td></td>
<td>29.5</td>
</tr>
</tbody>
</table>
### Recommended and elective courses

Courses listed in the table in section 13. Upon approval by the study advisor, courses from the MSc in Environmental Biology or outside the University of Fribourg.

#### Recommended courses

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Semester</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>SBL.10007</td>
<td>Polar biology</td>
<td>SS</td>
<td>8</td>
</tr>
<tr>
<td>SBL.10008</td>
<td>Omics approaches in marine sciences</td>
<td>AS</td>
<td>8</td>
</tr>
<tr>
<td>SBL.10009</td>
<td>Advanced marine biology practical course</td>
<td>AS, block course</td>
<td>40</td>
</tr>
<tr>
<td>SBL.00411</td>
<td>Signalling and transport</td>
<td>AS</td>
<td>8</td>
</tr>
<tr>
<td>SBL.00416</td>
<td>Biological rhythms</td>
<td>SS</td>
<td>8</td>
</tr>
<tr>
<td>SBL.00417</td>
<td>Evolution on the bench</td>
<td>SS</td>
<td>8</td>
</tr>
<tr>
<td>SBL.00418</td>
<td>Microbial metabolism and genetics</td>
<td>SS</td>
<td>8</td>
</tr>
<tr>
<td>SBL.00419</td>
<td>Advanced imaging</td>
<td>SS</td>
<td>8</td>
</tr>
<tr>
<td>SBL.00420</td>
<td>Career profiling in life sciences</td>
<td>SS</td>
<td>8</td>
</tr>
<tr>
<td>SBL.00421</td>
<td>Oceanography and marine ecosystems</td>
<td>AS</td>
<td>8</td>
</tr>
<tr>
<td>SBL.00428</td>
<td>Optogenetics and photopharmacology</td>
<td>SS</td>
<td>8</td>
</tr>
<tr>
<td>SBL.00123</td>
<td>Cellular and genetic networks (BeFri lecture)</td>
<td>SS</td>
<td>28</td>
</tr>
<tr>
<td>SBL.00126</td>
<td>Established and emerging organisms for marine science</td>
<td>SS, block course</td>
<td>10 days</td>
</tr>
<tr>
<td>SBL.00128</td>
<td>BeFri research colloquium in cell and developmental biology II</td>
<td>SS</td>
<td>12</td>
</tr>
<tr>
<td>SBL.00451</td>
<td>Introduction to mass spectrometry and proteomics</td>
<td>AS</td>
<td>8</td>
</tr>
<tr>
<td>SBL.00452</td>
<td>Advanced quantitative proteomics (incl. practical course)</td>
<td>SS</td>
<td>12</td>
</tr>
<tr>
<td>SBL.00453</td>
<td>Protein homeostasis: translation, quality control and degradation</td>
<td>AS</td>
<td>12</td>
</tr>
<tr>
<td>SBC.04202</td>
<td>Eucaryotic cell growth control</td>
<td>AS</td>
<td>12</td>
</tr>
<tr>
<td>SBC.04203</td>
<td>Genotyping (practical course)</td>
<td>AS</td>
<td>90</td>
</tr>
<tr>
<td>SBC.07110</td>
<td>Introduction to UNIX and BASH</td>
<td>AS</td>
<td>5 days</td>
</tr>
<tr>
<td>UNIL</td>
<td>Introductory course in laboratory animal science</td>
<td>SS</td>
<td>5 days</td>
</tr>
</tbody>
</table>

- **English for Masters Students of Science I**
- **English for Masters Students of Science II**

#### Elective courses from the section medicine *

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Semester</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>SME.07100</td>
<td>Models for human diseases</td>
<td>AS</td>
<td>28</td>
</tr>
<tr>
<td>SME.07200</td>
<td>Infection, inflammation and cancer</td>
<td>AS</td>
<td>28</td>
</tr>
<tr>
<td>SME.07300</td>
<td>Central nervous system regeneration and repair</td>
<td>AS</td>
<td>28</td>
</tr>
<tr>
<td>SME.07202</td>
<td>Hot topics in cancer research</td>
<td>AS</td>
<td>28</td>
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</table>

* prerequisites: human physiology and anatomy

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**Minimum ECTS credits from recommended and elective courses**

19.5

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*Version of 25.06.2020*
<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Duration</th>
<th>ECTS Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>SBL.10103</td>
<td>Research group meetings</td>
<td>3 sem.</td>
<td>3</td>
</tr>
<tr>
<td>SBL.10105</td>
<td>Research seminars in molecular life and health sciences</td>
<td>3 sem.</td>
<td>3</td>
</tr>
<tr>
<td>SBL.00431</td>
<td>Seminars in biology</td>
<td>4 sem.</td>
<td>2</td>
</tr>
<tr>
<td>SBL.10100</td>
<td>Journal club in molecular life sciences</td>
<td>3 sem.</td>
<td>3</td>
</tr>
<tr>
<td><strong>Total ECTS points in thesis-related activities</strong></td>
<td></td>
<td></td>
<td><strong>11</strong></td>
</tr>
<tr>
<td>SBL.05001</td>
<td>Master thesis</td>
<td>3 sem.</td>
<td><strong>60</strong></td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td></td>
<td></td>
<td><strong>120</strong></td>
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## 11.2 Option Neurobiology

[Version 2021, validation packages: PV-SBL.xxx, PV-SBL.yyy]

### 11.2.1 Study programme

<table>
<thead>
<tr>
<th>Code</th>
<th>Course</th>
<th>Semester</th>
<th>tot. h.</th>
<th>ECTS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>General skills (obligatory)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SBL.00501</td>
<td>Introduction to data analysis</td>
<td>AS</td>
<td>10</td>
<td>1</td>
</tr>
<tr>
<td>SBL.30001</td>
<td>Introduction to R</td>
<td>AS</td>
<td>3 days</td>
<td>2</td>
</tr>
<tr>
<td>SBL.00427</td>
<td>Visual communication of data</td>
<td>SS</td>
<td>8</td>
<td>1</td>
</tr>
<tr>
<td><strong>Obligatory courses</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SBL.00114</td>
<td>Experimental genetics</td>
<td>AS</td>
<td>8</td>
<td>1</td>
</tr>
<tr>
<td>SBL.00115</td>
<td>The RNA world</td>
<td>AS</td>
<td>12</td>
<td>1.5</td>
</tr>
<tr>
<td>SBL.00117</td>
<td>Neurogenetics (BeFri lecture)</td>
<td>AS</td>
<td>28</td>
<td>3</td>
</tr>
<tr>
<td>SBL.00118</td>
<td>BeNeFri workshop “Frontiers in neurosciences” block</td>
<td>AS</td>
<td>18</td>
<td>1.5</td>
</tr>
<tr>
<td>SBL.00119</td>
<td>Molecular genetics of model organism development (BeFri lecture)</td>
<td>AS</td>
<td>28</td>
<td>3</td>
</tr>
<tr>
<td>SBL.00123</td>
<td>Cellular and genetic networks (BeFri lecture)</td>
<td>SS</td>
<td>28</td>
<td>3</td>
</tr>
<tr>
<td>SBL.00125</td>
<td>Light and fluorescence microscopy for life sciences</td>
<td>AS</td>
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**Total ECTS credits in obligatory courses** 29.5
### Recommended and elective courses

Courses listed in the table in section 13. Upon approval by the study advisor, courses from the MSc in Environmental Biology or outside the University of Fribourg.

#### Recommended courses

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* prerequisites: human physiology and anatomy

### Minimum ECTS credits from recommended and elective courses

19.5

# must be taken together
### Thesis-related activities

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**Total ECTS points in thesis-related activities**  
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**TOTAL**  
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## 11.3 Option Biochemistry and Cell Biology

[Version 2021, validation packages: PV-SBL.xxx, PV-SBL.yyyy]

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### General skills (obligatory)

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### Obligatory courses

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**Total ECTS credits in obligatory courses**  30.5

# must be taken together
### Recommended and elective courses

Courses listed in the table in section 13. Upon approval by the study advisor, courses from the MSc in Environmental Biology or outside the University of Fribourg.

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#### Elective courses from the section medicine *

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* prerequisites: human physiology and anatomy

Minimum ECTS credits from recommended and elective courses **18.5**
### Thesis-related activities

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**Total ECTS points in thesis-related activities** 11

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**TOTAL** 120
### 11.4 Option Marine Biology

[Version 2021, validation packages: PV-SBL.xxx, PV-SBL.yyy]

#### 11.4.1 Study programme

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<td>Biostatistics I – generalized linear models and mixed effects models</td>
<td>AS</td>
<td>28</td>
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</tr>
<tr>
<td></td>
<td><strong>English for Masters Students of Science I</strong></td>
<td>AS</td>
<td>-</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td><strong>English for Masters Students of Science I</strong></td>
<td>SS</td>
<td>-</td>
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<tr>
<td><strong>Total ECTS credits in obligatory courses</strong></td>
<td></td>
<td></td>
<td><strong>30</strong></td>
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</tbody>
</table>
### Recommended and elective courses

- Courses listed in the table in section 13. Upon approval by the study advisor, courses from the MSc in Environmental Biology or outside the University of Fribourg.

#### Recommended courses

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Semester</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>SBL.00114</td>
<td>Experimental genetics</td>
<td>AS</td>
<td>8</td>
</tr>
<tr>
<td>SBL.00117</td>
<td>Neurogenetics (BeFri lecture)</td>
<td>AS</td>
<td>28</td>
</tr>
<tr>
<td>SBL.00119</td>
<td>Molecular genetics of model organism development (BeFri lecture)</td>
<td>AS</td>
<td>28</td>
</tr>
<tr>
<td>SBL.00123</td>
<td>Cellular and genetic networks (BeFri lecture)</td>
<td>SS</td>
<td>28</td>
</tr>
<tr>
<td>SBL.00127</td>
<td>BeFri research colloquium in cell and developmental biology I</td>
<td>SS</td>
<td>12</td>
</tr>
<tr>
<td>SBL.00128</td>
<td>BeFri research colloquium in cell and developmental biology II</td>
<td>SS</td>
<td>12</td>
</tr>
<tr>
<td>SBL.00129</td>
<td>BeFri research retreat in cell and developmental biology</td>
<td>SS</td>
<td>2 days</td>
</tr>
<tr>
<td>SBL.00416</td>
<td>Biological rhythms</td>
<td>SS</td>
<td>8</td>
</tr>
<tr>
<td>SBL.00418</td>
<td>Microbial metabolism and genetics</td>
<td>SS</td>
<td>8</td>
</tr>
<tr>
<td>SBL.00419</td>
<td>Advanced imaging</td>
<td>SS</td>
<td>8</td>
</tr>
<tr>
<td>SBL.00420</td>
<td>Career profiling in life sciences</td>
<td>SS</td>
<td>8</td>
</tr>
<tr>
<td>SBL.00428</td>
<td>Optogenetics and photopharmacology</td>
<td>SS</td>
<td>8</td>
</tr>
<tr>
<td>SBL.00451</td>
<td>Introduction to mass spectrometry and proteomics</td>
<td>AS</td>
<td>8</td>
</tr>
<tr>
<td>SBL.00452</td>
<td>Advanced quantitative proteomics (incl. practical course)</td>
<td>SS</td>
<td>12</td>
</tr>
<tr>
<td>SBL.10011</td>
<td>Structure, function and diseases of lipid metabolism</td>
<td>SS</td>
<td>8</td>
</tr>
<tr>
<td>SBL.10012</td>
<td>Systems biology</td>
<td>AS</td>
<td>28</td>
</tr>
<tr>
<td>SBL.20032</td>
<td>Population and evolutionary dynamics</td>
<td>SS</td>
<td>28</td>
</tr>
<tr>
<td>SBL.20036</td>
<td>Global change</td>
<td>AS</td>
<td>28</td>
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<tr>
<td>SBC.07110</td>
<td>Introduction to UNIX and BASH</td>
<td>AS</td>
<td>5 days</td>
</tr>
<tr>
<td>SBC.07107</td>
<td>Bioinformatics (practical + in silico)</td>
<td>AS</td>
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#### Minimum ECTS credits from recommended and elective courses **19**

### Thesis-related activities

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Activity</th>
<th>Length</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>SBL.10103</td>
<td>Research group meetings</td>
<td>3 sem.</td>
<td>3x14</td>
</tr>
<tr>
<td>SBL.10105</td>
<td>Research seminars in molecular life and health sciences</td>
<td>3 sem.</td>
<td>3x14</td>
</tr>
<tr>
<td>SBL.00431</td>
<td>Seminars in biology</td>
<td>4 sem.</td>
<td>4x10</td>
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<tr>
<td>SBL.10100</td>
<td>Journal club in molecular life sciences</td>
<td>3 sem.</td>
<td>3x14</td>
</tr>
</tbody>
</table>

**Total ECTS points in thesis-related activities **11**

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Activity</th>
<th>Length</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>SBL.05001</td>
<td>Master thesis</td>
<td>3 sem.</td>
<td>60</td>
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</tbody>
</table>

**TOTAL **120
11.5 Option Teaching

[Version 2021, validation packages: PV-SBL.xxx, PV-SBL.yyy]

11.5.1 Study programme

This option combines obligatory courses from the 4 research options and aims at giving a general overview of the MLHS Master programme. This 90-ECTS option is only accessible to students who need to acquire 30 additional ECTS credits in another domain.

<table>
<thead>
<tr>
<th>Code</th>
<th>Course Description</th>
<th>Semester</th>
<th>tot. h.</th>
<th>ECTS</th>
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</thead>
<tbody>
<tr>
<td>SBL.00501</td>
<td>Introduction to data analysis</td>
<td>AS</td>
<td>10</td>
<td>1</td>
</tr>
<tr>
<td>SBL.30001</td>
<td>Introduction to R</td>
<td>AS</td>
<td>3 days</td>
<td>2</td>
</tr>
<tr>
<td>SBL.00427</td>
<td>Visual communication of data</td>
<td>SS</td>
<td>8</td>
<td>1</td>
</tr>
<tr>
<td>SBL.00114</td>
<td>Experimental genetics</td>
<td>AS</td>
<td>8</td>
<td>1</td>
</tr>
<tr>
<td>SBL.00115</td>
<td>The RNA world</td>
<td>AS</td>
<td>12</td>
<td>1.5</td>
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<tr>
<td>SBL.00119</td>
<td>Molecular genetics of model organism development (BeFri lecture)</td>
<td>AS</td>
<td>28</td>
<td>3</td>
</tr>
<tr>
<td>SBL.00414</td>
<td>Cell fate and tissue regeneration</td>
<td>AS</td>
<td>8</td>
<td>1</td>
</tr>
<tr>
<td>SBL.00415</td>
<td>Cell proliferation</td>
<td>SS</td>
<td>8</td>
<td>1</td>
</tr>
<tr>
<td>SBL.00416</td>
<td>Biological rhythms</td>
<td>SS</td>
<td>8</td>
<td>1</td>
</tr>
<tr>
<td>SBL.00421</td>
<td>Oceanography and marine ecosystems*</td>
<td>SS</td>
<td>8</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>or</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>SBL.10007 Polar biology*</td>
<td>SS</td>
<td>8</td>
<td>1</td>
</tr>
<tr>
<td>SBL.00453</td>
<td>Protein homeostasis: translation, quality control and degradation</td>
<td>AS</td>
<td>12</td>
<td>1</td>
</tr>
<tr>
<td>SBL.10001</td>
<td>Modelling human disease in experimental genetic systems</td>
<td>SS</td>
<td>20</td>
<td>2</td>
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<tr>
<td>SBL.10002</td>
<td>From bench to bedside</td>
<td>SS</td>
<td>5</td>
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<tr>
<td>SBL.10004</td>
<td>Ethics in stem cell research</td>
<td>SS</td>
<td>8</td>
<td>1</td>
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<tr>
<td>SBL.10006</td>
<td>Developmental biology of marine animal° models</td>
<td>AS</td>
<td>8</td>
<td>1</td>
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<tr>
<td></td>
<td>or</td>
<td></td>
<td></td>
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</tr>
<tr>
<td></td>
<td>SBL.10008 Omics approaches in marine sciences°</td>
<td>AS</td>
<td>8</td>
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</tbody>
</table>

Total ECTS credits in obligatory courses: 19

* only one course is obligatory, the other is recommended
° only one course is obligatory, the other is recommended
### Recommended and elective courses

Courses listed in the table in section 13. Upon approval by the study advisor, courses from the MSc in Environmental Biology or outside the University of Fribourg.

#### Recommended courses

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Semester</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>SBL.10003</td>
<td>Health-related topics in developmental biology</td>
<td>SS</td>
<td>20</td>
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<tr>
<td>SBL.10007</td>
<td>Polar biology</td>
<td>SS</td>
<td>8</td>
</tr>
<tr>
<td>SBL.10008</td>
<td>Omics approaches in marine sciences</td>
<td>AS</td>
<td>8</td>
</tr>
<tr>
<td>SBL.00117</td>
<td>Neurogenetics (BeFri lecture)</td>
<td>AS</td>
<td>28</td>
</tr>
<tr>
<td>SBL.00123</td>
<td>Cellular and genetic networks (BeFri lecture)</td>
<td>SS</td>
<td>28</td>
</tr>
<tr>
<td>SBL.00125</td>
<td>Light and fluorescence microscopy for life sciences</td>
<td>AS</td>
<td>28</td>
</tr>
<tr>
<td>SBL.00130</td>
<td>Nuclear organization and chromosome dynamics</td>
<td>AS</td>
<td>8</td>
</tr>
<tr>
<td>SBL.00127</td>
<td>BeFri research colloquium in cell and developmental biology I</td>
<td>SS</td>
<td>12</td>
</tr>
<tr>
<td>SBL.00128</td>
<td>BeFri research colloquium in cell and developmental biology II</td>
<td>SS</td>
<td>12</td>
</tr>
<tr>
<td>SBL.00129</td>
<td>BeFri research retreat in cell and developmental biology</td>
<td>SS</td>
<td>2</td>
</tr>
<tr>
<td>SBL.00411</td>
<td>Signalling and transport</td>
<td>AS</td>
<td>8</td>
</tr>
<tr>
<td>SBL.00417</td>
<td>Evolution in the bench</td>
<td>SS</td>
<td>8</td>
</tr>
<tr>
<td>SBL.00418</td>
<td>Microbial metabolism and genetics</td>
<td>SS</td>
<td>8</td>
</tr>
<tr>
<td>SBL.00420</td>
<td>Career profiling in life sciences</td>
<td>SS</td>
<td>8</td>
</tr>
<tr>
<td>SBL.00428</td>
<td>Optogenetics and photopharmacology</td>
<td>SS</td>
<td>8</td>
</tr>
<tr>
<td>SBL.00429</td>
<td>Animal models of regeneration</td>
<td>SS</td>
<td>20</td>
</tr>
<tr>
<td>SBL.00451</td>
<td>Introduction to mass spectrometry and proteomics</td>
<td>AS</td>
<td>8</td>
</tr>
<tr>
<td>SBL.00452</td>
<td>Advanced quantitative proteomics (incl. practical course)</td>
<td>SS</td>
<td>12</td>
</tr>
<tr>
<td>SBC.07110</td>
<td>Introduction to UNIX and BASH</td>
<td>AS</td>
<td>5 days</td>
</tr>
<tr>
<td>UniL</td>
<td>Introductory course in laboratory animal science</td>
<td>SS</td>
<td>5 days</td>
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#### Minimum ECTS credits from recommended and elective courses

17.5
<table>
<thead>
<tr>
<th>Thesis-related activities</th>
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<tbody>
<tr>
<td>SBL.10104 Research group meetings</td>
<td>2 sem.</td>
<td>2x14</td>
<td>2</td>
</tr>
<tr>
<td>SBL.10105 Research seminars in molecular life and health sciences</td>
<td>3 sem.</td>
<td>3x14</td>
<td>3</td>
</tr>
<tr>
<td>SBL.00432 Seminars in biology</td>
<td>3 sem.</td>
<td>3x10</td>
<td>1.5</td>
</tr>
<tr>
<td>SBL.10102 Journal club in molecular life sciences</td>
<td>2 sem.</td>
<td>2x14</td>
<td>2</td>
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</table>

**Total ECTS points in thesis-related activities**

8.5

<table>
<thead>
<tr>
<th>SBL.05002 Master thesis</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>2 sem.</td>
<td>45</td>
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</tbody>
</table>

**TOTAL**

90
12 Description of the teaching units

Statistics, genomics and bioinformatics

Introduction to data analysis (SLB.00501): This course aims at teaching basic knowledge in data management and analysis. Specifically, it introduces concepts such as dot-plot, box-plot, bar-plot, histogram, mean, standard deviation, population and samples, standard error, 95% C.I., logarithmic scale, pseudo-replication, and a short introduction to statistical testing (p-value, t-test, ANOVA).

Introduction to R (SBL.30001): This course introduces the basic usage of the statistical programming language R. The focus will be on data structures (vectors, matrices and data frames), import / export of data, basic plotting, writing of functions and scripts for reproducible data analysis. The course will be largely “hands-on” and does not require any prior knowledge on R.

Introduction to UNIX and BASH (SBC.07110): The students will learn the basics of computing and programming, with an emphasis on UNIX operating system and command-line examples. They will learn BASH scripting using modern tools, including regular expressions.

Biostatistics I - generalized linear models and mixed effects models (SBL.20001): From this lecture with exercises, students will learn basic and advanced techniques in biostatistics, they will perform exercises with data from ecological experiments. Specifically, the following topics will be introduced: linear, Poisson, and Binomial regression; AIC, BIC, model selection, and model averaging; random effects and mixed effects models; correlation structure (e.g., time series, spatial, phylogeny). This course is given biennially.

The lecture course SBL.10012 Systems biology introduces the methods and tools commonly used to address questions in systems biology. It requires a good knowledge in R programming (SBL.30001)

The block course SBL.30004 Organisation and annotation of eukaryote genomes examines the main evolutionary processes shaping the organization plant and animal genomes. It compares and operates complementary approaches to characterize gene models as well as transposable element in model and non-model organisms. Using adequate tools to identify duplicated sequences and ‘junk DNA’, it will also address how to benefit from genomic variation. A mix of lectures and practical exercises will enable students to take advantage of current approaches to robustly describe and understand Eukaryote genomes.

The lecture with exercises SBL.00425 teaches Metagenomics data analysis. Students will learn the basic principles of metagenomics data analysis and their associated methods. The course will cover the targeted methods (16S, ITS) as well as the Whole Genome/Transcriptome Sequencing methods, both in prokaryotes and eukaryotes. Students will learn which kind of data could be extracted from metagenomics analysis and how to analyse and represent these data. SBC.07110 or equivalent is a prerequisite to access this course.

General skills

The goal of the course Visual communication of data (SBL.00427) is to provide students with the theoretical background and practical skills needed to design and create efficient graphics that fairly present quantitative data. The course content includes an overview of classical and less classical graphic types available, guidelines on how to choose the best representation based on the type of data, tricks to emphasize specific messages without inducing bias, as well as major pitfalls to avoid. Practical exercises are carried out using Excel and other simple software.

Career Profiling in life sciences (SBL.00420): After having completed their Master degree, students start applying for jobs. In this interactive course, we present the curricula of several people
who are now active in the professional world. We chose different paths, from academia to industry and even less related fields. From this course you will also learn how to write a CV, how to write an application, and how to get prepared for a job interview. 15-minute interviews will be held in front of the other participants or in private. We also provide information on where to look for jobs in Switzerland.

*English for Masters Students of Science I*: this elective course aims to help Master’s students in scientific disciplines develop the English language skills relevant to their studies and future careers. The emphasis will be placed on oral presentation skills, academic writing, strategies for reading comprehension and analysis of texts, and academic listening skills. Target level is B2-C2.

*English for Masters Students of Science II*: this elective course is a follow-up to *English for Masters Students of Science I*. As such, it will focus more heavily on issues surrounding the writing and oral defence of the Master’s thesis. Target level is B2-C2.

More info: [https://www3.unifr.ch/centredelangues/en/courses/students/english/](https://www3.unifr.ch/centredelangues/en/courses/students/english/)

**Technical skills**

*Light and fluorescence microscopy for life sciences (SBL.00125)*: Fluorescence microscopy has become one of the core techniques in biological research. Its applications range from the study of the expression of specific molecular markers with high spatial resolution in single cells to the probing of cell functions in living organisms. Constant progress in microscope design and in fluorescent probe development has led to a large choice of applications based on the principles of fluorescence microscopy. This course will aim at giving an understanding of key concepts of the main techniques used in life sciences. It will also insist on practical issues essential for a productive use of these techniques in biological and biomedical research.

Fluorescence light microscopy is a core technique to visualize biological processes in fixed and living tissue. With new development in microscope design and image acquisition progress was also made in digital image analysis. The aim of the course *Advanced imaging (SBL.00419)* is to give the students a theoretical background in digital image analysis and to train students to use state of the art software tools. In a first module the students obtain theoretical knowledge about principles of digital image analysis and learn about ethical aspect in image manipulation. In a second module, students are taught in workshops to use image analysis opensource software ImageJ/Fiji and commercial software Bitplane Imaris and Huygens Deconvolution. In self-directed teaching tutorials student acquire basic image analysis skills (File formats, Metadata, Contrast adjustment, Background correction, Filtering). In workshops advanced techniques are learned such as image segmentation, 3D rendering, deconvolution, and co-localization. An introduction in batch processing and macro language will complete the session. The course will give practical guidelines that will help students with imaging projects in their line of research.

The laboratory course *Genotyping (SBC.04203)* teaches students molecular methods how to distinguish between different alleles. In principle, this laboratory course is performed on tissue samples from mice.

The courses *Introduction to mass spectrometry and proteomics* and *Advanced quantitative proteomics (SBL.00451 and SBL.00452)* are each two days block courses at the end of respective semesters. The courses teach theoretical and practical principles of mass spectrometry (MS)-based proteomics. The first course SBL.00451 introduces principals of MS analysis of peptides and proteins. Current mass analysers and underlying physical principals are introduced in lectures. Hands-on analyses of mass spectra are performed in a practical course. The second course SBL.00452 introduces quantitative MS-based proteomics principles in lectures. In a practical course proteomics experiments are performed and data is analysed by current bioinformatics approaches.
After both courses, participants will be able to design and perform MS-based proteomics experiments and to analyse respective data. SBL.00451 is a prerequisite to take part in SBL.00452.

*Introduction to metabolomics: data acquisition and processing (SBL.20004)*: This lecture with a practical part is an introduction to metabolomics (the large-scale study of small molecules in complex mixtures). It will cover extraction methods, sample preparation, separation techniques and chromatography, detection procedures and data analysis (quantitative and qualitative). A particular focus will be given to mass spectrometry-based metabolomics of specialized metabolomes and its applications in environmental biology and natural products research. The course includes a practical part on GC or LC-MS (Gas Chromatography or Liquid Chromatography coupled to Mass Spectrometry) and data processing.

The *Introductory course in laboratory animal science* takes place in Lausanne in July ([www.unil.ch/resal/home.html](http://www.unil.ch/resal/home.html)). Summary: This education gives expertise and practical skills for a responsible and gentle handling of laboratory vertebrate animals. Theoretical and practical parts take about 20 hours each, and include the following topics: ethics and legislation, 3R concept, nutrition, transport, husbandry, breeding, transgenic techniques, observation of behaviour, anaesthesia and euthanasia, surgeries, treatments, collection of samples. This course is officially recognized by the Federation of Swiss Cantonal Veterinary Officers (VSKT) as requested by legislation (Swiss ordinance N° 455.171.2, October 1998) to get the accreditation to perform animal experimentation. This training module is relevant to all students working with vertebrate animals. Conditions for registration to this module: 1) The host laboratory must have permission to work with vertebrate animals. 2) Students must be announced to the cantonal veterinary office by the supervisor.

**Molecular sciences**

The course *Eucaryotic cell growth control (SBC.04202)* covers the latest advances in our understanding on how nutrient signals are integrated to properly adjust cellular growth in eukaryotes.

The two courses *Introduction to protein structure and protein homology modelling* and *Introduction to docking of small molecules to large macromolecules and molecular graphics* (SBC.07104 and SBC.07105) describe the methodologies for 3D protein structure modelling (ab initio and by homology), as well as how to dock small molecules or large macromolecules to proteins. They also describe basic methods for producing nice molecular graphics for publications. The course *Bioinformatics (practical + in silico) (SBC.07107)* will allow the students to sequence a genome and analyse real genomic data. The goal is to identify potential mutations responsible for the phenotype. SBC.07104 and SBC.07105 must be taken together.

*Altered Carbohydrate Metabolism in Disease (SBL.10010)*. This course covers disease-relevant alterations in carbohydrate metabolism. Carbohydrates play important roles in energy generation and in posttranslational modifications of proteins. Here we discuss how these processes are dysregulated in the context of human diseases.

*Structure, function and diseases of lipid metabolism (SBL.10011)*. Lipids are fundamental building blocks of cellular membranes, serve to store metabolic energy, and play key roles in signal transduction and membrane trafficking. Here we discuss the different types of lipids made by eukaryotic cells, their specific structure, function, synthesis and turnover, and diseases associated with defects in lipid metabolism, both at the cellular and organismal level.
**The RNA world (SBL.00115):** The flow of genetic information goes from DNA to RNA, and from RNA to proteins. Then how could the first proteins be made if they are needed for transcription and translation? The hypothesis of the RNA world suggests that catalytic RNAs (ribozymes) may have preceded proteins. This lecture will briefly describe the origins of life and emphasize the importance of ribozymes, their mode of action and their roles in today's world. Other themes include the discovery and mechanism of RNA interference, the importance of small and long non-coding RNAs, RNA-based technologies including RNA vaccines, the evolution of RNA-based adaptive CRISPR immunity.

The course Signalling and transport (SBL.00411) will focus on the plant signal transduction at first place. By comparing bacterial and plant signalling pathways over membranes, students will learn functional differences between the cytokinin receptor and bacterial sensor histidine kinases. As a side effect they will be also taught how structural models can be visualized. Using the example of the ethylene-sensing pathway it will be illustrated how evolution has 'modernized' plant histidine kinases. By comparing typical mammalian signal transduction pathways, such as G-protein coupled receptors or Toll-like innate immune receptors, with leucine-rich repeat (LRR) receptor(-like) kinases, such as BRI1, it will explain how plants differently sense steroid hormones over membranes. This course will compare eukaryotic signal transduction in plant, bacterial and mammalian systems, and is thus also recommended for “non-plant” Master students.

The course Introduction to protein structure and function (SBL.00412) will focus on the properties and functions of proteins and how to detect those using bioinformatics tools and databases. Due to its lateral chain properties, each amino acid of a peptide will adopt a specific orientation or fold driven by a series of non-covalent interactions such as ionic interactions, Van de Waals forces, hydrogen bonds and hydrophobic packing. These conformations are necessary for the proteins to perform their biological function. Based on the primary structure of a protein (the amino acid sequence), bioinformatics tools aim at predicting several possible secondary structure conformations such as alpha helices, beta sheets, coils, turns, signal peptides and localisation signals, transmembrane regions and their topologies, protein domains and motifs, metal binding sites, post translational modifications, to cite a few. Going further would reach the 3D modelling subject covered by another course. Students are kindly requested to bring a personal laptop computer (Windows, MacOS, or Linux). This course is recommended for those who intend to follow SBC.07104 and SBC.07105.

The course Microbial genetics and metabolism (SBL.00418) treats various aspects of microbial genetics with the focus on bacteria, fungi, and oomycetes. It deals with fundamental aspects of microbial genetics and applied aspects related to disease or beneficial mutualistic interactions. Furthermore, important examples of metabolic pathways will be discussed in the context of microbial life and interactions with the biotic and/or abiotic environment.

In the course Protein homeostasis: translation, quality control and degradation (SBL.00453), we discuss molecular mechanisms regulating protein homeostasis. In the first part, we highlight co-translational and post-translational quality control mechanisms that ensure the synthesis of functional proteins. Once a protein has been made, how is its half-life determined? In the second part, we therefore outline the cellular protein degradation pathways focusing on the ubiquitin-proteasome-system (UPS) and autophagosomal /lysosomal protein degradation.

**Developmental biology and regeneration**

The lecture course Experimental genetics (SBL.00114) gives the theoretical background of the main techniques used in modern genetics. Students will learn how to localise genes using deletions, polymorphisms, recombination frequencies and the candidate gene approach. Furthermore, this course presents the design of forward genetic screens, reverse genetics, how to construct strains and the use of sequence databases, and CRISPR technology for gene editing. This
The course Molecular genetics of model organism development (SBL.00119) is an introduction into some of the most popular model systems used for the study of development. These include Xenopus, Mouse, C. elegans, Drosophila and Zebrafish. The value of different technical approaches will be discussed. Further emphasis will be on presenting key experiments and the most recent findings for each system. Topics may vary from year to year but are likely to include transcriptional, translational, post-translational and epigenetic control of gene expression.

The course Cellular and genetic networks (SBL.00123) describes how genes and cells function in a complex web of networks to regulate any biological system. Opposite to the reductionist approach to understand life sciences, the systems level approach is much needed and has been emphasized in recent years. In this course, we will cover the cutting-edge topics including transcriptional regulatory networks, neuronal networks, interactions between environment and cellular metabolisms, as well as mathematical modelling. The goal of this course is to learn and discuss how to approach systems-level biological problems by integrating different experimental methods.

BeFri Research colloquium in cell and developmental biology I and II (SBL.00127, SBL.00128) consist in half day meetings with 6 presentations by PhD students or junior post-docs of participating groups from the Universities of Fribourg and Bern. MSc students are requested to attend the meetings, to participate to discussions and to provide a short summary of 4 presentations for SBL.00127, and four presentations for SBL.00128. The meetings will alternatively be held in Fribourg and Bern. The two-day research retreat (SBL.00129) gives the opportunity to MSc students to present their projects or related topics.

Nuclear organization and chromosome dynamics (SBL.00130): DNA associated processes, such as transcription, replication and recombination, but also chromosome pairing during meiosis occur in the context of the highly organized cell nucleus. Several structural elements of the nucleus such as the nuclear lamina or special nuclear compartments are known to regulate these processes. Changes in the nuclear organization are accompanying development and differentiation processes and defects in the nuclear architecture are known to be responsible for several human diseases. This course will focus on the elements that are shaping the nuclear architecture and their role in the activity of the genome, such as transcription, replication and DNA recombination. Since meiotic nuclei are the home of a beautiful chromosome choreography and an intense nuclear reorganization, this course will also include an overview of the mechanisms underlying these processes. Understanding the molecular mechanisms underlying nuclear organization and chromosome dynamics is essential for human health and fertility. Key concepts of the lecture are nuclear architecture, chromatin domains, nuclear compartment, chromosome territories and pairing, recombination and genome stability.

The course Health-related topics in developmental biology (SBL.10003) provides the basic conceptual background of the anatomical, experimental, genetic, cellular, molecular and biotechnical approaches to modern developmental biology. For every topic, examples related to human health and disease will be presented. Current topics are limb formation, aging, germ line formation, sex determination, and fertilization.

Lecture course Cell fate and tissue regeneration (SBL.00414). Tissues rely on stem cells for homeostasis and repair. Recent research shows that the fate and lineage potential of stem cells can change depending on whether a stem cell exists within its resident niche and responds to normal tissue homeostasis, whether it is mobilized to repair a wound, or whether it is taken from its niche and challenged to de novo tissue morphogenesis after transplantation. This course offers teaching in basics of stem cell biology, pluripotency and induced pluripotency. The particular focus will be given to the molecular control of mammalian stem cell fate decisions. It will be discussed how different populations of naturally lineage-restricted stem cells and committed progenitors can display remarkable plasticity and reversibility and reacquire long-term self-renewing capacities.
and multi-lineage differentiation potential during physiological and regenerative conditions. Finally, it will be also discussed what are the implications of cellular plasticity for regenerative medicine, as exemplified by cardiac and skeletal muscle differentiation.

The course **Cell proliferation** (SBL.00415) covers a wide range of issues related to the regulation of cell proliferation in eukaryotic cells. These include fundamental aspects of cell cycle control and their coordination with environmental cues that are mediated by signal transduction pathways. Lectures will provide detailed information on both the recent conceptual and technical advances in the field of cell proliferation control.

The course **Biological rhythms** (SBL.00416) focuses on the properties and functions of the circadian clock and other biological rhythms. The circadian clock is a cellular property defined by a set of clock genes that establish an auto-regulatory transcriptional/translational feedback-loop. These cellular clocks interact with each other via neuronal, hormonal and biochemical pathways to establish a coherent systemic hierarchy of physiological functions. This organizes body functions such as sleep and feeding in a temporal manner. Prerequisite: Basic understanding of biochemistry and physiology.

The lecture SBL.00429 **Animal models of regeneration** describes the processes of wound healing following injury. The ability to recreate a fully functional copy of the missing organ is a rare and fascinating phenomenon occurring in certain groups of animals. This course deals with conceptual models of regenerative principles in animals, as well as cellular and molecular mechanisms underlying efficient regeneration of body parts in various invertebrates and vertebrates. The course offers microscopic and molecular experiments aiming to assess regeneration in several model organisms. The techniques include animal procedures in hydra, tunicates and zebrafish embryos, live analysis of fin regeneration in adult zebrafish, collection and fixation of regenerating adult organs for molecular analysis, histological preparation, fluorescent visualization of specific tissues, microscopic imaging, and data interpretation.

**Neurosciences**

The course **Neurogenetics** (SBL.00117) consists of an introduction into developmental genetics of *Drosophila* followed by a comprehensive coverage of neurogenetics, the key discipline of developmental neurobiology. The neurogenetic part begins with an overview of modern genetic and neurobiological methods in *Drosophila* and then focuses on the major highlights of neurogenetic research in *Drosophila, C. elegans* and vertebrates. Topics include: early neurogenesis, nervous system regionalization, tissue specification, axonal pathfinding, neuromuscular specificity, biological rhythms, learning and memory, mechanosensation, and olfaction. The topics are covered by an up-to-date script. This lecture is also accessible to MSc students from Berne.

The BeNeFri workshop **Frontiers in neurosciences** (SBL.00118) is intended to make students familiar with current frontiers in neurobiological research. The course is given by national and international experts working in very diverse fields of neuroscience. Previous block courses included topics such as brain mapping, hypothalamus, motor systems, neurogenetic model systems, neuroinformatics, olfaction, sensory systems, synaptic function, and visual cortex.

**Optogenetics and photopharmacology** (SBL.00428) are two modern, fast-developing fields that use light-responsive molecules as tools for scientific research and hold promises for medical interventions. The lecture course will present ‘sensors’ used to monitor specific molecular events, as well as light-controlled molecules used to manipulate the activity of specific cells within a cellular network or the activity of specific signaling pathways within a cell. Richly illustrated with examples, the course covers the principles of these approaches, their main advantages and limitations, as well as current challenges for their application in translational medicine.
Health sciences

**SBL.10001 Modelling human diseases in experimental genetic systems.** Model organisms have long served for research on fundamental aspects of basic biology. More recently, they have also proven helpful in modeling human diseases, in the identification of drug targets, and in the evaluation of potential therapeutic agents. In this context, this course provides an overview on the most commonly used model organisms (ranging from simple eukaryotes such as budding yeast to more complex ones including nematodes, flies, zebrafish, and mice) and model systems (such as human cell cultures and organoids). We will discuss the specific advantages and limitation of each of these organisms and systems for modeling human diseases including neurodegenerative, cardiovascular, respiratory, muscular, skin, and hyperproliferative diseases including cancer. In addition, we will also delineate how these model systems can be exploited to identify molecular mechanisms and therapeutic strategies for the treatment of diverse human diseases. This lecture requires knowledge of the main genetic organisms (SBL.00119).

The lecture **SBL.10002 From bench to bedside** presents a broad overview of the many steps separating fundamental biomedical discoveries from therapeutic applications. Covered aspects include drug development, clinical trials, drug repurposing, as well as the use of biomarkers in the emerging field of precision medicine.

The course **SBL.10004 Ethics in stem cell research** provides an overview of this wide-ranging and fast-moving field of biomedical sciences. We will address ethical implications and policy issues that are the most significant for this research domain, including controversy surrounding human embryonic stem cells, human-animal chimeras, and gametes. We will discuss the importance of information disclosure, the risk for overpromising and the therapeutic misconception of stem cells.

The course **Models for human diseases (SME.07100)** presents relevant experimental models and integrative approaches for understanding physio-pathological processes of human diseases, including aging and age-related diseases such as heart failure, atherosclerosis, metabolic disorders and renal disease. Advantages and pitfalls of the models for the human diseases will be analysed. Prospective translational aspects of modifying the disease process by nutrition, therapeutics, gene/stem cell therapy, development of new drug candidates as well as choice of the best animal model for the targeted therapeutic area will be discussed.

The course **Infection, inflammation and cancer (SME.07200)** provides a comprehensive theoretical basis to the understanding of novel paradigms and emerging areas of research in the field of infection diseases, inflammation and cancer. The course will cover topics such as mechanisms of initiation of inflammation, perception of inflammation, the role of inflammation in cancer initiation and progression and novel pathogens and emerging resistance in infection diseases. Emphasis will be put on highlighting the significance of recently acquired knowledge in these areas and its relevance to experimental research and clinical medicine.

The course **Central nervous system regeneration and repair (SME.07300)** provides the conceptual background necessary for understanding major approaches for helping the brain recover from neural pathologies. The importance of behavioural characterization, functional measurements as well as therapeutic interventions such as psychopharmacology or electrical brain stimulation is illustrated by relevant examples drawn from clinical and basic science.

The course **Hot topics in cancer research (SME.07202)** comprises a selection of current topics at the forefront of biomedical research presented by experts in each field. Topics vary each year and usually include cancer immunotherapy, biomarkers in cancer, vaccines and nanomedicine. The course consists of overview lectures, scientific workshops, and demonstrations in the lab. Students
will gain insights into some of the hottest and rapidly evolving research topics in the field as well as experience in critical discussion of emerging scientific questions.

**Evolution**

The lecture *Population and evolutionary dynamics* (SBL.20032) focuses on the ecological and evolutionary dynamics of populations. In the 1st part students will study basic and advanced concepts of population dynamics, including population growth and growth rates, age-structured models (Leslie matrix; Euler-Lotka equation), limiting factors and density-dependence, and demographic principles of life-history evolution. In the 2nd part, students will be introduced to evolutionary dynamics, including replicator dynamics in population genetics, the principles of evolutionary game theory and adaptive dynamics. Students will learn, for example, the key concept of fitness landscapes and how they are defined from the underlying population dynamics. They will then study the evolution of fitness landscapes and, in particular, how selection acts on different evolutionary strategies. The students are expected to have a basic knowledge (BSc level) of ecology, evolutionary biology, and population genetics. This course is given biennially and alternates with *Community ecology*.

Lecture *Global change* (SBL.20036): How is biodiversity affected by environmental challenges? Describing the evolutionary ecology of organisms from local to global scales, this course provides an overview of processes that shape the origin, expansion and extinction of species in space and time. Through series of lectures and personal work, it compares the biodiversity and biogeography of varied ecosystems such as drought-related deserts, long-populated Mediterranean regions and alpine ranges in order to organize main drivers of variation in a coherent framework. Such an integrated approach to species responses to environmental changes is key to interpret the current distribution of biodiversity and to appraise and manage future challenges. This course is given biennially and alternates with *Invasion biology*.

In the course *Evolution on the bench* (SBL.00417) we will discuss the main processes and factors determining the rate of evolution of microorganisms and cell lines. We will compare the time scales of these processes to the time scales of experiments frequently carried out in cell biology and microbiology, and realize that evolution is an integral part of almost any such experiment. The goal of this course is then to develop an intuition for the expected evolutionary change over the course of your own experiments and to discuss how evolution may help or limit discovery and how the speed of evolution can be manipulated in the laboratory.

**Marine sciences**

*Developmental biology of marine animal models* (SBL.10006). Classical studies in developmental biology were often making use of the abundance of live eggs and embryos of marine organisms. Pioneering studies in sea urchins and sea squirts have paved the way to fundamental biological concepts. The advent of molecular techniques as well as modern imaging techniques has further made such models a cornerstone of modern approaches in developmental biology but also in marine biology. Moreover, the diversity of different animal species and phyla allow direct comparison of mechanisms underlying developmental processes and pathways and thus are linked to evolution in a field often referred to as Evo-Devo.

The course *Polar Biology* (SBL.10007) is focused on the biological specialties and particularities of animals and ecosystems at the poles. We will introduce similarities and differences between
fauna of the arctic and Antarctica. Since the poles are severely affected by climate change, we will also, put phenomena currently occurring in the polar regions into a global context.

*Omics approaches in marine sciences (SBL.10008).* During the past decade life science has experienced impacting technical and methodological advances. While initially molecular techniques allowed the study of a single molecule or gene, we are now able to study entire systems in a single experiment. Next generation sequencing as well as proteomic technologies allow scientist to identify the genomes, transcriptomes and proteomes. Similar approaches on metabolomics allow to identify and characterize metabolites with unprecedented precision. While this technical revolution has impacted the canonical laboratory model organisms it had an even more profound impact on the study of non-model organisms, since these approaches typically can be used for virtually any species. The current course will provide an introduction on recent developments and advances on omics approaches in various domains of research connected and related to the marine environment and marine species.

*Advanced practical course in marine biology (SBL.10009):* The scientific themes will cover an initial general introduction to the marine environment and its diverse ecosystems followed by theoretical and practical introductions to plankton, oceanic nekton, intertidal organisms, and subtidal benthic animals. In subsequent practical comparative work, the morphology and diversity of major invertebrate phyla, including sponges, cnidarians, arthropods, echinoderms and tunicates, and of teleost fish will be explored. Experimental benchwork will focus on fundamental aspects of developmental biology and neurobiology of marine animals. Developmental processes such as fertilization, cell lineage, cell differentiation, organogenesis and larval development will be analysed in representative marine organisms (echinoderms, ascidians, annelids). Comparative neurobiological experiments will elucidate major sense organ types, central nervous system organization and behavioural control systems in marine organisms. Developmental evolutionary (Evo-Devo) aspects will be emphasized in both experimental areas by demonstrations and theoretical presentations. Independent practical work and literature reports by the participating students will be encouraged. This two-week course will be credited with 4 ECTS.

The practical course, *Established and emerging organisms for marine science (SBL.00126)* presents modern experimental and scientific approaches to study marine organisms. The location is Roscoff Biological Station in Brittany, France. Students will be actively involved in practical laboratory work. They also participate in discussions and debates on selected topics from published scientific articles. The number of participants is limited. Please contact the responsible professor, as indicated in the timetable ([http://www.unifr.ch/timetable](http://www.unifr.ch/timetable)).

Block course SBL.00421, *Oceanography and marine ecosystems:* Oceans are home of a vast diversity of animal life forms from all animal phyla. Variable abiotic physical and chemical conditions as well as geographic location strongly impact the marine biosphere. This module will provide a comprehensive introduction into oceanography, diversity of marine biotopes and ecological interactions.

**Seminars and Master thesis**

*Master thesis-related activities* in the options DBR, NEU, BCB, MAR: these consist of different activities comprising seminars with national and international speakers presenting their research and seminars organized in common, or within the different laboratories in relation to their research activities. *Journal Club in molecular life sciences (SBL.10100)* are meetings where PhD and MSc students report and debate recently published articles. SBL.10103 are laboratory meetings where members of a research group expose and discuss their current work. SBL.10100 and SBL.10103 take place within the respective research groups. SBL.10105 are research seminars given in front of
a larger audience by Master students, doctoral students and post-doctoral fellows. Biology seminars (SBL.00431) are given by external speakers on a 1-2 weekly basis and should be taken from the start of the MSc studies.

The Master thesis-related activities in the option TE consist of different activities: Journal Club in molecular life sciences (SBL.10102) are meetings where PhD and MSc students report and debate recently published articles. SBL.10104 are laboratory meetings where members of a research group expose and discuss their current work. SBL.10102 and SBL.10104 take place within the respective research groups. SBL.10105 are research seminars given in front of a larger audience by Master students, doctoral students and post-doctoral fellows. Biology seminars (SBL.00432) are given by external speakers on a 1-2 weekly basis and should be taken from the start of the MSc studies.

The Neurobiology seminars (SME.05001, SME.06001) are given by invited speakers and give an overview on recent developments. Students will have to attend and document their participation by submitting in writing what they think are relevant questions or criticisms after each seminar. This usually requires that they read a small review or some publication abstracts on the presented topic beforehand.

During the Master thesis (SBL.05001, SBL.05002) the student learns and applies modern techniques, and execute a research project under the guidance of a group leader of the Department of Biology. Except for the option TE, the topic of the Master thesis must be relevant to the specific research option. This work requires designing and carrying out a research strategy, writing a complete and clear lab journal and data analysis. The abstract, introduction, results, methods, and discussion will be written as a separate document in the form of a scientific article. A 30-40-minute final presentation in English is mandatory. For the options DBR, NEU, BCB, and TE, the Master thesis work can be accomplished in the Medicine section, upon approval by the Biology and BMS study advisors, and the hosting research group. Such Master thesis carried out in the Section Medicine must include molecular techniques. Information regarding the duration of the Master thesis can be found in section 6.
13 Appendix: teaching units proposed in the MLHS Master

The teaching units are shown as O (obligatory), R (recommended), E (elective), - not possible, A: Obligatory, but alternating every year (this means that only one is obligatory) AS, Autumn semester; SS, Spring semester.

Options are:
• Developmental Biology and Regeneration (DBR); • Neurobiology (NEU);
• Biochemistry and Cell Biology (BCB); • Marine Biology (MAR); • Teaching (TE)

Teaching units from the MSc in Environmental Biology or the Master of Bioinformatics and Computational Biology can replace recommended teaching units if prerequisites are met.

Some teaching units alternate and are thus given every two years:
Biennial A: given for the 1st time during the academic year 2021/2022 and then every two years Biennial B: given for the 1st time during the academic year 2022/2023 and then every two years

<table>
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<th>Code</th>
<th>Title</th>
<th>ECTS</th>
<th>DBR</th>
<th>NEU</th>
<th>BCB</th>
<th>MAR</th>
<th>TE</th>
<th>Schedule</th>
<th>Prerequisites Comments</th>
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<td>Modelling human disease in experimental genetic systems</td>
<td>2</td>
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<td>-</td>
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Some elective courses are shared with the Master in Environmental Biology and the Master in Bioinformatics and Computational Biology. For details please refer to the corresponding study plan: [https://www3.unifr.ch/scimed/fr/plans/master](https://www3.unifr.ch/scimed/fr/plans/master)

* Courses from the specialized EBR Master are accessible only if space allows and if prerequisites are met. Evaluation modalities are found in the corresponding annex of the EBR study plan in biomedical sciences.

PREREQUISITES shown here mainly concern Master-level courses to be taken in parallel. The general admission rules take into account prerequisites at Bachelor level (see Chapter 8).