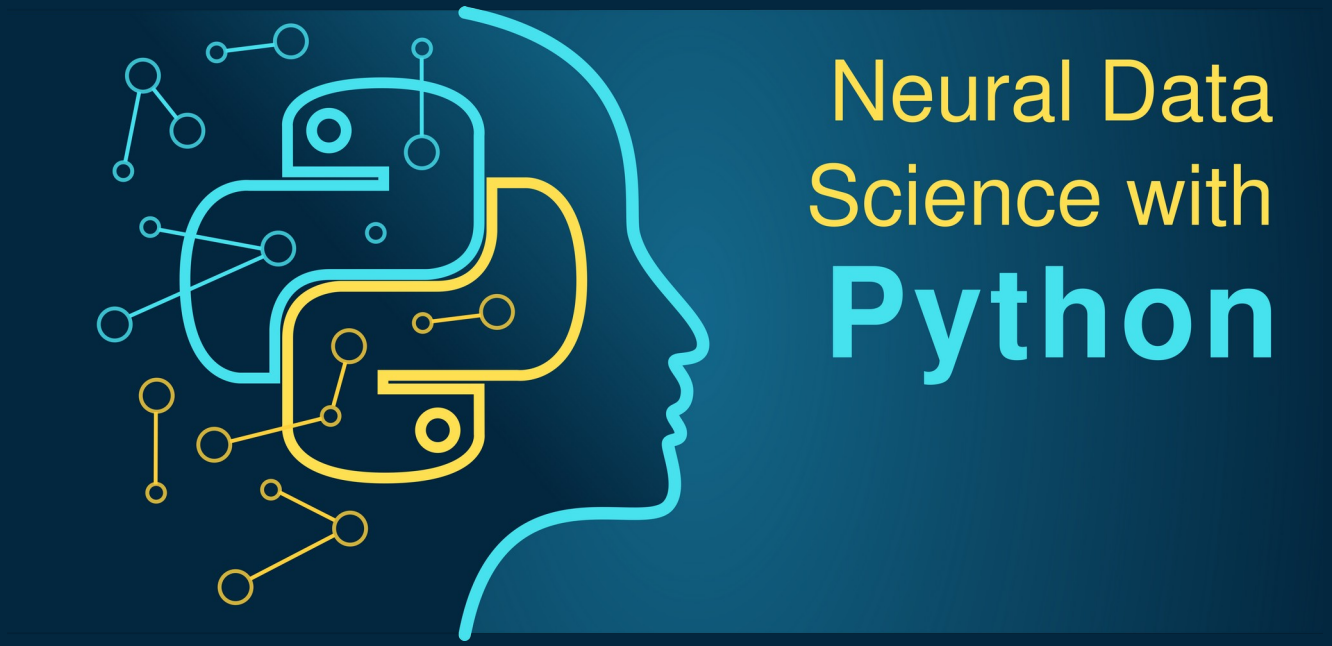



# End-of-Course Projects: Selection and Realization

*Michael Graupner*
*SPPIN – Saint-Pères Institute for the Neurosciences*
*Université Paris Cité, CNRS*

# 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/solidify your knowledge** : use the knowledge/expertise 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 your 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?
- **Look back at the course material for help and example implementations :** the techniques used have been discussed in the course, this should be your first reference
- **Use the internet to get help :** Be precise in your question and key-words; common sites for useful help : *stackoverflow, askubuntu, github*.

# Tips for the project jupyter-notebook

- evaluation will be based on the **jupyter-notebook** which you developed while working on the project
- besides the python code, the jupyter-notebook should be annotated (with explanations and comments) and contain the following

| | | |
|---|---|---|
| **Title** | Should be concise and precise | maximal 2 lines |
| **Abstract** | What did you do in a nutshell?<br>Question – Method(s) – Results | 1 paragraph |
| **Introduction** | What is the question? | 2-3 paragraphs |
| **Annotate the python code** | Describe concisely what your aim to do with each code snippet | |
| **Results** | Explain, interpret your results; figures should have captions explaining them (labels too!) | |
| **Discussion** | What does it all mean? | 2-3 paragraphs |
| **References** | Whose work did you refer to? | |

# Tips on preparing the presentation

- Do not prepare slides ! the presentation and discussion will be solely based on the jupyter-notebook
- follow the logic :

  Question – Method(s) – Results
- stick to the 10 min presentation duration (hard limit): requires training
- in case you worked as a team : present the project *together*
- do not go into the details of the python code, rather provide the general purpose

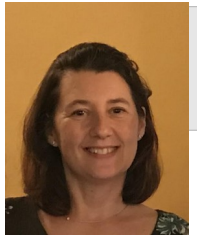
# Timeline of the project

- **Nov 18th, '22** (today) : introduction, presentation of possible projects
- **Nov 25th, '22** : final determination of who works on which project
- soon after **Nov 25th** : meet the tutor and get introduced to the project (you have to set up the meeting yourself)
- between **Nov 25th , '22** and **Jan 2nd (23h59), '23** : work on the project, try to spread the work during that period (~2-3 full days of work are required)
- **Jan 2nd (23h59), '23** : submit the project jupyter-notebook file
- **Jan 6th , '23 9h30-12h30** : project presentation/discussion in front of jury, each student/team of two has 10 min for presenting their project + 5 min of questions

# List of End-of-Year Project proposals

- 16 diverse projects are listed here : https://github.com/mgraupe/DataSciPy2022/blob/master/EndOfYearProjects.md
- go through the list and **pick out three proposals ranked by your order of preference** : **send** this list together with your team configuration to Michael **until Nov 25th, 9am**
- each project has contact person (Karine, Jonas, Marcel, Heike, 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

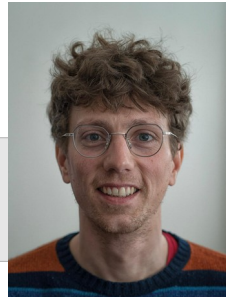
# The five project tutors



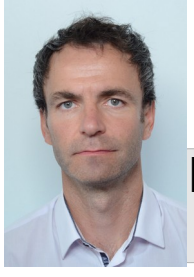
Karine Audouze, Université Paris Cité
karine.audouze@u-paris.fr

Heike Stein, ENS
heike.c.stein@gmail.com

Marcel Stimberg, Institute de la Vision
marcel.stimberg@inserm.fr



Jonas Ranft, ENS
jonas.ranft@ens.psl.eu

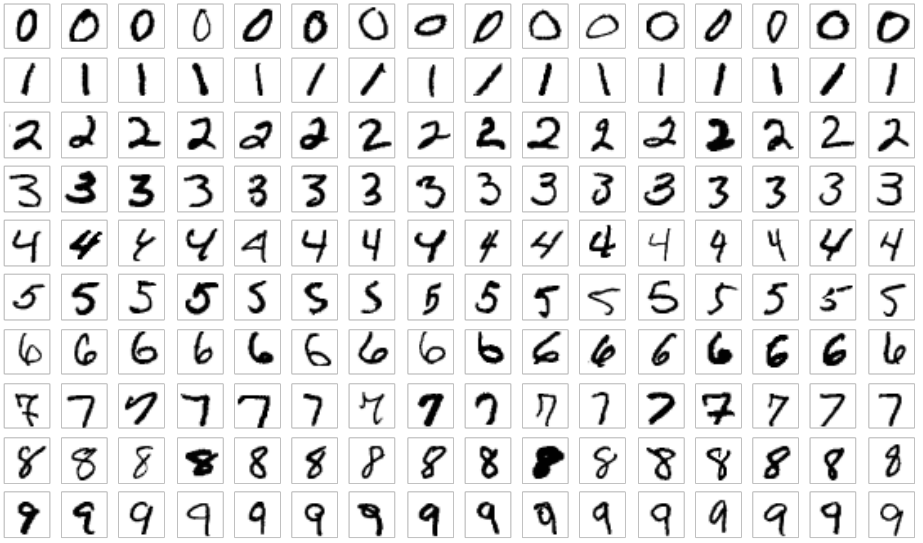


Michael Graupner, Université Paris Cité
michael.graupner@u-paris.fr

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

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

**MNIST** handwritten digit database



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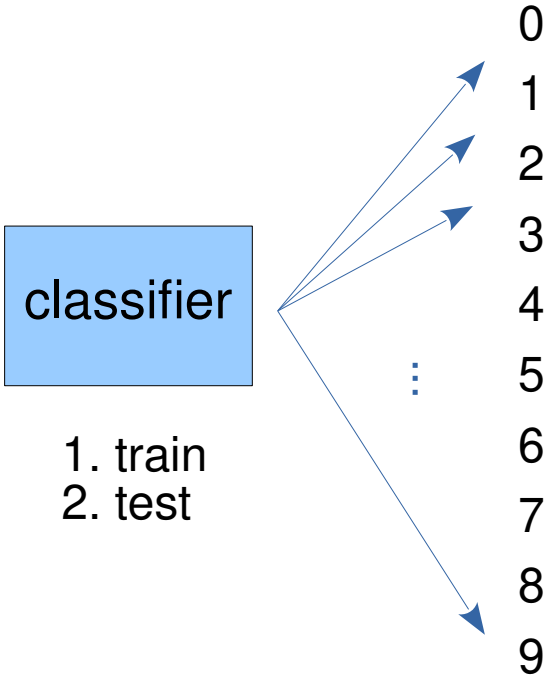
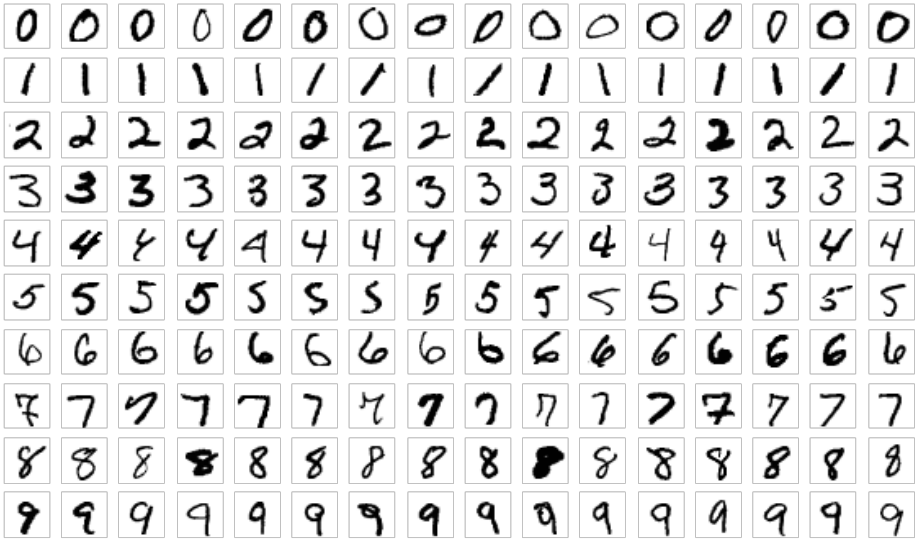


# P#2: Exploring existence of clusters in hand-written digits

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

**MNIST** handwritten digit database



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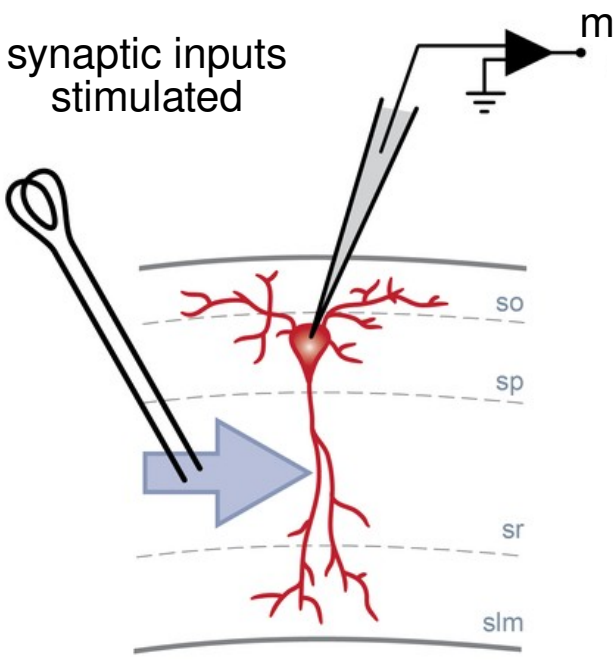
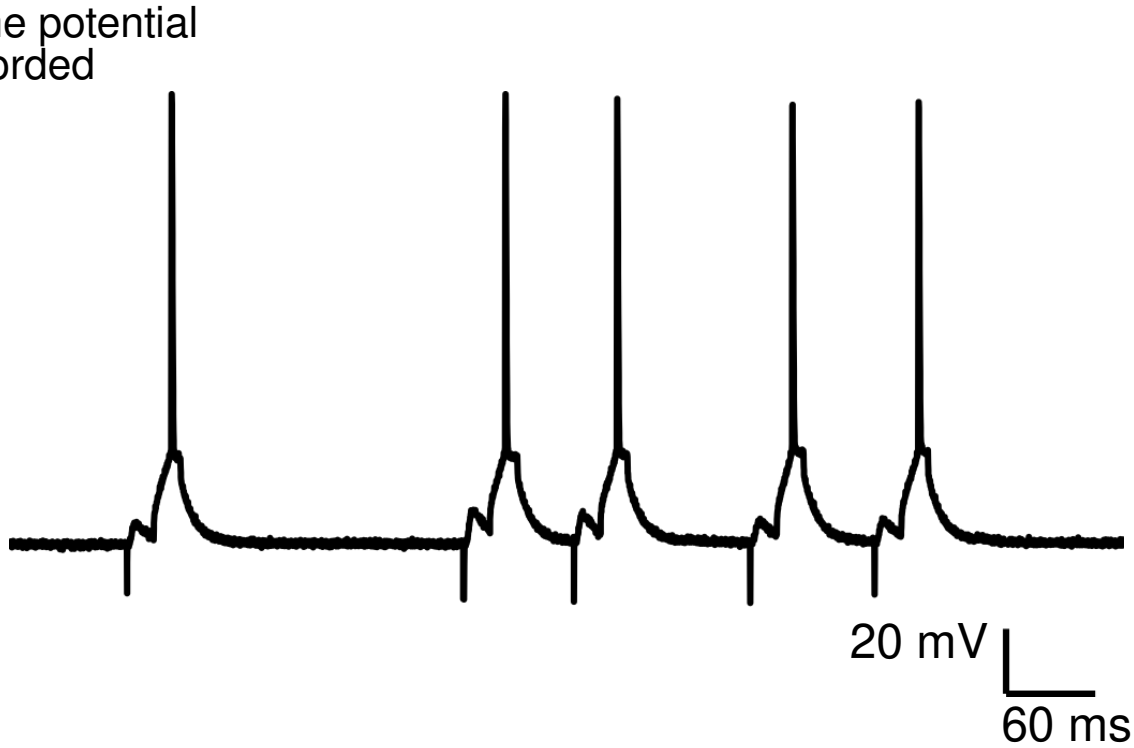
clustering algorithm → investigate existence and number of distinct clusters in the data-set

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

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



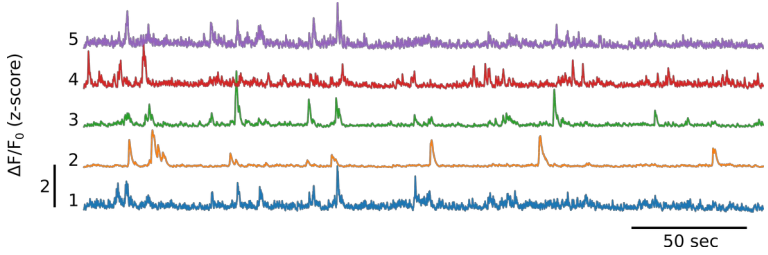



# P#4: Calculate head-direction tuning curves of presubicluar neurons from calcium imaging

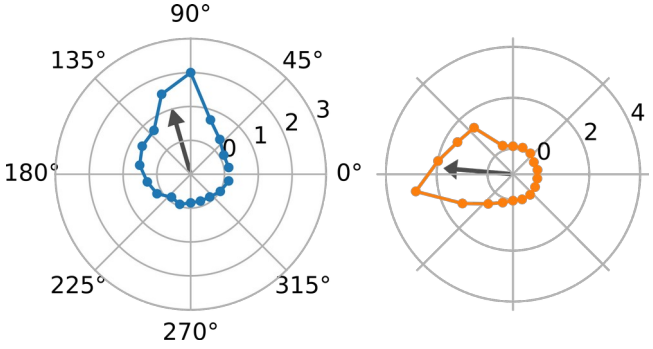
- *calcium imaging analysis* : compute the histogram and determine preferred head-direction

recordings with miniscope in presubiculum

calcium traces



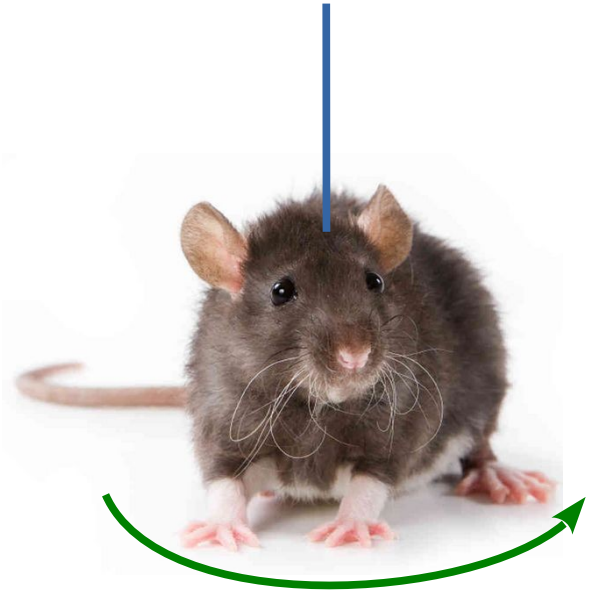

head-direction tuning curves



# P#5: Calculate head-direction tuning curves of presubicluar neurons

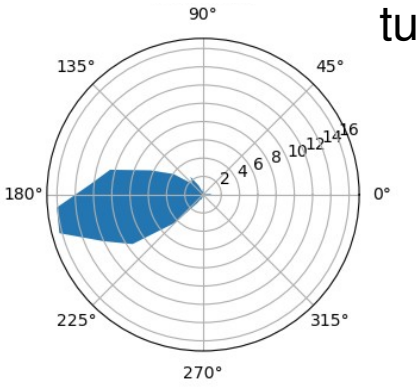
- *spike train analysis* : calculate tuning curves, preferred direction, spiking statistics

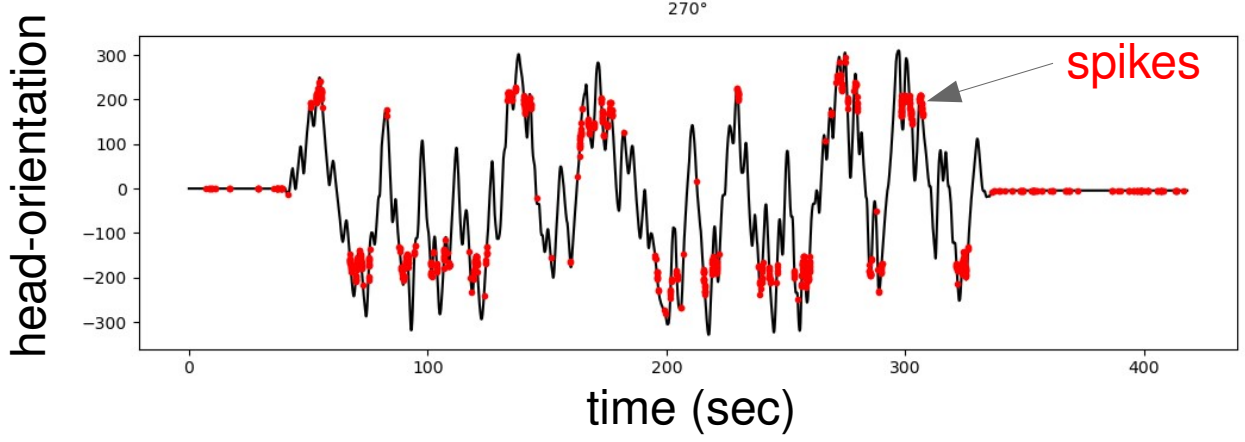
neuropixel probe
in presubiculum



mouse is rotated

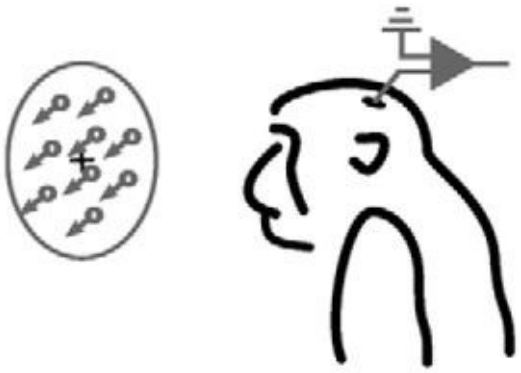
tuning curve



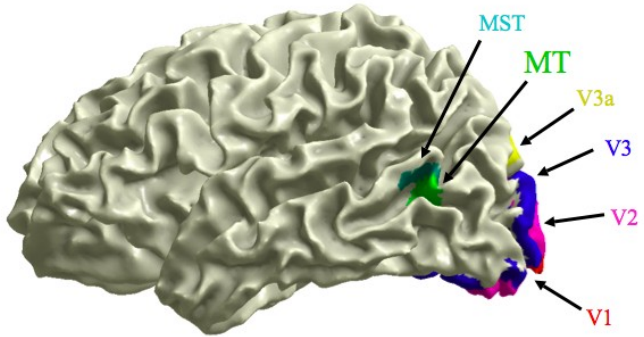



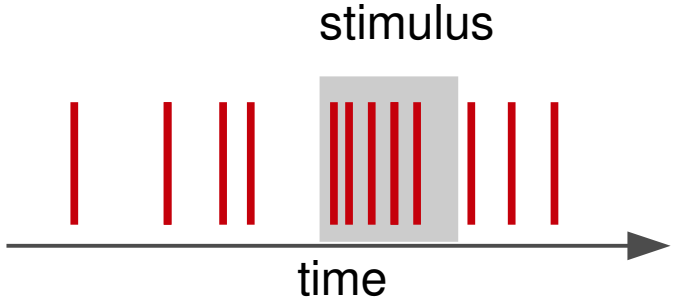
# P#6: Compute tuning curves of monkey visual cortex neurons

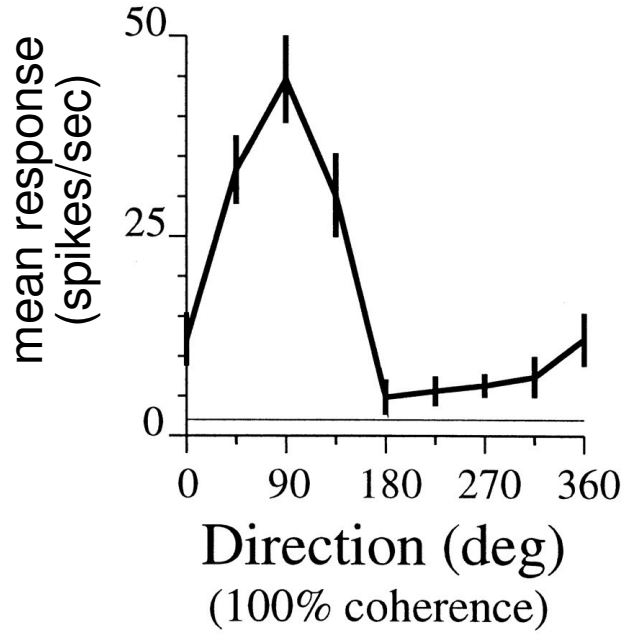
- *spike train analysis* : calculate tuning curves, PSTH, calculate spiking statistics



tetrode recording in visual area MT of awake fixating monkey

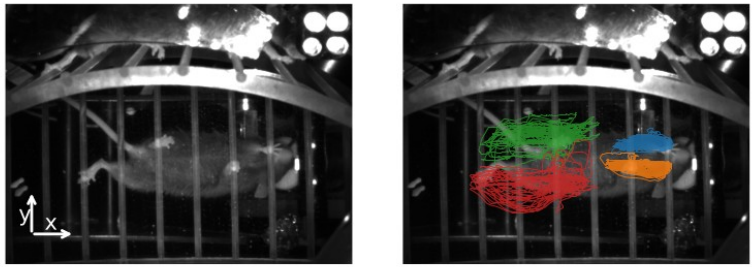


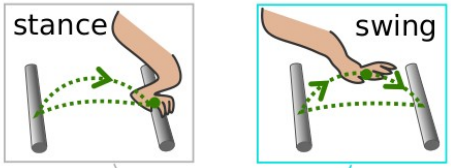



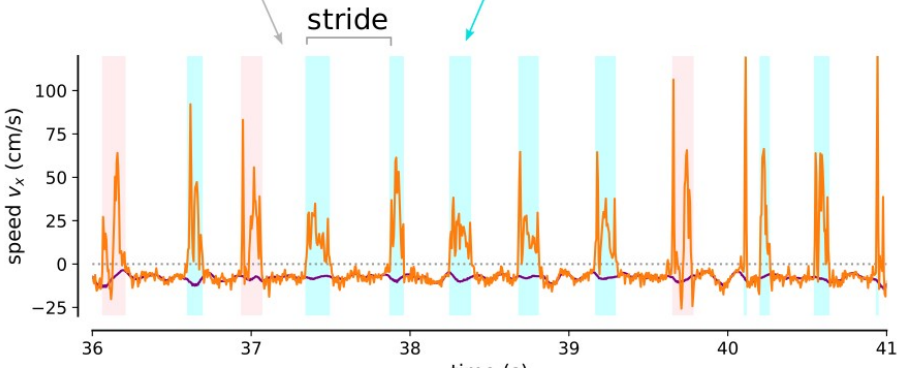
# P#7: Study the link of cerebellar activity to the step cycle

- *spike train analysis* : align spike times, PSTH, calculate spiking statistics



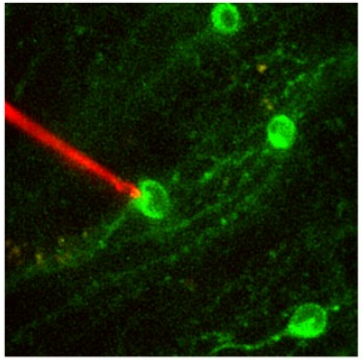


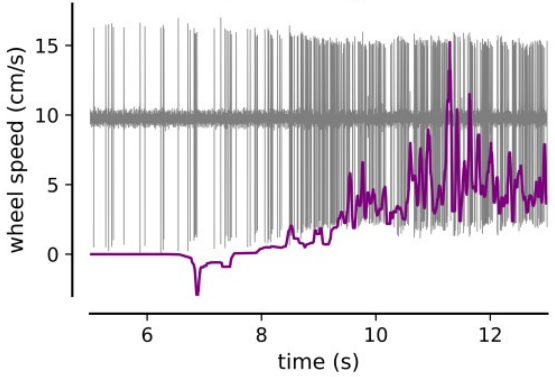




study link between step cycle and spiking activity :
which event for which paw induces firing rate changes ?

Visually guided targeting of an MLI



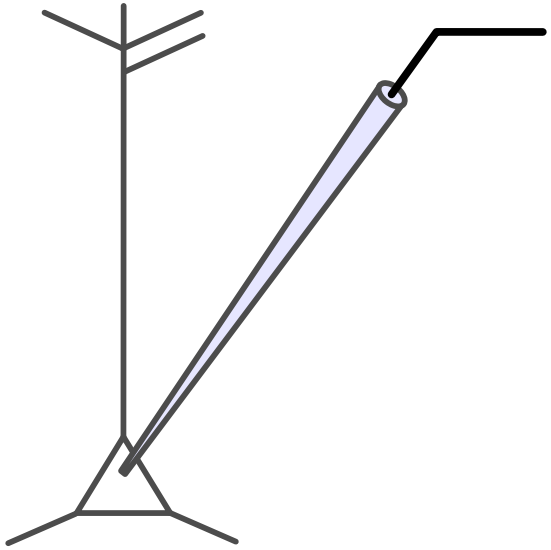
Example recording of an MLI



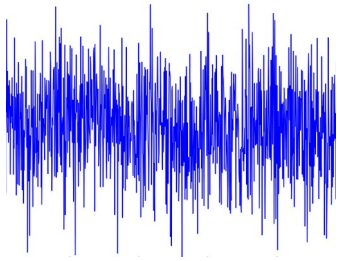
# P#8: Leaky-Integrate-and-Fire model with refractory period

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

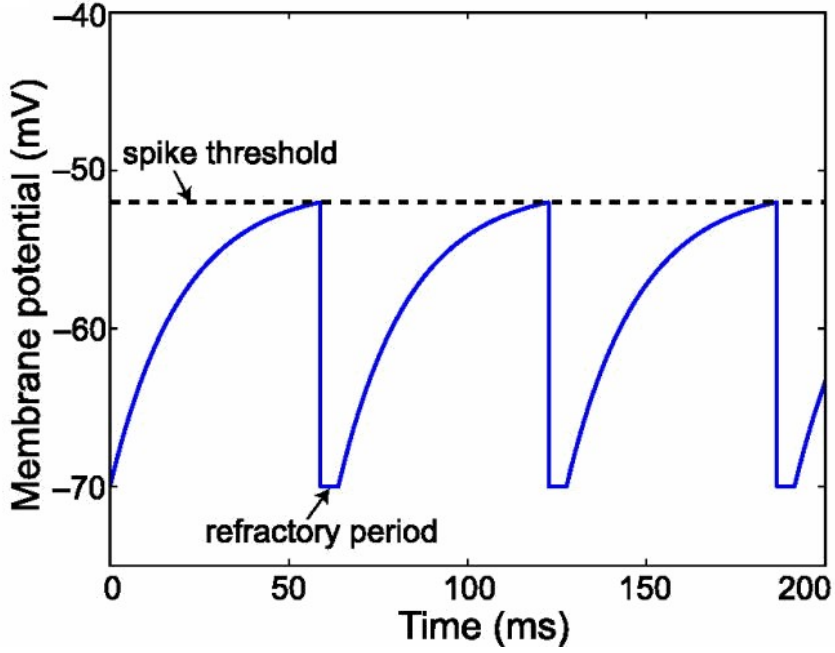
Single neuron model



Noisy input



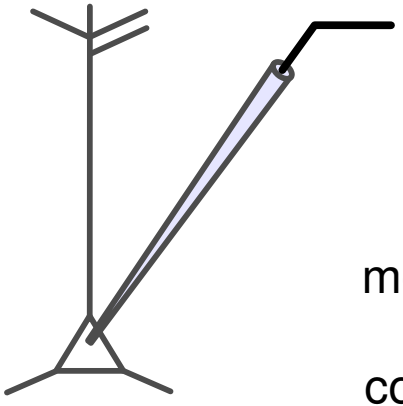
Leaky-Integate-and-Fire Model



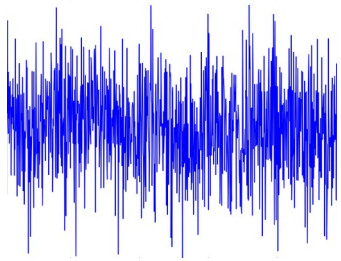
# P#9: Exponential-Integrate-and-Fire model

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

Single neuron model

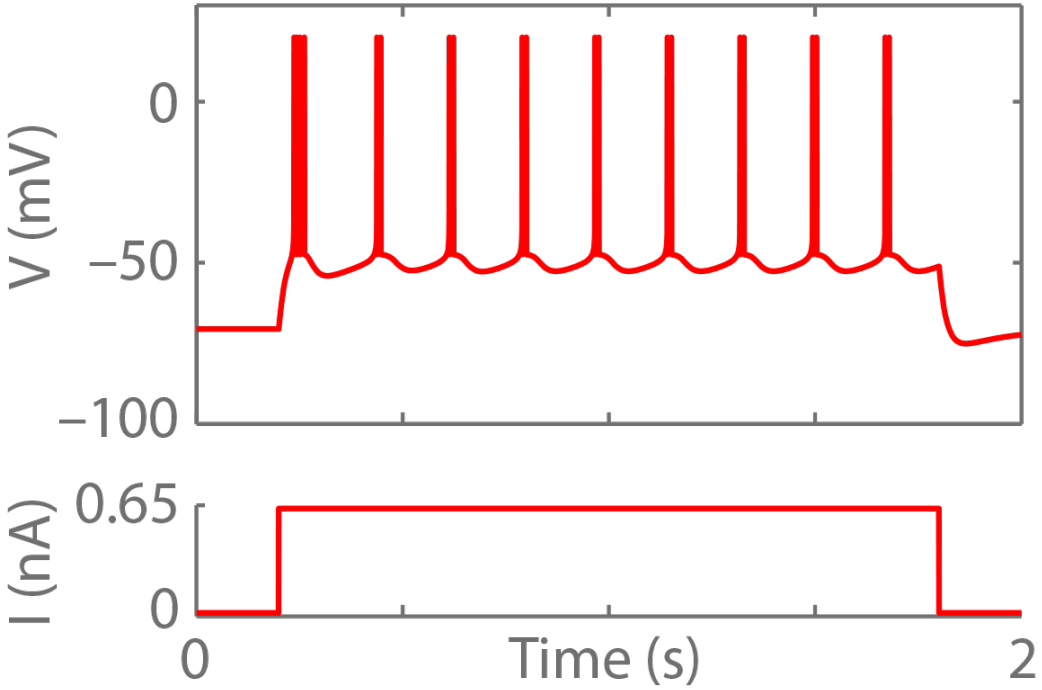


Noisy input



model captures better the spike initiation compared to the leaky integrate-and-fire model

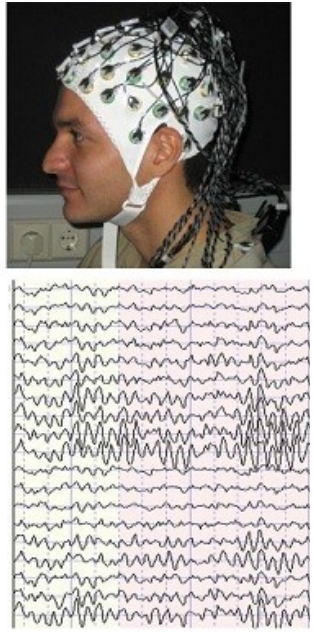
Exponential-Integrate-and-Fire



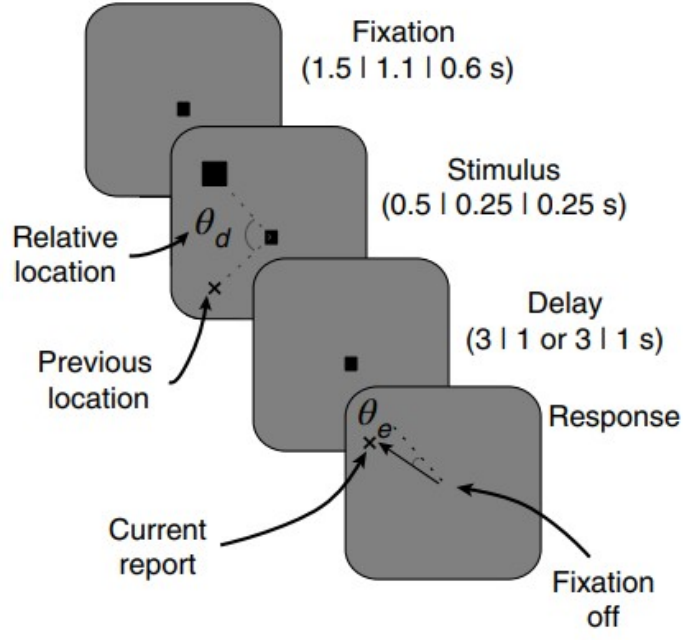
# P#10: Decode working memory content from EEG recording

- *decoding a time series* : train a linear classifier on time-series data, use cross-validation

Human EEG recording



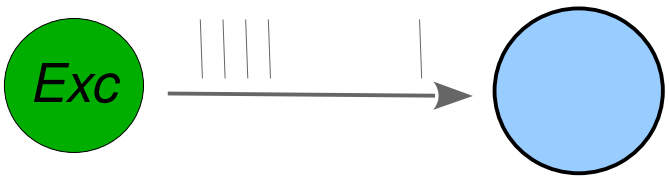
Working memory task



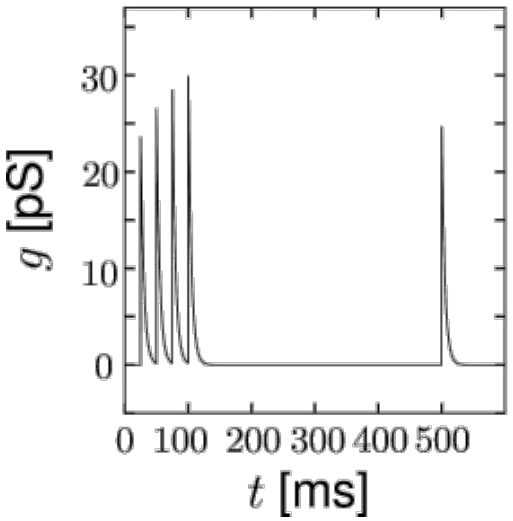

Train a decoder on the EEG data to predict where the stimulus occurred

# P#11: Short-term synaptic plasticity

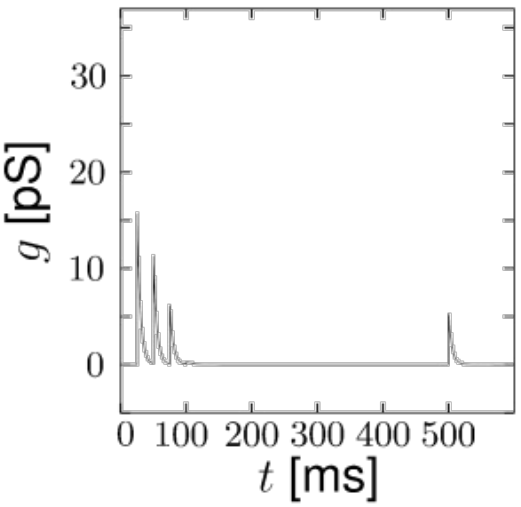
- *two neuron simulation :* synaptic transmission changes, use Brian




facilitating synapse



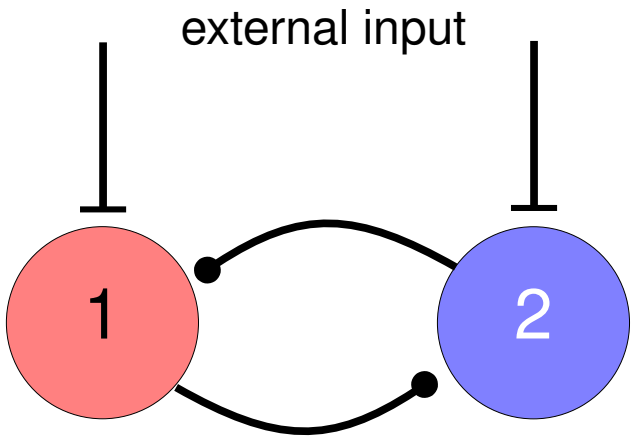

depressing synapse



# P#12: Coupled oscillators

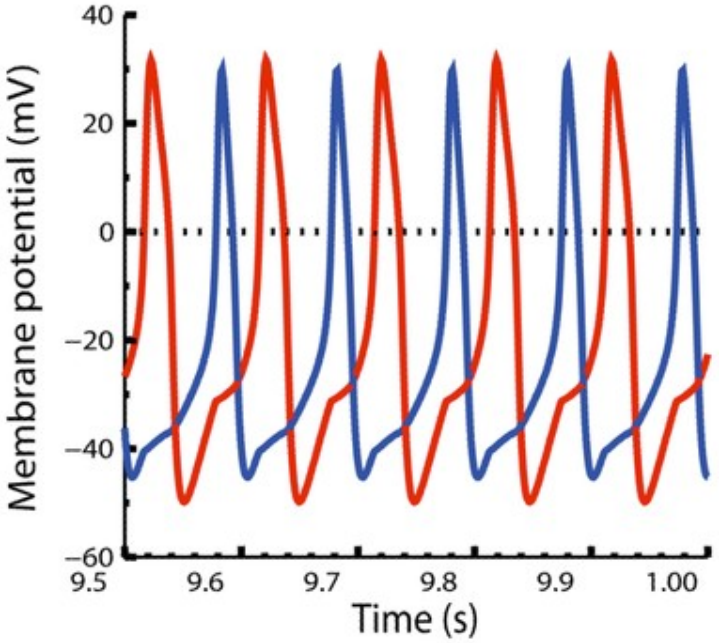
- *2-neuron network simulation* using Brian

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




no connection, exc. synapses, inh. synapses

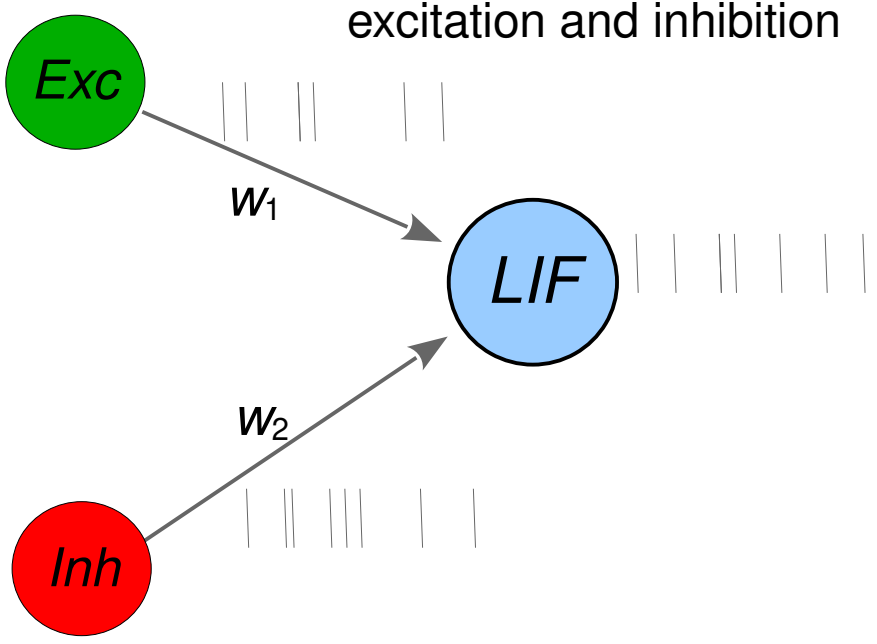
explore temporal relationship of
the activity between
both neurons



# P#13: Interplay of excitation and inhibition

- *single neuron simulation in Brian* : analyze input and spike output of a single neuron

implement a leaky-integrate-and-fire neuron model in Brian receiving excitation and inhibition




→ Explore how the excitatory and inhibitory synaptic inputs shape the spike output of the neuron

# P#14: Phytopharmaceutical compounds and neuro-developmental disorders

- *Bioinformatics* : literature search based project, query Pubmed

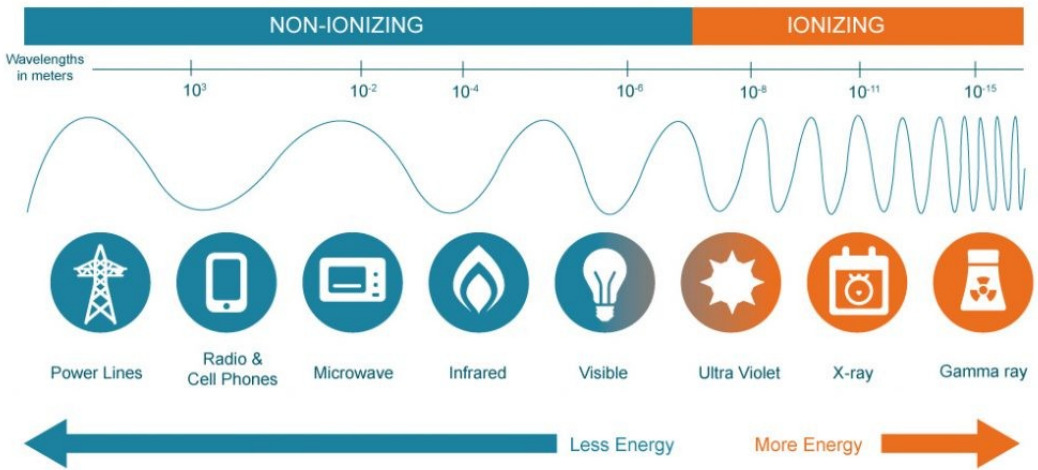
Phytopharmaceuticals, i.e. “herbal” medicines, consist of several compounds with a therapeutic effect. Plants or parts thereof are used for the production of herbal medicines. Herbal medicines are sold in dry form as granules, tablets, capsules and lozenges. Medicinal oils such as arnica flower oil can be used to make ointments.

You will investigate research on phytopharmaceutical compounds and which type of neurodevelopmental disorders they have been linked with based on publications on Pubmed.

# P#15: Evaluation of health risks from ionizing radiation exposure

- *Bioinformatics* : literature search based project, query Pubmed

electromagnetic spectrum

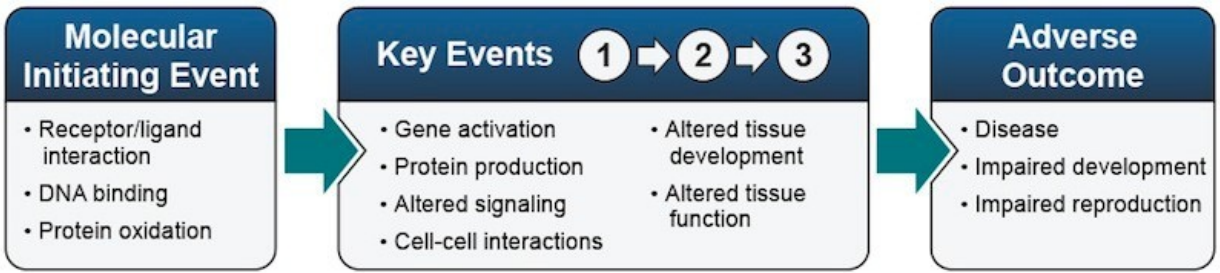



Ionizing radiation consists of subatomic particles or electromagnetic waves that have sufficient energy to ionize atoms or molecules by detaching electrons from them.

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

# P#16: Exploring the usage of AI in toxicology

- *Bioinformatics* : literature search based project, query Pubmed

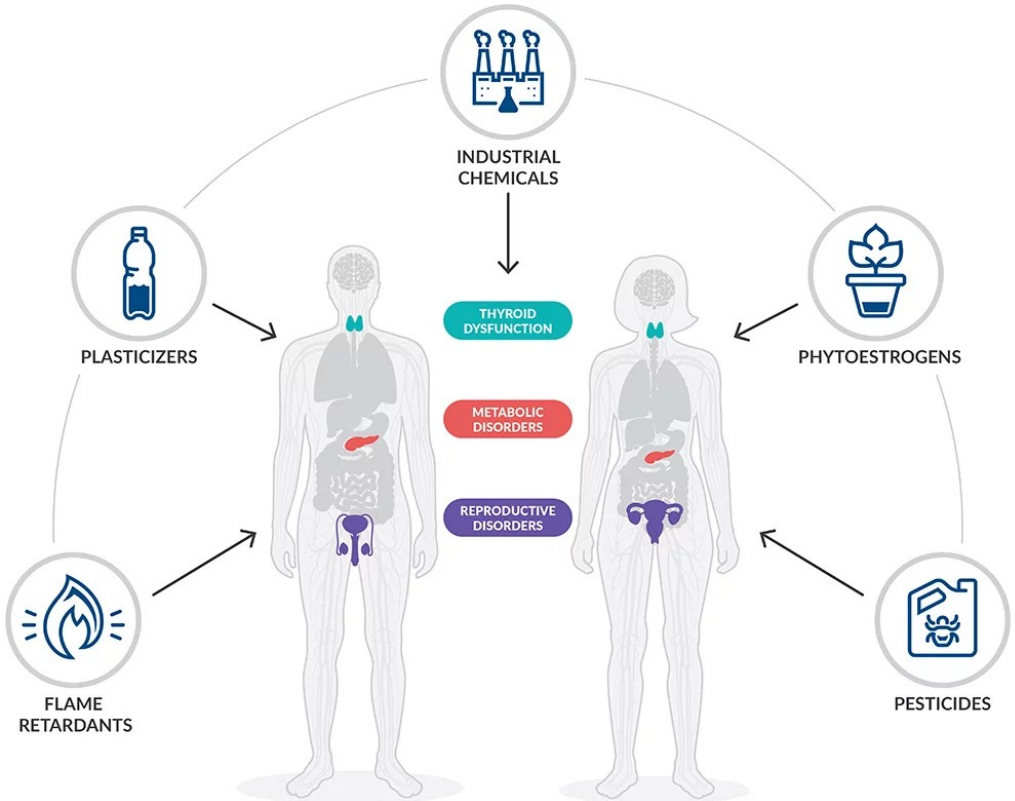



The adverse outcome pathway (AOP) concept is a theoretical framework that describes the activity of a chemical from its initial interaction with a biological system (the molecular initiating event) through a series of intermediate events to the eventual toxic response (adverse outcome).

You will investigate research using artificial intelligence approaches to investigate adverse outcome pathways based on publications on Pubmed.

# P#17: Endocrine disrupting chemicals and obesity

- *Bioinformatics* : literature search based project, query Pubmed




Endocrine disruptors are natural or man-made chemicals that may mimic or interfere with the body's hormones, known as the endocrine system.

Study endocrine disruptors and their links to **obesity**.