Aim of this course

Learn to use mathematical models as a tool for investigating biological questions

Learn to develop and analyze models (second hour)
   Phase planes, steady states, and stability

Learn to rigorously interpret results from a mathematical model

Focus on populations (cells, prey & predators, bacteria, viruses, molecules)
   Not on neurobiology, space, transduction networks, ....
Structure of this course

First 6 weeks study math-reader (week 1) and BM-book (2-7)

Exam in week 7 (after Xmass): open book for math-reader only. After the exam the master students leave us

Week 8-10 bachelor students work on a project and attend seminars. Week 10: open book exam and present project (English)
## Biological Modeling

### My peers

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<tr>
<th>Name</th>
<th>Role</th>
<th>Location</th>
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<tr>
<td>Álvaro Ropero Lopez</td>
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<td>Amalia Tsakali</td>
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<td>Bas Gulzar</td>
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<td>Dana Westbeek</td>
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<td>Daniël Tieleman</td>
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<td>Daphne van Dulst</td>
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<td>Fleur Wallis</td>
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<td>Gemma Bel Bordes</td>
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<td>Ilse ten Boske</td>
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<td>Jan Paul van Meenen</td>
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<td>Maarten Saat</td>
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<td>Magdalini Stefanopoulou</td>
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<td>Myrthe Versteijnen</td>
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<td>Peter de Greef</td>
<td>staff</td>
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<td>Rob J. de Boer</td>
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<td>Shotaro Hato</td>
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<td>Simon García Moreno</td>
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<td>Thomas Wind</td>
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<td>Netherlands</td>
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The major aim of the course is to learn how to develop mathematical models to study biological systems, and to become experiences in the mathematical and computational techniques used for analyzing these models. The first week we will cover most of the ‘Matrices Linearization and the Jacobi matrix’ book (hereafter called the ‘math-reader’, and during weeks 2–6 we will cover most of the ‘Biological Modeling of Populations’ book (hereafter called the ‘BM-book’). In week 7 we will have the main exam on Thursday, January 13. For the master students this is the end of the course. The bachelor students will continue to work on a project in small groups, and will read a number of papers. They will have an additional exam on Monday, January 31, and a symposium on Thursday, February 3.

The basic scheme during the first 6 weeks will be 2x45 minutes of lecture on Monday, Tuesday and Thursday, followed by a pen-and-paper and computer practical. Lectures are recorded and can be viewed after about one day for self-study. We also provide clips explaining all material covered in the books as online lectures (also for self study, available before the lecture). We ask you to read the book before the lecture, and watch these videos in case you have to miss a lecture. During the lectures we will together devise a number of mathematical models by discussing the variables, terms and functions to be included (and ignored).

Practicals are coordinated by Peter de Greef (p.c.degref@uu.nl). Peter and the teaching assistant Daniel Tieleman together form a team to help you with the exercises to be made during these practicals. During the practicals you can work alone or in a small group. Answers to the exercises are provided, and can be used as hints if you don't know how to get started. It is even better to ask the teaching assistants because many questions can be answered in several ways.
Monday Lecture MIN - 2.02: Introduction lecture

Monday Practical MIN - 2.01: Ask questions + study tutorials

Tutorial: Nullclines and phase plane analysis

Tutorial: Algebra

Tutorial: Sketching functions

Monday Lecture clips

Tuesday Lecture RUPPERT - 116: Chapter 2 (math reader)
General program

**Mondays**
13:15-15:00 Lecture and 15:00-17:00 Practical

**Tuesdays & Thursdays**
9:00-11:00 Lecture, 11:00-15:00 Practical, 15:00- Self Study time

Read the book beforehand. Watch afterwards if necessary

**Practicals**
Make exercises in small groups. Ask for help from TAs!

**Corona**
Do not come to the lectures and practicals if you have corona-like symptoms. 
Test yourself regularly (selftests are free).
Lectures are recorded. During practicals Peter is on MS Teams.
First week: Intro, Math and Tutorials

Crash course into eigenvectors and eigenvalues required for stability analysis
Understanding concepts more important than math skills

Several tutorials to refresh your math skills (videos with script):

- Sketching functions with free parameters
- Solving equations composed of variables and free parameters
- Sketching nullclines and vector fields in phase spaces

Next week Monday we start with Chapter 3 of BM book
Please check out Chapter 2 this week
You are all supposed to know some R:

A (very) short introduction to R

Paul Torfs & Claudia Brauer

Install R and RStudio on your own device

Read the first pages of the Grind tutorial (read it again while doing a project)

Install the 3 required libraries (once). Source grind.R before you start (each time).

We do provide a Mathematica notebook on analyzing the Lotka Volterra model (Wolfram alpha).
Chapter 13

Make a model

Question 13.1. Seedlings over-shadowed by adult plants
Consider a field in which the seeds of one particular plant species are sprouting from a large slow seed bank. The seeds in the seed back are so long lived that the production of novel seeds by the current population hardly matters. On a daily basis a few seed sprout from the soil to form a small seedling that either dies or matures to become an adult plant (we ignore seasonality). Adult plants die (and produce seeds), and have to be replaced by novel seedlings that successfully mature. Since adult plants are larger than the small seedlings, seedlings growing under the cover of adult plants will receive less sunlight, and hence mature slower than those that directly exposed to the sun. Make a natural model for the number of seedlings and adult plants in the field.

Question 13.2. Whales
Develop a simple model for a population of whales in the oceans. The special thing about whales is that at low population densities the females face difficulties finding a male. Therefore include the likelihood of finding a mate in your model. Also make sure that the population has

First define variables, processes, and then interaction functions
First define variables, processes, and then interaction functions.
Question 3.12. Seedlings over-shadowed by adult plants
Figure made with the model seedling.R: