

# Génie des bioprocédés environnementaux

## ENV-503

### Syllabus (Spring 2019)

Course level:	Master
Teacher:	Marc Deront (EPFL-LBE, CH C3 495; 021 693 4734) <a href="mailto:marc.deront@epfl.ch">marc.deront@epfl.ch</a>
Time/Location :	Tuesday 14:15 – 17:00 EPFL CH B3 31 (on average of 2 hours of lecture followed by 1 hour of Lab-Tutorial-Exercise) in GR C0 02 (ENACIT1 computer room)
Language	Oral presentations in French, most of the support materials in English
Teaching assistants:	Alan Tournefier – SIE-MA4 Sebastian Strobl – SIE-MA4

### **Objectives and purpose**

In Environmental Science & Engineering, bioprocesses play key roles, either in wastewater treatment plant or solid wastes biological treatment (biomass). The course concerns biotechnology in its environmental suggestion. More precisely, it will focus more on bioprocess rather than biomolecular biology/biochemistry/microbiology or process engineering (which are considered in other dedicated courses). Here, the course concerns biological process engineering where biomass/microorganisms play the key role by its physiology and its dynamics. To be ready in the field of Environmental Science & Engineering, one should be aware of this tricky reality where biomass is a key element. It will allow better assess other environmental systems where biological subsystems are concerned.

### **What the course is NOT**

Even if this course is not an exhaustive program in environmental bioengineering and biotechnology, anyone, who wishes to work in the field of “Chemistry and Environmental Bioprocess” and “wastewater treatment”, should be aware of the matter of this course. Those fields are so vast, that the limited time does not allow to cope completely with all of them.

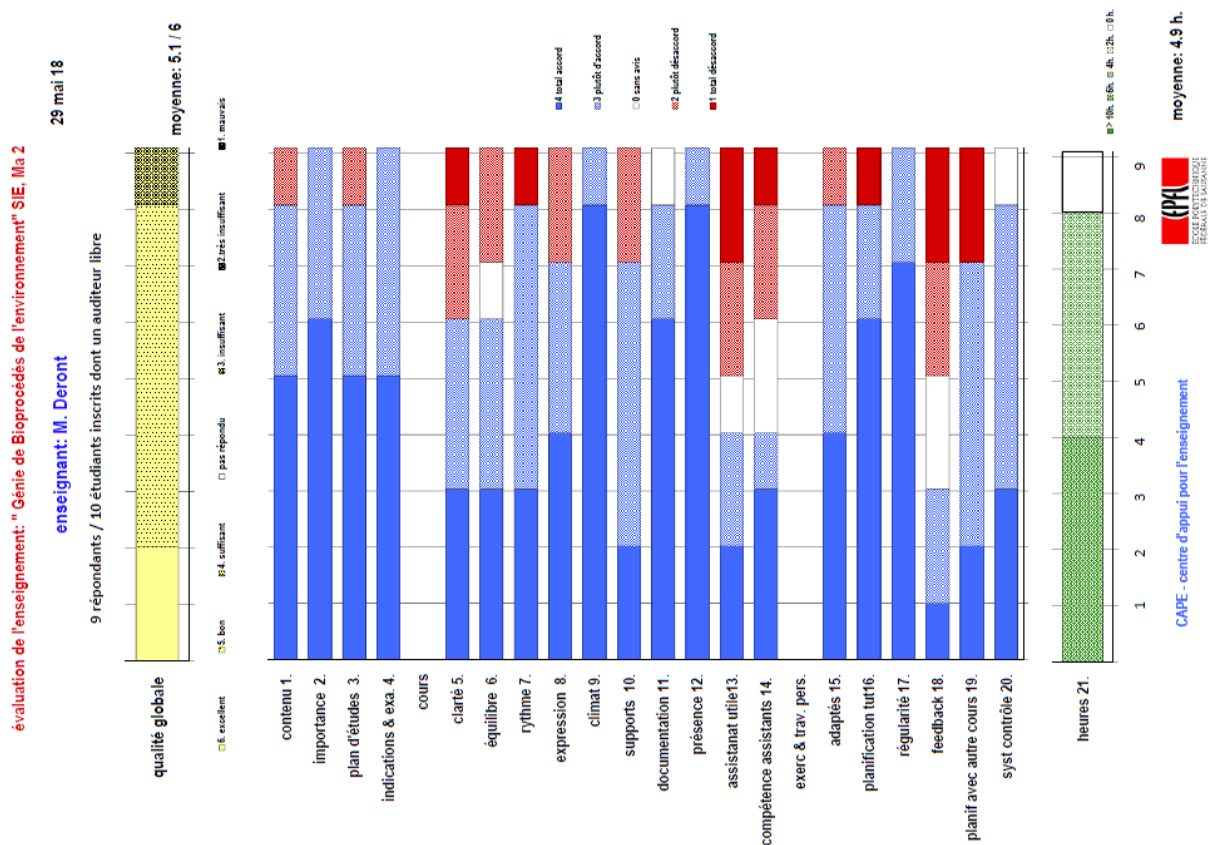
### **Program overview**

- Quantification of Microbial Rates
- Fundamentals of Microbial Growth Stoichiometry - - Degree of reduction
- Fundamentals of Microbial Growth Stoichiometry
- Introduction to ASM Modeling
- Fundamentals of Microbial Growth Stoichiometry - Continued - Undefined chemical systems
- Kinetics of microbial growth: Herbert-Pirt and Monod relations

- Kinetics of microbial growth - Extended Herbert-Pirt beyond pH, Temperature & Competition
- **Thermodynamic of growth**
- Growth of microorganisms in **BATCH** reactors
- Growth of microorganisms in **CHEMOSTAT** reactors
- **COMPETITION** in Chemostat
- Growth of microorganisms in reactors FEDBATCH
- General aspects of transport processes in bioreactors - **Gas transfer (K<sub>la</sub>)**
- Coupled transport/Conversion in bioreactors (limitation)
- Fixed biomass bioprocess - **Biofilm**
- Coupled transport-reaction kinetics in immobilized microorganisms
- Introduction to **Measurement & Instrumentation** on environmental bioprocesses

**Course evaluation by the students:**

A full and complete CAPE (<http://cape.epfl.ch>) evaluation is done every year.



Below is the history of the evaluation by the students along the past years... 1<sup>st</sup> column is the standard IS Academia query. 2<sup>nd</sup> column is the full and complete CAPE (<http://cape.epfl.ch>) evaluation of this course.

	Intermediat IS-Academia Evaluation	Final full CAPE Evaluation
2005-06	4	-
2006-07	5.3	-
2007-08	5.3	5.5
2008-09	5	5.1
2009-10	3.4	4.3
2010-11	4.4	4.8
2011-12	4.7	4.4
2012-13	-	4.4
2014	3.9	4.4
2015	4.5	4.6
2016	5	5
2017	4.85	5.3
2018	-	5.1

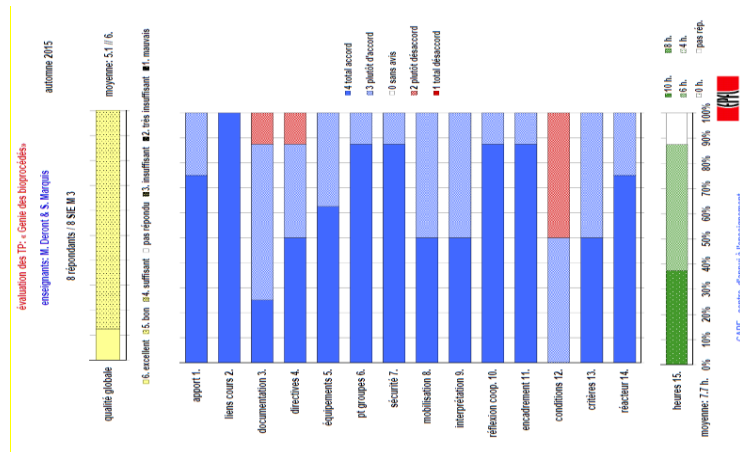
Note: The 2006-07 shift was due to the rewriting of the course given by Sirous Ebrahimi former LBE Post-Doc collaborator.  
The 2010-11 shift was due to the introduction of the final MCQ.

### Credits and Workload

Génie des Bioprocédés Environnementaux (GBE) distributes 5 ECTS (since 2017). According to the European Commission guidelines, 1 ECTS should be equivalent up to 30 h of workload with about 14h of contact time with teacher. Therefore, the total workload for GBE will be about 150h over the whole semester. The approximate breakdown of the workload is 30h for lecture attendance and their preparation, 50h for exercises (lab and homework sets, preparation time included), and 70h for carrying out global assignment-projects. There is no exam (and its preparation workload) during exams session.

### “Travaux Pratiques de Génie des Bioprocédés” ENV-506

Note: For information, this course is THE prerequisite to the practical labs “Travaux Pratiques de Génie des Bioprocédés” ENV-506: <http://moodle.epfl.ch/course/view.php?id=13952>. Unless this course is not available! Here is CAPE 2015 evaluation: 5.1/6



## **Collaboration Policy vs Personal Work**

Unless otherwise noted, **you should collaborate** with your fellow students on the homework exercises and assignments. Collaboration means that, when you are working to solve homework exercises, **you should discuss and exchange altogether**. **You should not stay alone face to your unsolved problem**. We also invite you to help your fellow students, by sharing your knowledge and understanding and even, the partial solution you found personally for solving. This way of studying is very much valuable, not only for the helped student, but also for the student who helps, who are able to explain his found solution. This is Win-Win collaboration for the best assimilation of the course.

**HOWEVER, you ought not to copy at other students' work when writing up your homework solutions**. You can try to understand and solve collectively your homework, but always write up individually to produce your own report! This is the only guarantee that you will personally understand the course material, which will be assessed by the MCQ.

Your performance during the semester is also considered for the final grade. You may not divide the tasks required to solve exercises even if you can consider that it can be your interpretation of collaboration. You may discuss and exchange about the lecture material, even share your solutions for tutorials and assignment-project with anyone, but you must write them personally to acquire the course.

Our recommendation:

**EXCHANGE TOGETHER - WRITE UP INDIVIDUALLY!**

*Advice: It is strongly suggested to respect these recommendations. The MCQ (Multiple Choice Questionnaire) used for the evaluation, will allow to check your real and "personal" involvement, your understanding and your acquisition of the course. The Copy/Paste method to solve your homework will be worthless regarding the MCQ.*

*Note: For this exchange, we ask you to use extensively the Moodle Forum exchange tool to share all together. As mentioned in assistantship (below) about Q/A (Queries & Answers) you will have to use principally this forum. Thus, all answers will be available to all the students. It is also strongly recommended and very much appreciated that students, who are able to answer to posted queries, to reply directly on the forum, without waiting for the answer from the assistants...*

*Note: This is not a course for "student selection". This course is a "Master" course, which aims to provide and pass, as much as possible, the knowledge in the field of "Génie des Bioprocédés de l'Environnement". We are expecting that all the students succeed and get their credits!*

## **Grade**

For this course, the evaluation of the students is based on a continuous controlling.

The final grade for GBE will take into account:

- the tutorial-exercises
- the assignment projects
- the final MCQ (Multiple Choice Queries)

3/5 of the grade will be acquired during the semester, based on your performances for the tutorial and homework sets (1/5), for the assignment projects (2/5). The MCQ will count for 2/5 of the final grade.

Note: The MCQ weight is rather important. It is because this is **the sole and really personal evaluation for this course.**

As mentioned above, the MCQ will cover key features of the entire course. **The MCQ will only address on what should have been understood from the course and the required knowledge to solve the exercises and the assignments... Nothing else!** One who has solved homework by himself (by understanding them (collectively or not) and producing its own solution) will be ready for the MCQ. **The MCQ should not be prepared!** It will be done at last session to check your personal knowledge understanding of the course.

## **Reading**

Most of the reading material will be available each week of the course. Reading material will be available for downloading from the Moodle EPFL eLearning resource. Access to this material will be limited to people enrolled in the class and controlled via username and password. Some of these papers are copyrighted and therefore, and should be exclusively used for course purpose.

## **Lecture Notes**

Lectures will be given with the help of a LCD projector and black board when appropriate. Lecture notes (slide format), in **PDF format will be available on the Moodle EPFL** eLearning resource, before a given lesson (usually previous Friday evening).

## **Labs and Homework**

Each week, personal homework are requested, which consist:

- 1) To **come back on lectures notes** (this is essential). Exercises shouldn't be solved without good comprehension of the lectures, as they are dedicated for each of them.
- 2) To **write up the final version of the tutorials** (begun during each exercise session)
- 3) To carry out the **2 assignment projects during the semester.**

Each week, with some exceptions, there will be a 1 hour tutorial exercise. These tutorial exercises generally relate on the lecture previously presented (or from previous week). Normally a PDF version of the statement will be available the week before when they have to be completed (**so at least 2 weeks before that they have to be carried out** (it allows the reading of the tutorial before the concerned lesson)). Thus, the homework is due the following week and no later than next lecture session. Date-time stamping of your file will be used to check the respect of the deadline.

No postponement will be accepted, unless justified by real motives. If there are any network/server problems, they should be pointed out immediately.

No official exercise solutions will be delivered. However, resolution and feedback about tutorials and assignments will be presented.

For each tutorial and each tutorial & assignment-project each student will have to produce/provide:

- **Excel Workbook file** AND its **PDF version [2 files]** [2 files]
- In case of a Word file (provide it, AND ALSO its **PDF version**) [2 files]
- For Aquasim, provide the Aquasim file, the results in a Word file (with its **PDF version**) [3 files]

Note: Excel sheets and their PDF version should be clear and readable, well commented and well presented... Moodle student PDF files will be used for feedback.

## **Course Assignment-Projects**

GBE involves 70h for assignment projects. The aim of these assignments is to go beyond the course and allow the students to access complementary tools to improve their training.

### **Assignment-Project #1 – Aquasim**

Beyond all the engineering concepts of the course, **modelling and simulation of bioprocess** are the first justifications and interests of bioengineering in environmental biotechnology. **Aquasim** is a powerful tool for modelling and simulation for wastewater treatment bioprocesses (in fact much more). The students should learn about it, to understand its potential usability and to be confident with such specific powerful tools in the field. Due to time limitation, students will have to do by themselves a **personal training, through a guided training material**. Using a **simplified ASM model**, the students will achieve to simulate the **bioprocesses occurring during BOD<sub>5</sub> measurement**.

### **Assignment-Project #2 – Bioprocess (chemostat) evaluation and simulation**

According to skills, knowledge and tools acquired during the course and the training on Aquasim during assignment-project #1, the students will be able:

- 1) To define the **chemostat behavior** of a given bioprocess by means of **mass balance approach**
- 2) To compute the **dynamic behavior of this chemostat by means of the Aquasim simulation tool**

Note: Checking/comparing the good agreement of both approaches will provide a **self-correction**.

Moreover, this project is a key preparation to get ready for the lab experiments (which will be held the next semester). This assignment is the study to set up the chemostat experiments for the determination of the biokinetics parameters of real microbial growth in a chemostat bioreactor.

## **Assistantship**

The assistant(s) will be available for understanding of the course, and will help the students for their tutorials and assignments. To avoid the misuse of the assistant time, the following rules should be respected:

- **All Q/A should be done via Moodle Forum of the course** (not by email neither with teacher nor with assistants)
- In case of extraordinary personal query (oral) asked to the assistant personally, **the student will have to rewrite/share the answers** to the other students on the Moodle course forum

## **Computing and Software details**

During the course, to complete the tutorial exercises and assignment projects, you will use:

- MS Office, mostly **MS Excel and its Add-ins**
- **Aquasim**: A tool designed for the simulation and identification of aquatic systems in the laboratory, in technical plants and in nature <http://www.aquasim.eawag.ch>. As EPFL, belongs to CEPF, its use is free to EPFL Students for their personal use.



Both of these 2 software tools are available in ENAC-IT1 computer rooms in the GR building. However, **we recommend the use your personal laptop**. Students have access to these tools freely. Installation of these tools will be done during first session.

## **Moodle**

All the resources of this course are provided through the Moodle EPFL eLearning server, <http://moodle.epfl.ch>.

All Students, which had subscribed to the course in IS-Academia, have normally access and can enrol the course “Génie des Bioprocédés de l’Environnement” at <https://moodle.epfl.ch/course/view.php?id=6581> .

## **Planning**

This planning may have to be updated during semester.

### **18 February - 24 February**

Introduction of Master course: Génie des Bioprocédés de l'Environnement!

WHERE/WHEN : Room CH B3 31 - Time 14:15 to 17:00

PROGRAM

- Syllabus (All about the GBE course...)
- **Quantification of microbial rates**
- [Excel Solver Add-In & Aquasim installation](#)

IMPORTANT REQUIREMENT: Bring your private **Windows PC**, which should be : Windows Updated + Antivirus + EPFL VPN Ready !!!

Resources of the session:

Files: 7

### **25 February - 3 March**

Classroom CH B3 31 hours 14:15-16:00

- Concept of **Reduction Degree**
- Fundamentals of **Microbial Growth Stoichiometry**

Classroom GR C0 02, hours 16:15-17:00

- Tutorial0 - Excel Use

Resources of the session:

Files: 5 Assignment: 1

### **4 March - 10 March**

Classroom CH B3 31, hours 14:15-16:00

- **#2.2 - Fundamentals of Microbial Growth Stoichiometry - Continued - Undefined chemical systems**
- **WWT modeling introduction**

Classroom GR C0 02, hours 16:15-17:00

- Tutorial1 Linear and non-linear fitting of Monod growth

Resources of session:

Files: 4 Quiz: 1 Assignment: 1

□ **11 March - 17 March**

Classroom CH B3 31 hours 14:15-16:00

- #ASM - Introduction to ASM (Activated Sludge Modelling)
- introduction to Assignment#1 DBO5

Classroom GR C0 02, hours 16:15-17:00

- Tutorial2 Catabolic & Anabolic Stoichiometry

Resources of the session:

Files: 7 Assignment: 1

□ **18 March - 24 March**

Classroom CH B3 31 hours 14:15-17:00

- #3 - Black box kinetics of microbial growth (Herbert-Pirt and Monod relations)
- Introduction to Aquasim

Resources of the session:

Files: 6 Quiz: 1 Assignment: 1

□ **25 March - 31 March**

Classroom CH B3 31 hours 14:15-16:00

- #3.1 - Black box kinetics of microbial growth (Extended Herbert-Pirt) Beyond substrate limitation, pH, temperature, inhibition & competition
- Introduction to Assignment A.2.1. - A.2.2.

Classroom GR C0 02, hours 16:15-17:00

- Tutorials feedback (optional)

Resources of the session:

Files: 4 Quiz: 1 Assignment: 1

□ **1 April - 7 April**

Classroom CH B3 31 hours 14:15-16:00

- #4 - Thermodynamic of growth
- Tutorial feedback (optional)

Classroom GR C0 02, hours 16:15-17:00

- Tutorial4 (Estimation of microbial growth system YGXmax)

Resources of the session:

Files: 5 Assignment: 1

□ **8 April - 14 April**

Classroom CH B3 31 hours 14:15-16:00

- #5 Growth of microorganisms in BATCH reactors
- #5.1 Growth of microorganisms in CHEMOSTAT reactors

Classroom GR C0 02, hours 16:15-17:00

- Tutorial5 Chemostat

Resources of the session:

Files: 3 Assignment: 1

□ **15 April - 21 April**

Classroom CH B3 31 hours 14:15-16:00

- #5.2 COMPETITION in Chemostat
- Introduction Assignment-project#2 A 2.3
- #5.3 Growth of microorganisms in reactors FEDBATCH



Classroom GR C0 02, hours 16:15-17:00

- FeedBack Assignment#1 (optional)
- Tutorial5 (Kinetic parameters & Chemostat)

Resources of the session:

Files: 4 Assignment: 1

☐ [22 April - 28 April](#)

Vacances de Pâques ;-)

File: 1 Assignment: 1

☐ [29 April - 5 May](#)

Classroom CH B3 31 hours 14:15-16:00

- #6 General aspects of transport processes in bioreactors - **Gas transfer (K<sub>La</sub>)**

Classroom GR C0 02, hours 16:15-17:00

- Tutorial6 K<sub>La</sub> - Gas Transfer

Resources of the session:

Files: 2 Quiz: 1 Choice: 1 Assignment: 1

☐ [6 May - 12 May](#)

Classroom CH B3 31 hours 14:15-16:00

- #6.1 **Coupled transport/Conversion** in bioreactors (limitation)
- #7 Fixed biomass bioprocess - **Biofilm**

Classroom GR C0 02, hours 16:15-17:00

- Assignment#2 - A.2.1 & A.2.2

Resources of the session:

Files: 4 Quiz: 1 Assignment: 1

☐ [13 May - 19 May](#)

Classroom CH B3 31 hours 14:15-16:00

- #7.1 Coupled transport-reaction kinetics in immobilized microorganisms

Classroom GR C0 02, hours 16:15-17:00

- Feedback Tutorial (optional)
- Q/A Assignment#2

Resources of the session:

Files: 3 Quiz: 1 Assignment: 1

☐ [20 May - 26 May](#)

Classroom CH B3 31 hours 14:15-17:00

- **Introduction to Measurement & Instrumentation** on environmental bioprocesses
- Introduction to SIE-M3 Environmental **bioprocess practical labs**
- Feedback Assignment#2 (optional)
- Visite LBE GBE Practical Lab setups (optional)

Files: 8 URLs: 2

☐ [27 May - 2 June](#)

**WARNING:** We begin in the IT Classroom !!!

->>> Please have fulfilled the CAPE evaluation questionnaire in advance

IT Classroom **GR B0 01 (exceptionally)**, hours 14:00-16:00

- MCQ Final Evaluation
- Evaluation of the course (Evaluation of [Centre d'Appui à l'Enseignement CAPE](#))

- Apero (optional)
- Resources of the session:  
Quizzes: 4File: 1