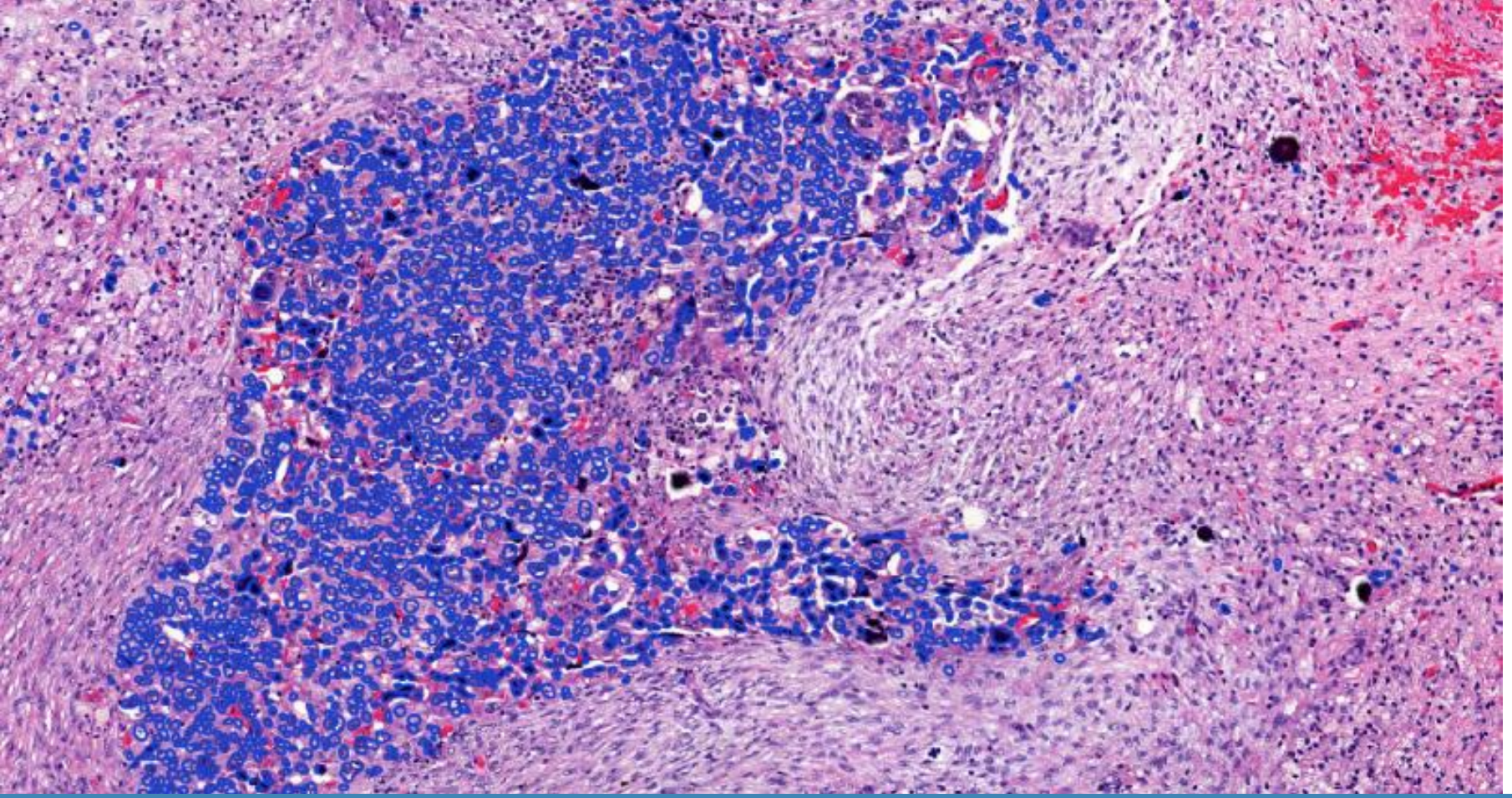

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Improving clinical decisions in cancer

# Lab Introduction

Marta Lovino, PhD

2023/2024

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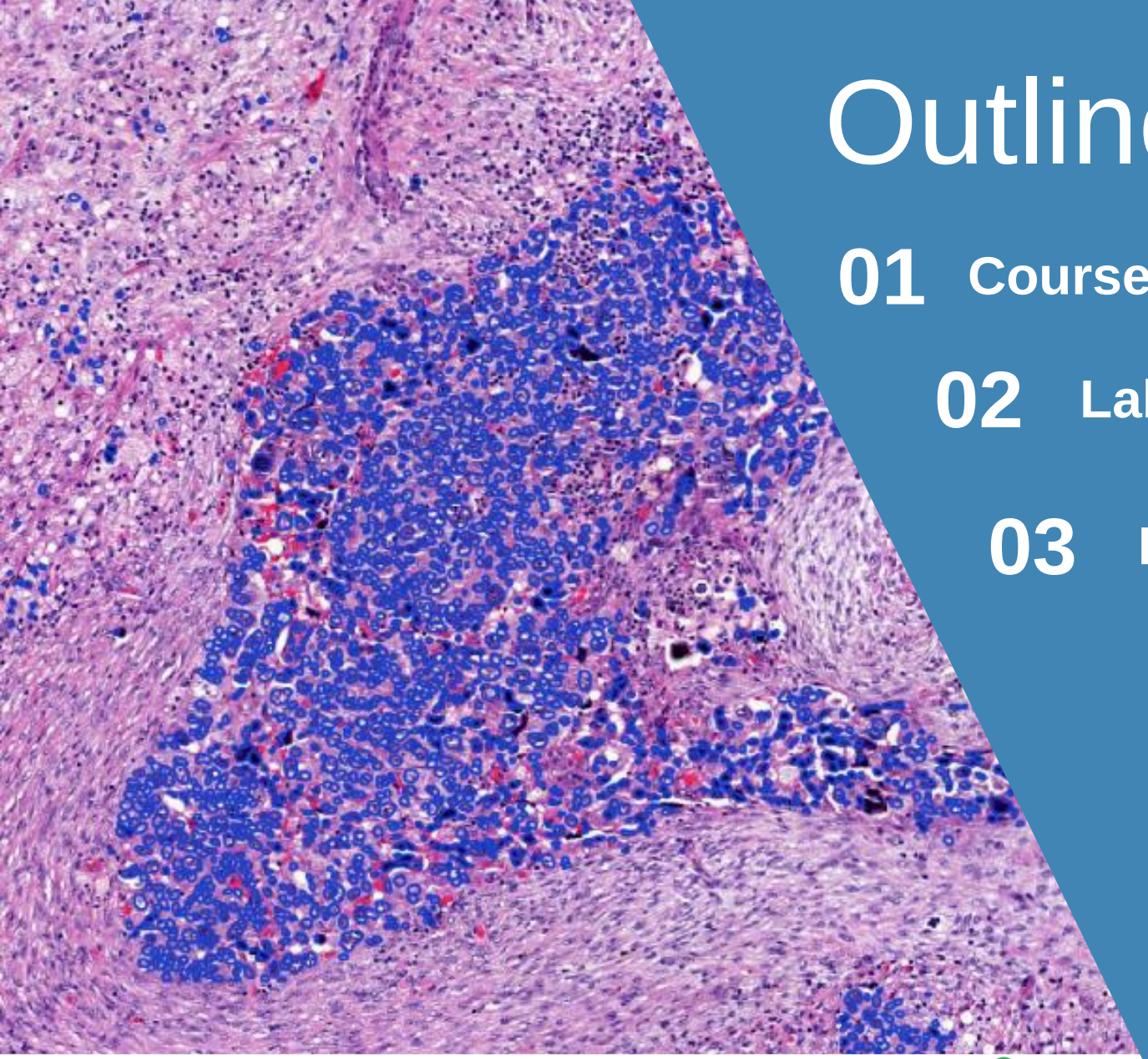
September 17, 2023



# Outline

**01** Course schedule

**02** Lab topics

**03** Lab setup - Live

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# Course schedule

**AI in Bioinformatics**

**9 CFU – I Semester**

**Monday, 8-10** → to be rescheduled
**Tuesday 9-11**
**Thursday 14-16**

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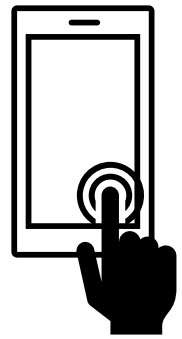

**http://bit.ly/45Ui8kx**

Sept 18 – Dec 14, 2023

Always check the course website and Slack channel to stay up-to-date on the course schedule
https://join.slack.com/t/2023aiinbioin-esm6867/shared_invite/zt-23e7dweoy-CyFqD5exlQZfoAgEfPnzMA

# Course schedule

**Consulting time:**

**- During Lab lessons**
**- Schedule an appointment with the Lab reference person, writing an email**

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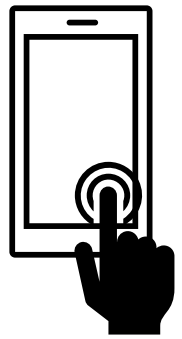

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# Course Objectives

- **This course introduces advanced AI models and problems for biomedical imaging and data analysis.**

- **Students will learn to address challenges such as:**
  - Data scarcity and annotation
  - Reliability and fairness of AI models
  - Integration of multiple data sources
  - Continuous learning

- **Through practical examples and lab sessions, students will learn techniques for:**
  - Multiple-instance learning (MIL)
  - Bias correction
  - Multimodal learning and co-learning
  - Statistical methods for AI model evaluation and data analysis
  - 2D and 3D segmentation (e.g., using UNet and Visual Transformers)

- **Specific topics will be covered in thematic seminars, such as continual learning, etc.**

# Lab Prerequisites

- **Required**:
  - Solid foundation in computer science, including algorithms, data structures, and programming (e.g., Python, C, C++, or Java).

- **Recommended**:
  - Completion of the course MACHINE LEARNING AND DEEP LEARNING (even without passing) or basic knowledge of machine and deep learning.

- **Support**:
  - Students who do not meet the prerequisites will receive explanations and offline materials to understand the basics of the course.

# Lab Prerequisites, details

**Required**:

- Expressions and Variables
- String Operations
- List and Tuples
- Dictionaries
- Sets
- Conditions and Branching
- Loops
- Functions
- Exception Handling
- Objects and Classes
- Reading Files with Open
- Writing Files with Open
- Pandas
- Numpy

# Lab Topics

**Course Introduction (0.5 CFU)**

- Course Objectives, Course Structure and Exam Rules, Setup for Lab Sessions
- Introduction to Bioinformatics:
  - Definition
  - Relevant problems and opportunities in research, industry, and economy
  - Computational problems and requirements of AI models

**Introduction to Biomedical Imaging (1 CFU)**

- Introduction to biomedical images (e.g., WSI Gigapixels images);
- Focus on relevant research topics and challenges in the design of AI models and systems:
  - Data dimensionality
  - Scarcity of annotations and labels
  - Uncertainty in annotations and labels
  - Data containing multiple annotations and labels (i.e., multi-labels)
  - Data at different resolutions
  - Data bias
  - Progressive knowledge, and therefore continuous learning
- Introduction to AI topics that address the above problems

# Lab Topics

**Deep learning architectures (2.5 CFU)**

- Graph neural networks (theory and laboratory)
- Bayesian neural networks (theory and laboratory)
- Transformers and Visual Transformers (theory and laboratory)
- Self-learning: examples of architectures (e.g., DINO)
- Multimodal learning and Co-learning: examples of architectures for integrating data from multiple sources (e.g., text, video, images, sound, etc.) with (partial/total) absence of data (theory and laboratory)

**Statistical methods for data science (0.5 CFU)**

**Biomedical imaging (2.5 CFU)**

- Multiple-Instance Learning (MIL):
  - definition
  - examples of MIL architectures (theory and laboratory)
- Debiasing AI:
  - examples of architectures for debiasing (with or without prior knowledge of the bias)
- 2D and 3D segmentation: UNet, Visual Transformers (theory and laboratory)

# Lab Topics

**Molecular Data: DNA and RNA-sequencing (2 CFU)**

• Brief description of genomic sequencing technologies, data formats, and most used tools for sequence analysis (e.g., Botwie, Arriba, CNV caller, GenomeSpy/Genome Browser) (theory and laboratory)

• Analysis of genomic sequences:

- Examples of architectures based on Transformers (BERT) and Perceivers
- Use cases: prediction of genetic and protein expression from genomic sequences (theory and laboratory)
- Explainability of results and model through inspection of attention mechanisms

• Multimodal learning for molecular data: examples of integration between genomic sequences and molecular data (theory and laboratory)

**Project presentation for the final exam.**

# Material

Lessons will be held in standard classrooms, not laboratories.

**Bring your own laptop to classes!** No particular hardware configuration is required. Please come back to us if you have problems.

**Aim of lab classes:**

practice in solving problems, improve programming skills, work group

# Local machine and Colaboratory

You can freely program on local machine or on your Colaboratory account.

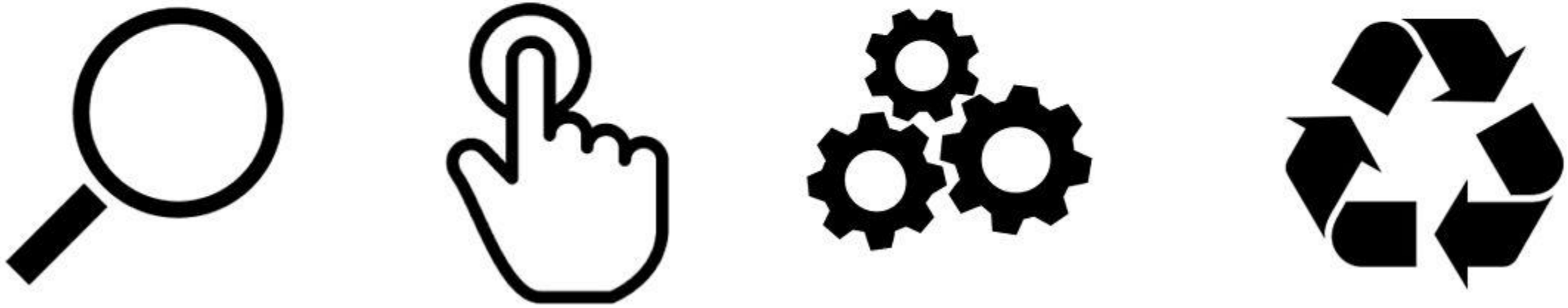
However, a few genomic tools require local installation.

# Github

Importance of version control and backup!

# FAIR principles

Findable Accessible Interoperable Reusable



# Implementation of FAIR principles

**Rule #1—For every result, keep track of how it was produced**

**Rule #2—Avoid manual data manipulation steps**

**Rule #3—Archive the exact versions of all external programs used**

Source: https://dataconomy.com/2017/07/03/10-rules-results-data-science/

# Implementation of FAIR principles

**Rule #4—Version control all custom scripts**

**Rule #5—Record all intermediate results, when possible in standardized formats**

**Rule #6—For analyses that include randomness, note underlying random seeds**

Source: https://dataconomy.com/2017/07/03/10-rules-results-data-science/

# Implementation of FAIR principles

**Rule #7—Always store raw data behind plots**

**Rule #8—Generate hierarchical analysis output, allowing layers of increasing detail to be inspected**

**Rule #9—Connect textual statements to underlying results**

**Rule #10—Provide public access to scripts, runs, and results**

Source: https://dataconomy.com/2017/07/03/10-rules-results-data-science/

# Exam rules

The exam consists of a **choice between an individual or group project**, with an oral presentation of the project and some open-ended questions on theoretical topics related to the project subject.

Individual or group project (maximum score 30L):
- The course instructors will present the available projects in the second part of the course.
- The presented projects will be characterized by analytical, design, and implementation/optimization objectives, depending on the specific project.
- Depending on the specific complexity of the project, the number of students in each group will be limited.
- There will be no intermediate deadlines for completing the project.
- Projects can be developed without time constraints and presented at any time of the year.
- Projects will be discussed in an oral presentation (via slides); the correct date for the presentation will be agreed upon with the student.

# Exam rules

**Preparation for the presentation and discussion of the project:**

• The oral presentation will cover the development of the project, the technological alternatives in the literature, the problems encountered, the solutions developed, and the results obtained (presentation via slides).
• The questions will cover the development of the project, the results, and the related theoretical topics covered during the course.
• A demo will also be required.
• A user manual on technical issues, as well as the developed code and results, will be provided to the teaching staff no later than three days before the project presentation.

# Exam evaluation criteria

**Project discussion evaluation**

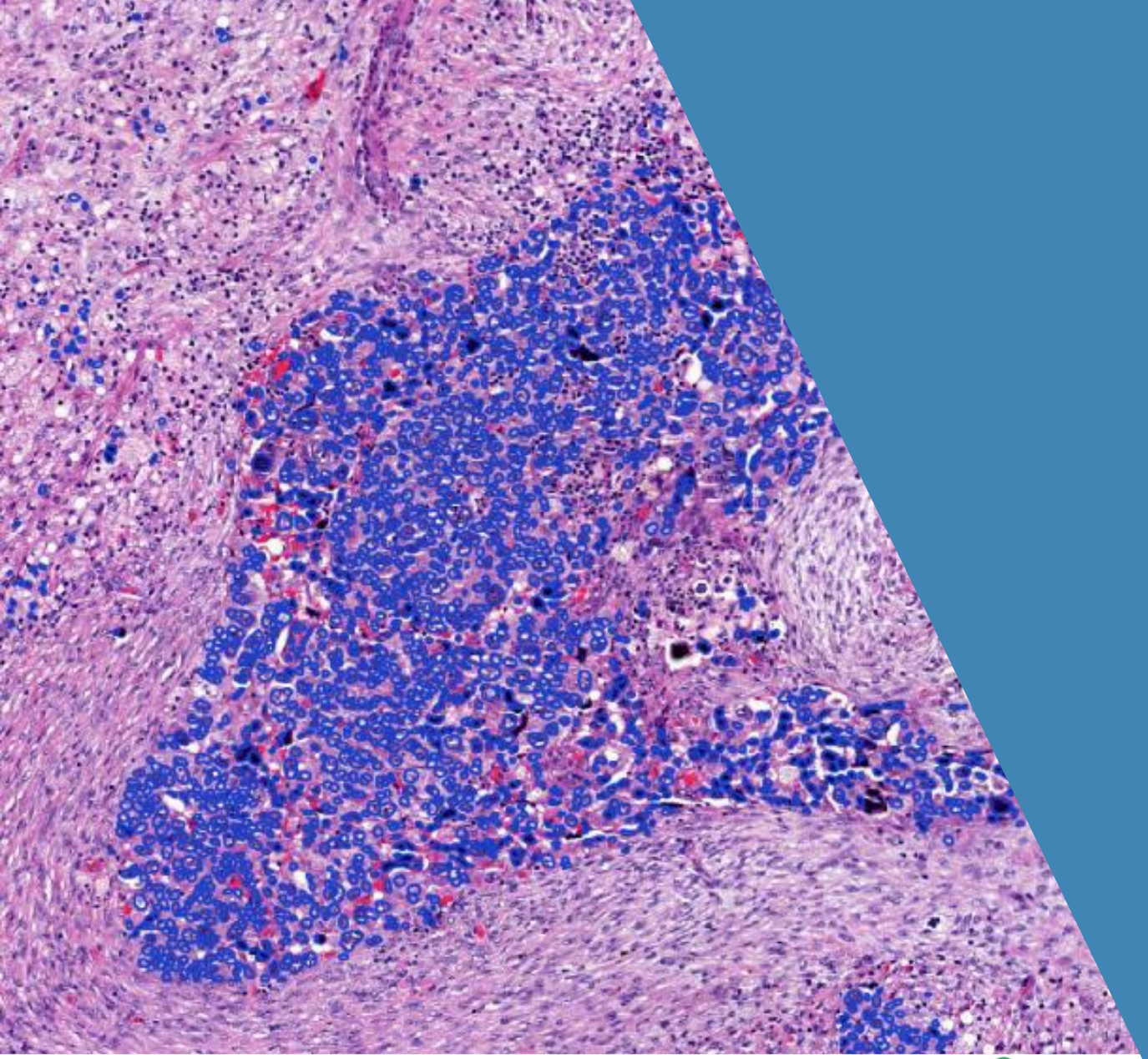
**The evaluation is composed of the following:**

- **24 points** for the design, implementation, documentation, and presentation of the **project**
- **2 optional points** for the laude if the project presents additional steps/analysis/objectives compared to those required in the specifications. Obviously, the additional contribution must be related to the assigned project and significant.
- **6 points** for open-ended questions on theoretical topics seen during the course and related to the project topic.

# SLURM scheduler

# Environment setup

# Python basics for Bioinformatics



# Questions?

*Better a stupid question in class than a stupid answer in the exam*

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