



# Neural Data Science with **Python**

## End-of-Course Projects: Selection and Realization

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# Aim of the End-of-Course project

- **Time for your emancipation** : realize a small-scale project using python on your *own* or in a *team of two*
- **Apply your knowledge** : use the knowledge acquired in course and extend it and apply it to a specific scientific project/question
- **Extend your understanding** : dive in-depth into a scientific topic and question

# Expected from you for the project work

- **Work independently** : after a kick-off meeting with the project organizer, you should strive to advance without further interaction (unless you are completely stuck)
- **Get involved in the project/question** : Use all available resources to learn about the underlying science, the scope of the question and how to implement the project realization.

# Tips for advancing the project

- **Set yourself small, achievable goals** : advance in small steps, go only further once you achieved your goal.
- **Start to work on the project as early as possible** : Learn about the project early and identify the challenges. Thinking about the project for a longer period of time will improve your result.
- **Spread your work on the project** : Committing small time periods here and there will avoid the deadline rush which is often not creative/productive.

# Tips for programming

- **Check at every step what you are doing** : look at results at each step and visualize: Does it make sense?
- **Validate your code if you have a reference or ground-truth** : use your code to run an example for which you know the outcome. Do you get the expected result?
- **Use the internet to get help** : Be precise in your question and key-words; common sites for useful help : *stackoverflow*, *askubuntu*, *github*.

# Tips on preparing the summary

<b>Title</b>	Should be concise and precise	maximal 2 lines
<b>Abstract</b>	What did you do in a nutshell? Problem – Method(s) – Results	1 paragraph
<b>Introduction</b>	What is the problem?	1/2 page
<b>Materials and Methods</b>	How did you solve the problem?	1/2 page
<b>Results</b>	What did you find out?	1 page
<b>Discussion</b>	What does it mean?	1/2 page
<b>References</b>	Whose work did you refer to?	

- **maximal 3 pages in total** (use template from github page)
- **no python code** in the summary

# Tips on preparing the presentation

- follow the logic :  
    Problem – Method(s) – Results
- keep it simple !!
- stick to the 10 min presentation duration (hard limit): requires training
- in case you worked as a team : present the project *together*
- *no python code* in the presentation

# List of End-of-Year Project proposals

- 16 diverse projects are listed here :  
<https://github.com/mgraupe/DataSciPy/blob/master/EndOfYearProjects.md>
- each project has contact person (Karine, Marcel, Jonas or Michael) with whom you should fix a kick-off meeting soon to get more details and information about the project
- own project ideas are possible and welcome but should be discussed with Michael Graupner beforehand



# P#1: Testing classifier performance on hand-written digits

- *classification project* : train classifier to recognize hand-written digits

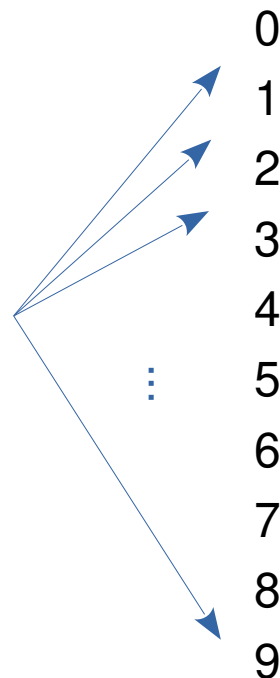
## MNIST handwritten digit database



[images 20x20 pixel]

classifier

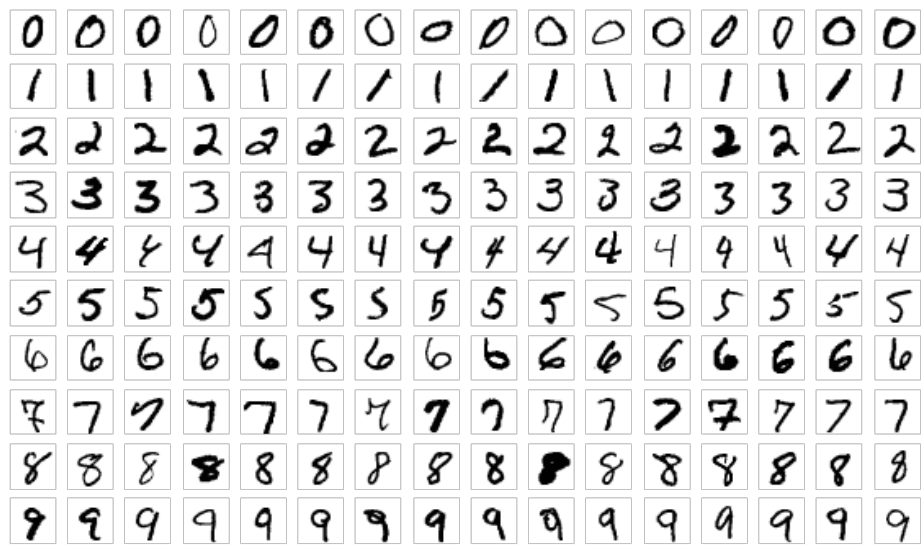
1. train
2. test



# P#2: Exploring existence of clusters in hand-written digits

- *clustering project* : explore number of distinguishable clusters in hand-written digits

## MNIST handwritten digit database



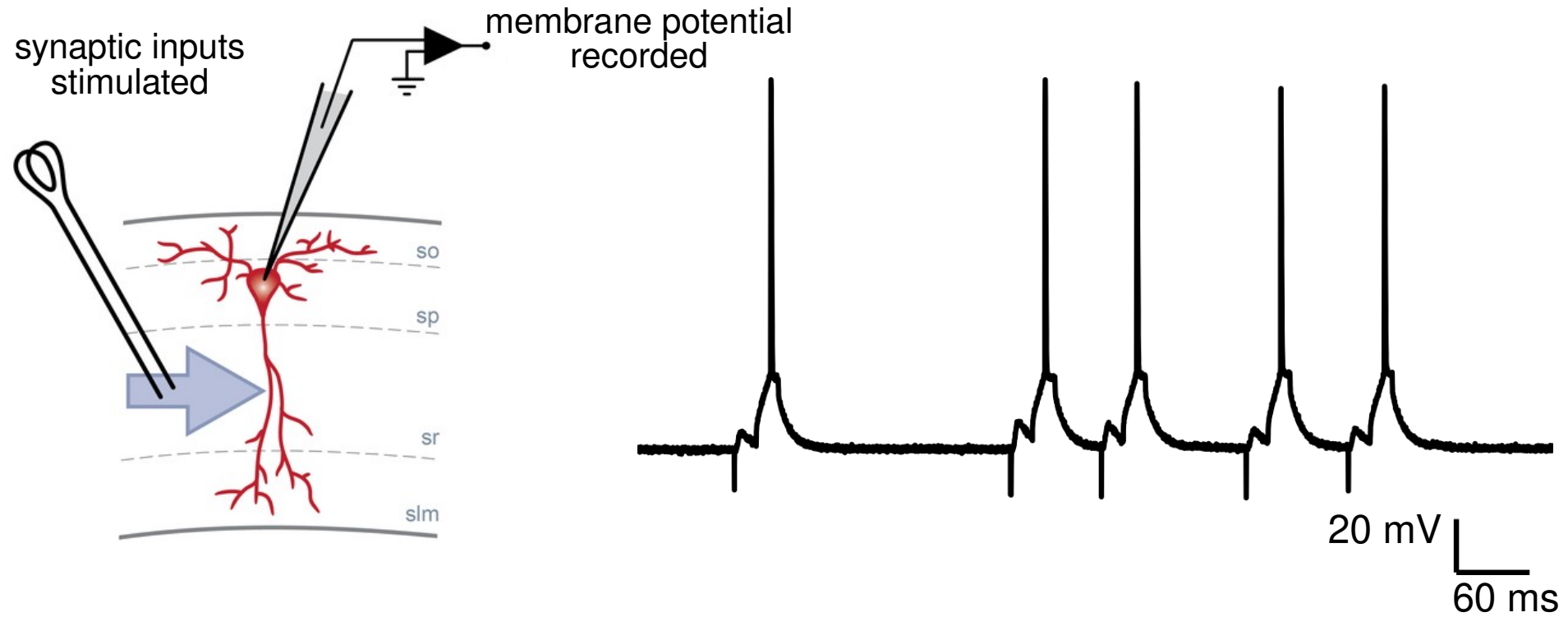
[images 28x28 pixel]

clustering  
algorithm

investigate  
existence  
and number of  
distinct clusters  
in the dataset

# P#3: Extracting and analyzing spike-times from membrane potential recording

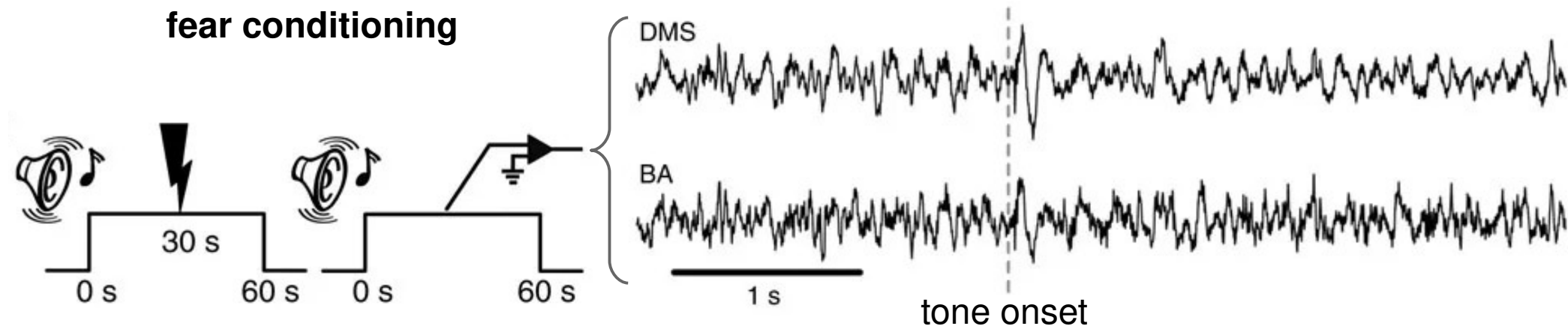
- *time-series analysis* : extract pre- and postsynaptic action potentials



# P#4: Analyze spectral content in an LFP recording

- *time-series analysis* : extract spectral content, generate spectrogram

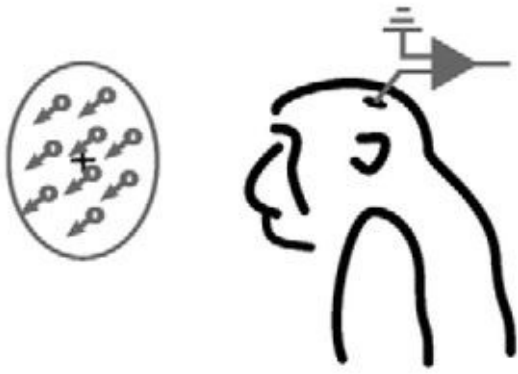
## fear conditioning



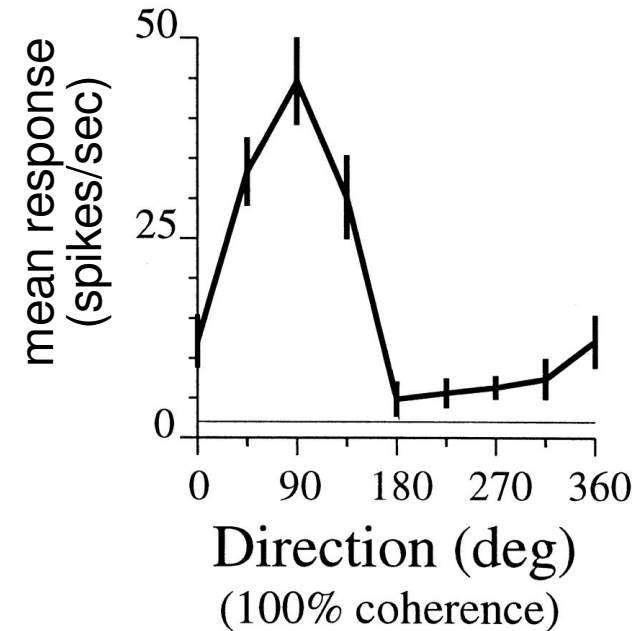
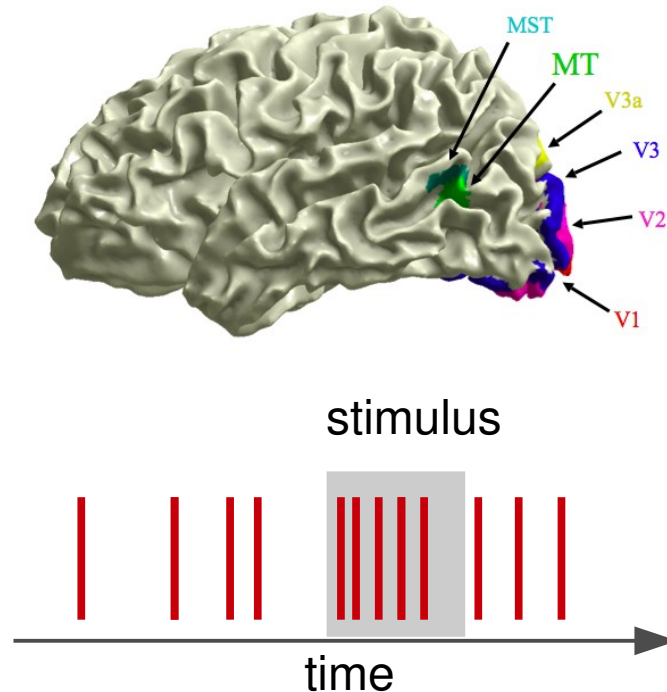
How does the frequency content of the local field potential trace change during a conditioning trial ?

# P#5: Compute tuning curves of monkey visual cortex neurons

- *spike train analysis* : calculate tuning curves, PSTH, calculate spiking statistics



tetrode recording in  
visual area MT of awake  
fixating monkey



# P#6: Extract local field potential and spikes from extracellular recording in the hippocampus

- *time-series analysis* : signal filtering, extract information in different frequency bands, extract spikes and statistics, as well as LFP (spectrogram)

neuronexus probe  
in hippocampus

raw extracellular  
signal

Local field potential

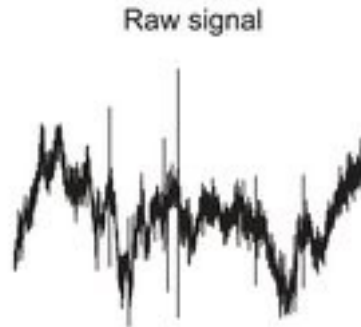
<250 Hz

Spiking activity

0.5 –  
10 kHz

0.2 mV

0.1 second



Low pass  
filter



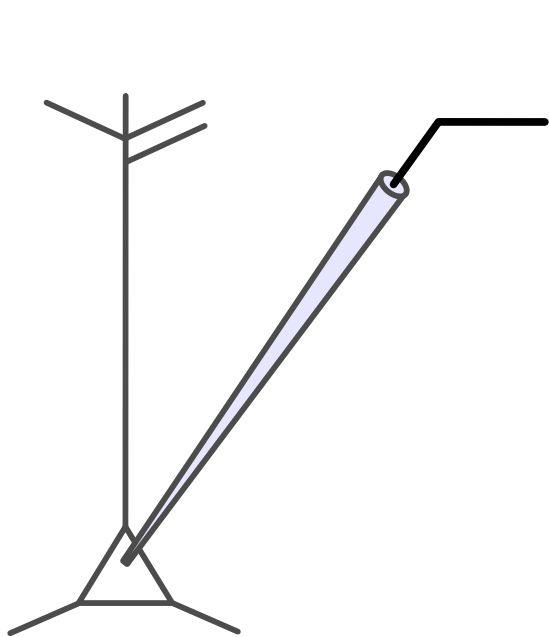
High pass  
filter



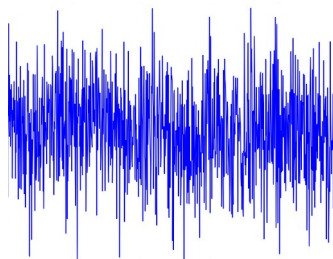
# P#7: Leaky-Integrate-and-Fire model with refractory period

- *model simulation*: numerical integration of a differential equation, spike analysis

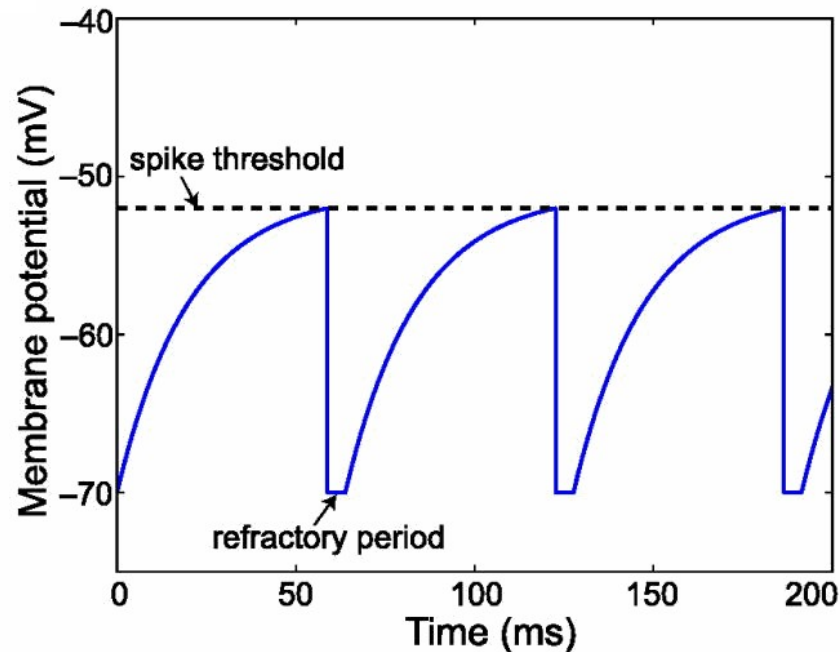
Single neuron model



Noisy input



Leaky-Integrate-and-Fire Model

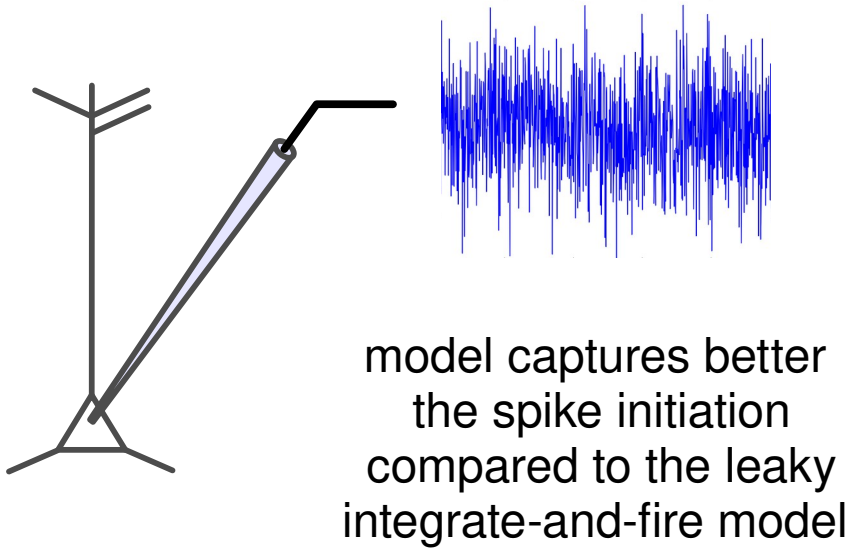


# P#8: Exponential-Integrate-and-Fire model

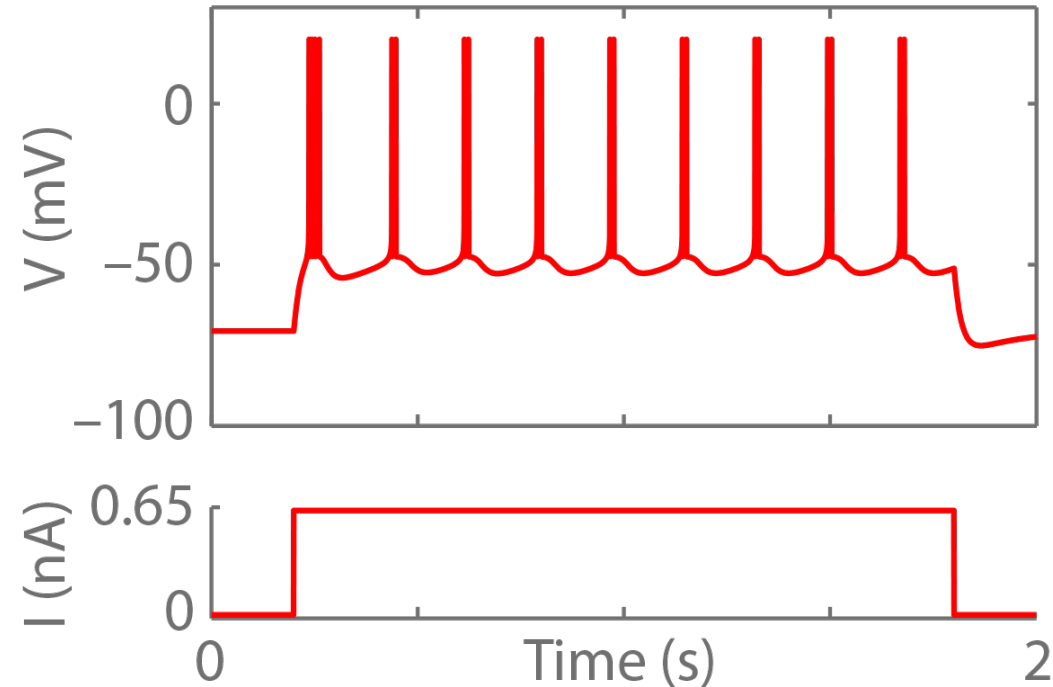
- *model simulation*: numerical integration of a differential equation, spike analysis

Single neuron model

Noisy input



Exponential-Integrate-and-Fire

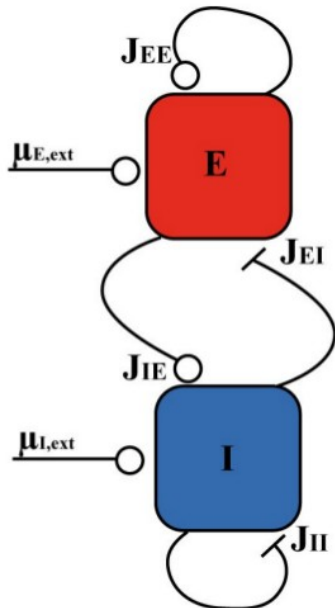




# P#9: Dynamics of a network of spiking neurons

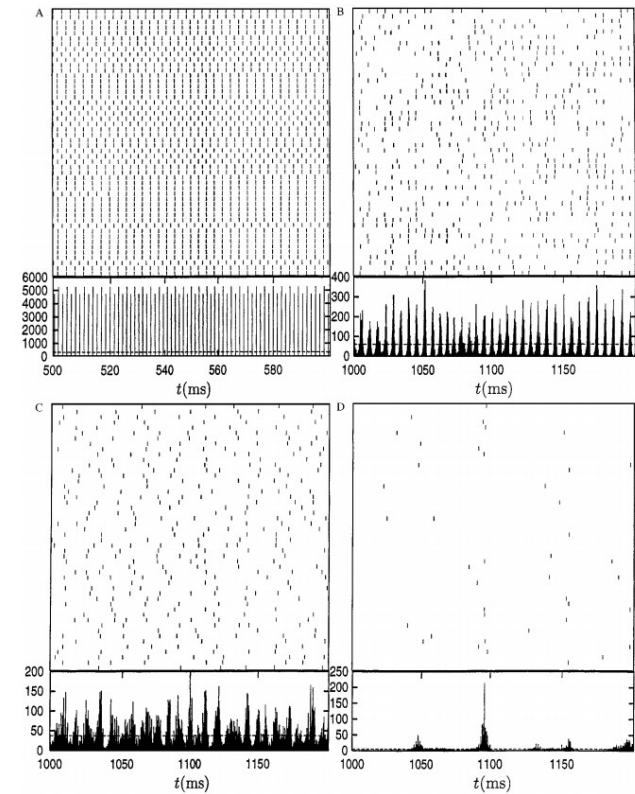
- *recurrent network simulation* using Brian

implement network of connected  
excitatory and inhibitory neuron



[Brunel, J Comp Neurosci 2000]

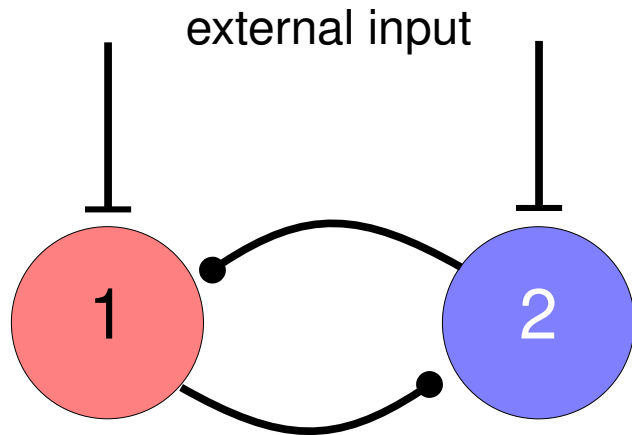
explore different activity regimes



# P#10: Coupled oscillators

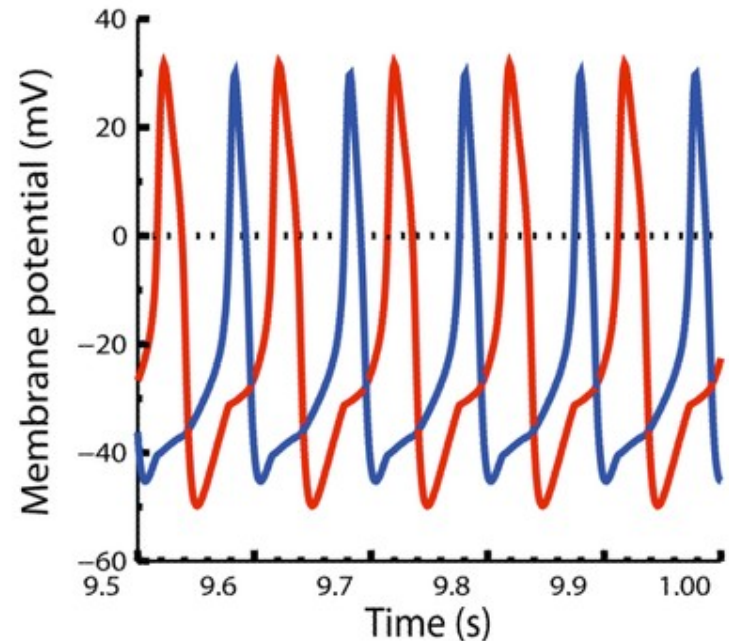
- *2-neuron network simulation* using Brian

implement network of 2 connected neurons  
and explore activity as function of  
synaptic connection



no connection, exc. synapses, inh. synapses

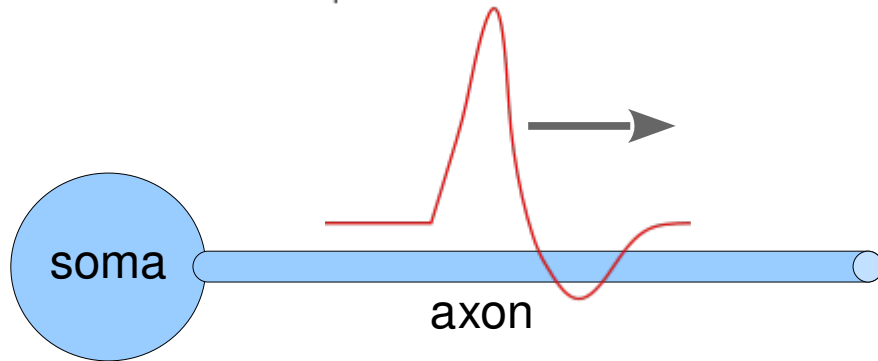
explore temporal relationship of  
the activity between  
both neurons



# P#11: Simulate spike propagation in an axon

- *single neuron with extended morphology simulation* : using Brian

implement single neuron with axon, use Hodgkin-Huxley equation in axon

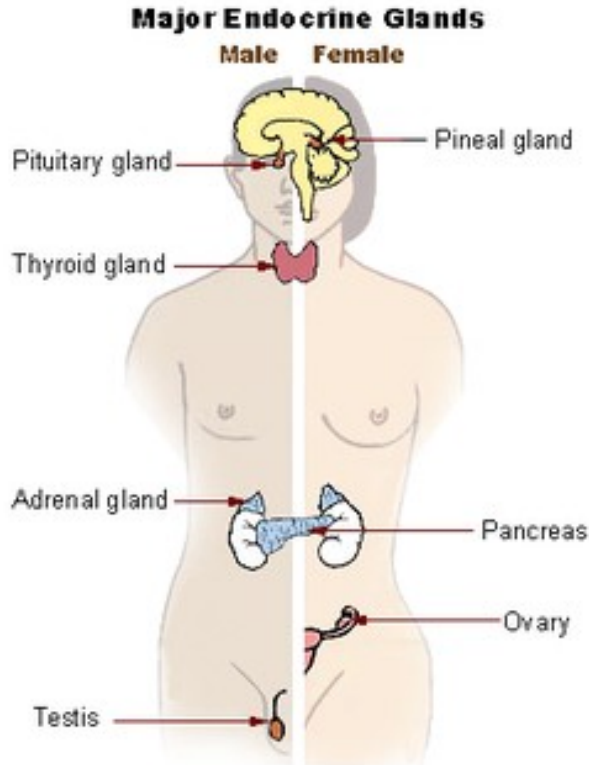


study directional propagation of action potential along axon just like Hodgkin-Huxley



# P#12: Endocrine disruptors and metabolic disorders

- literature search based project: query Pubmed



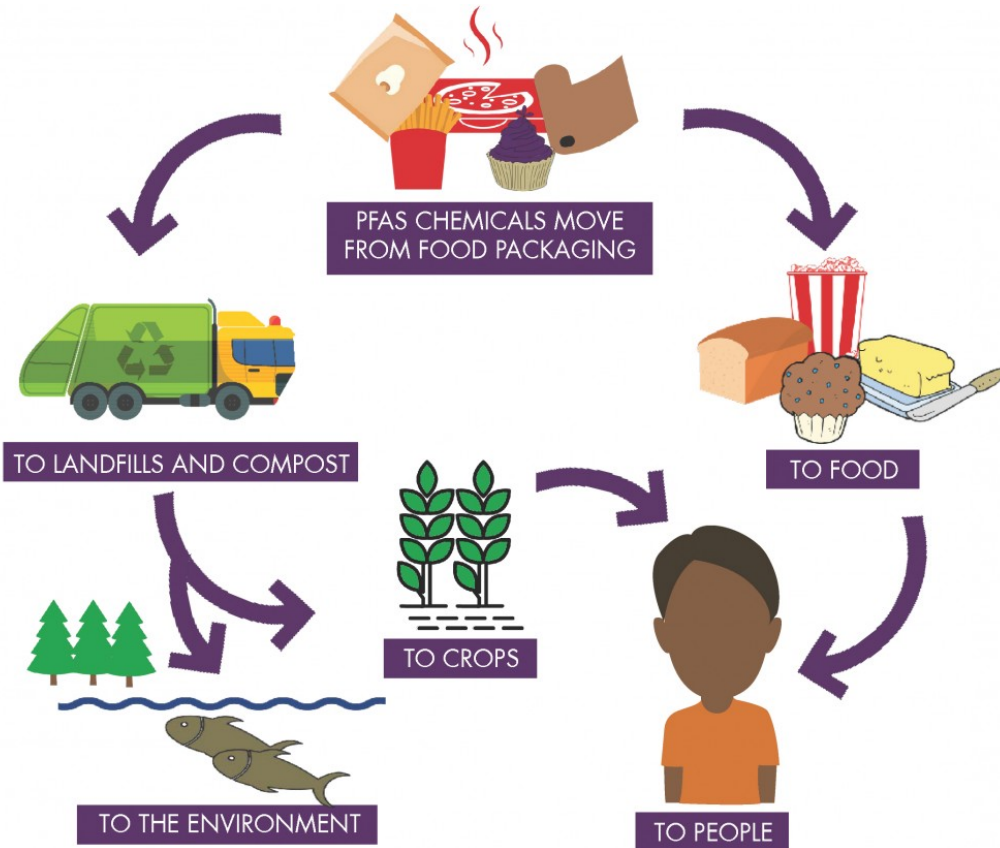
The endocrine system is a chemical messenger system comprising feedback loops of the hormones released by internal glands of an organism directly into the circulatory system, regulating distant target organs.

Endocrine disruptors are chemicals that can interfere with endocrine (or hormonal) systems at certain doses.

You will investigate research on endocrine disruptors and which type of diseases they have been linked with based on publication on Pubmed.

# P#13: Evaluation of health risks from PFAS exposure

- literature search based project: query Pubmed



Per- and polyfluoroalkyl substances (PFAS) are a group of man-made chemicals that includes PFOA, PFOS, GenX, and many other chemicals

PFAS are manufactured and used to produce resistant coatings. They are very persistent in the environment and in the human body.

There is evidence that exposure to PFAS can lead to adverse human health effects.

You will investigate research on PFAS and which type of diseases they have been linked with based on publications on Pubmed.