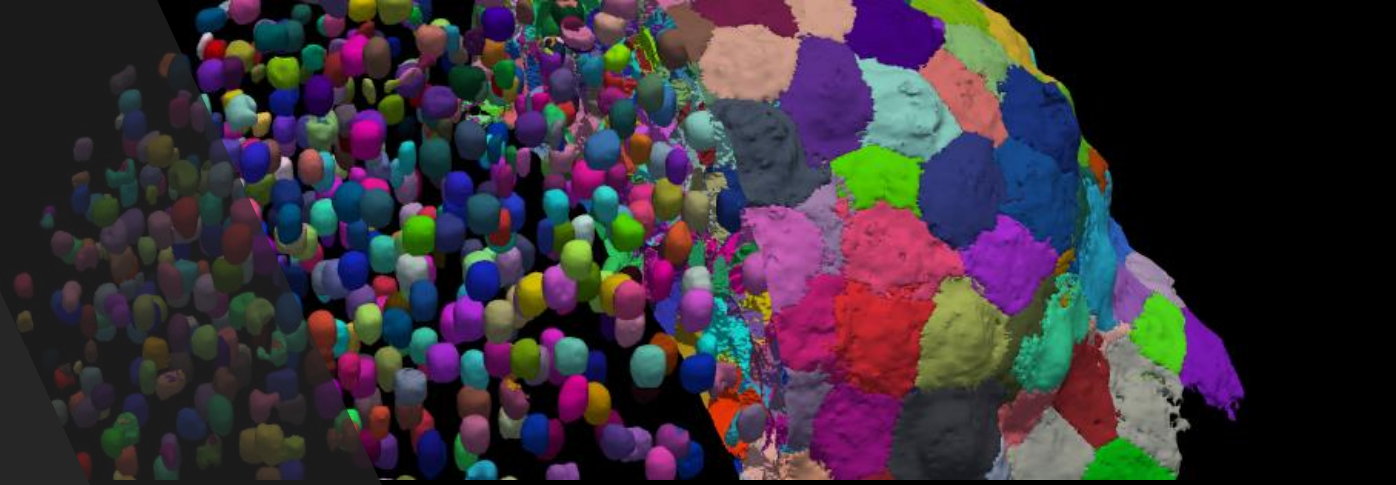
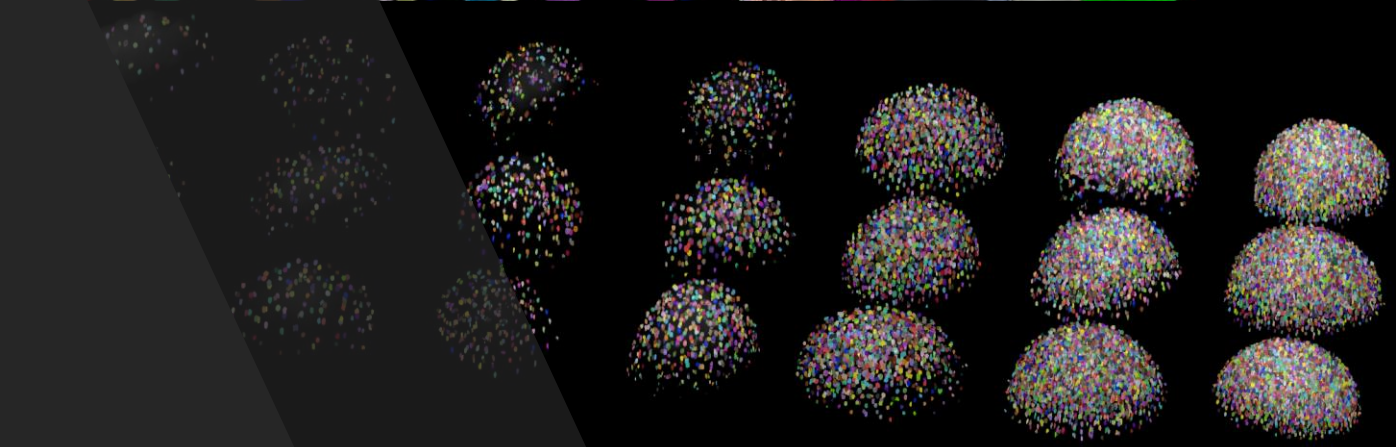
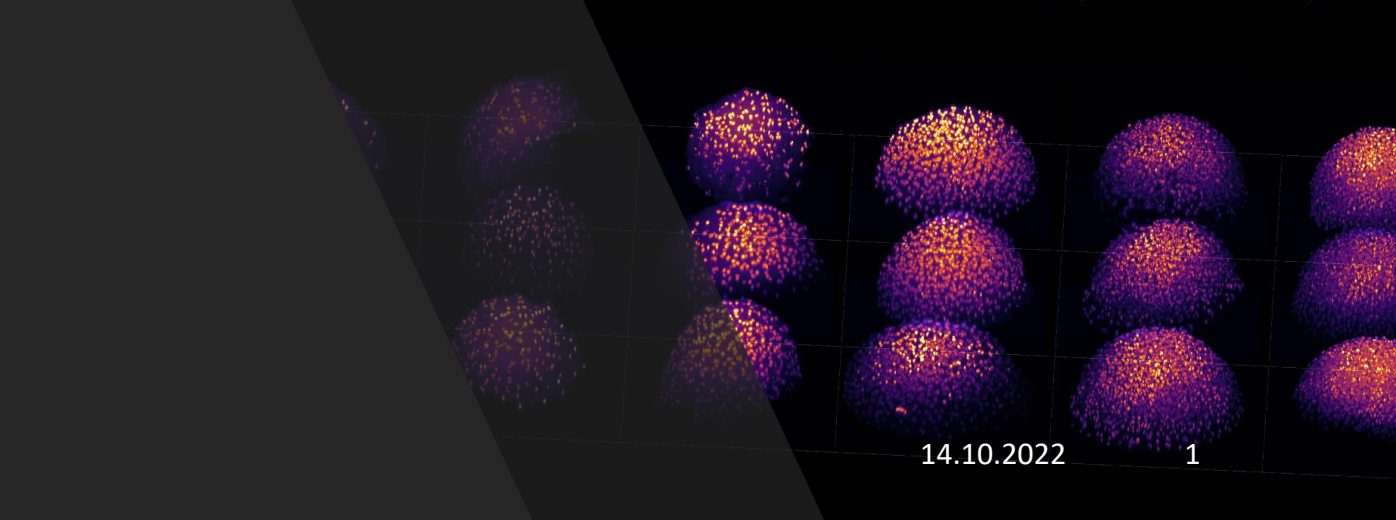
Systems dynamics in cell and developmental biology

IT introduction



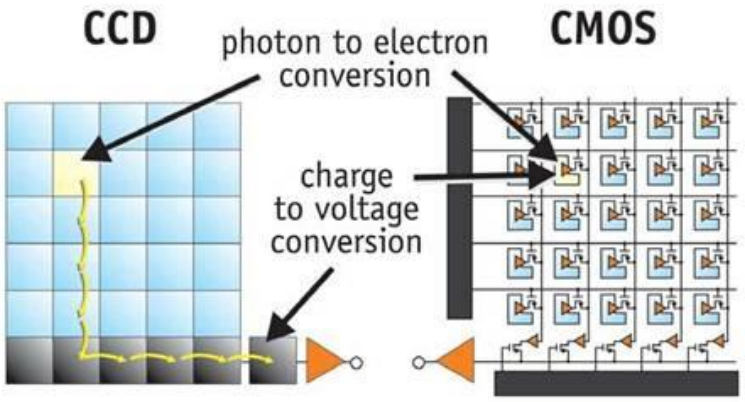




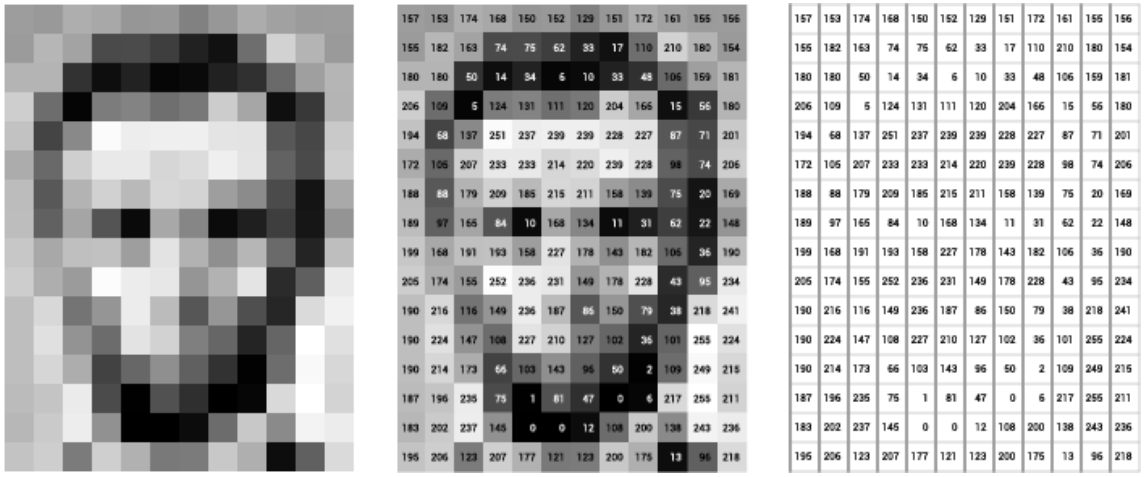
What is a digital image?

- Digital images of real objects are generated by light-sensitive sensors (e.g. CCD or CMOS)
- These sensors are made of small units (pixels) arranged in a grid.
- For each pixel, the incident light is converted into an intensity value.
- The bit-depth of an image defines how many different values a pixel can have
  - E.g. 8-bit image: 256 (2^8) different gray values (0-255)

First digital image (Russel Kirsch, 1957)



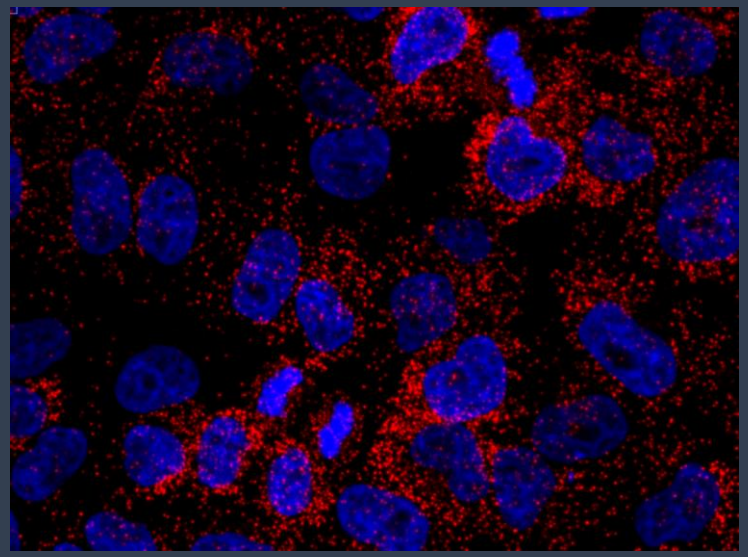
Working principle of CCD and CMOS sensors
(https://meroli.web.cern.ch/lecture_cmos_vs_ccd_pixel_sensor.html)

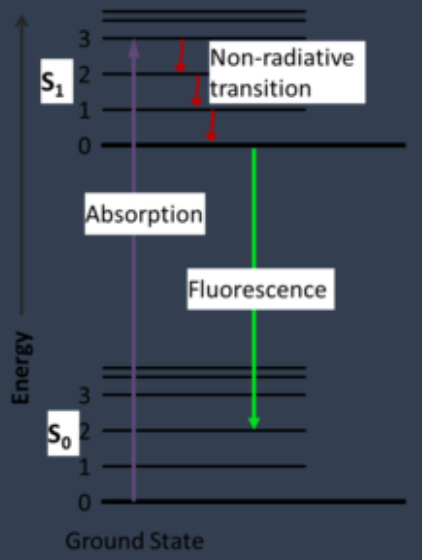


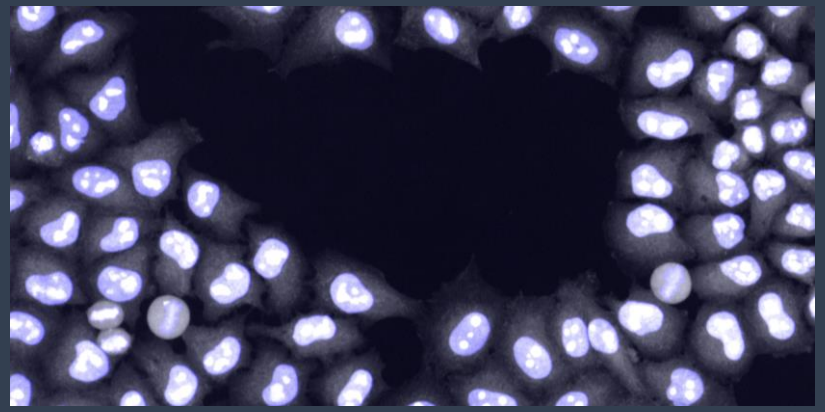
Matrix representation of a grayscale image
(https://ai.stanford.edu/~syyeung/cvweb/tutorial1.html)

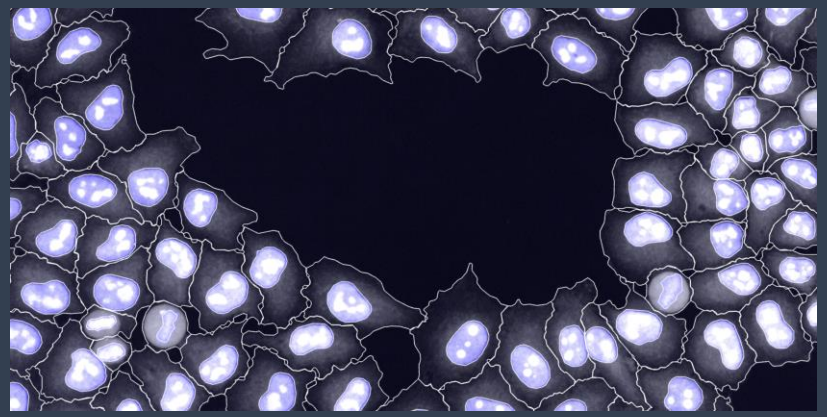
Images in fluorescence microscopy

- In fluorescence microscopy, images are generated in the same way just explained
- Fluorescent probes can be excited with a specific wavelength of light and will emit light of a longer wavelength
- The emitted light is then captured by a camera that turns it into a digital image
- We call these types of images **«intensity images»**, as opposed to other types of digital images









	A	B	C	D	E	F	G
1	unique_object_id	timepoint	label	area	perimeter	solidity	eccentricity
2	0	0	1	4968	268.651804	0.97699115	0.362955953
3	1	0	2	1747	179.63961	0.9765232	0.890612935
4	2	0	3	4005	246.095454	0.98137711	0.630587232
5	3	0	4	2078	187.053824	0.98065125	0.832344848
6	4	0	5	2166	200.160426	0.97831978	0.865934974
7	5	0	6	4739	261.923882	0.98339905	0.445478743
8	6	0	7	1463	166.325902	0.98187919	0.91467215
9	7	0	8	3918	267.663997	0.93866794	0.876095227
10	8	0	9	6388	309.865007	0.9844352	0.6610052
11	9	0	10	5152	275.4386	0.98659517	0.52864505
12	10	0	11	3495	248.030483	0.9684123	0.586215224
13	11	0	12	4668	266.409163	0.98501794	0.734728655
14	12	0	13	2816	234.124892	0.98255408	0.907836268

Image-based systems biology approach

- The goal is to extract information from images
- Typically, we are interested in measuring features of distinct objects in the image. For example:
  - Cells
  - Nuclei
  - Embryos

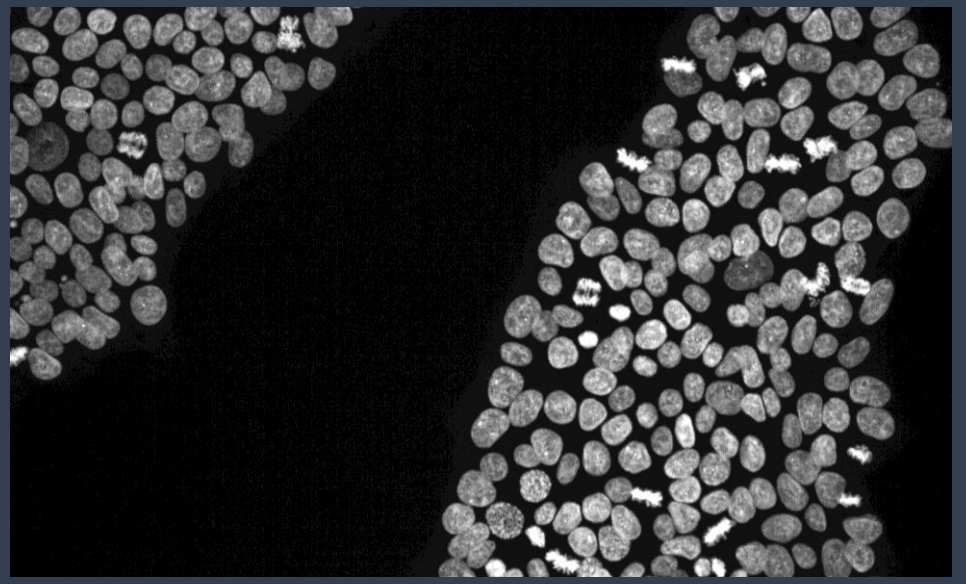
The first step in biological image analyis often is to identify where in the image our objects of interests are.

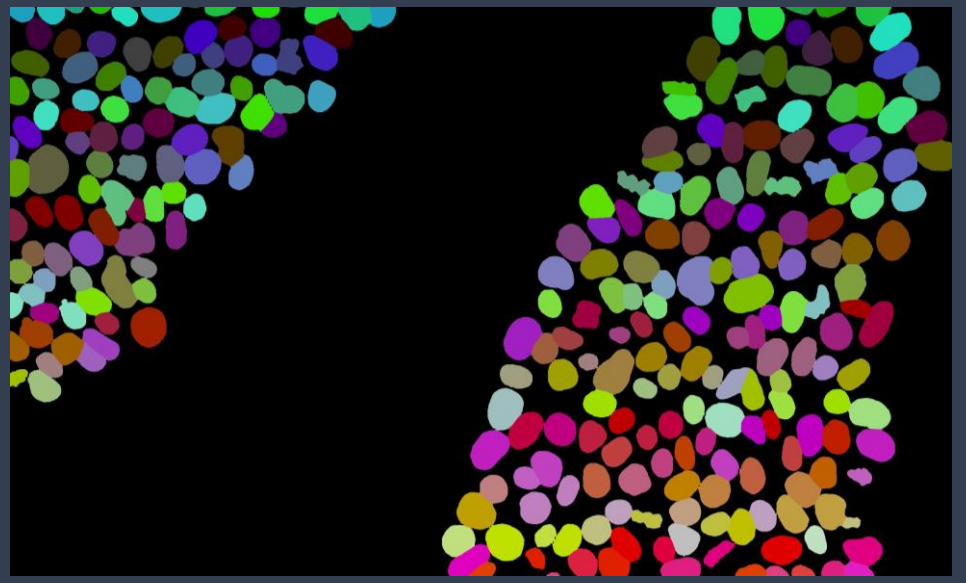
This process is called ***image segmentation***

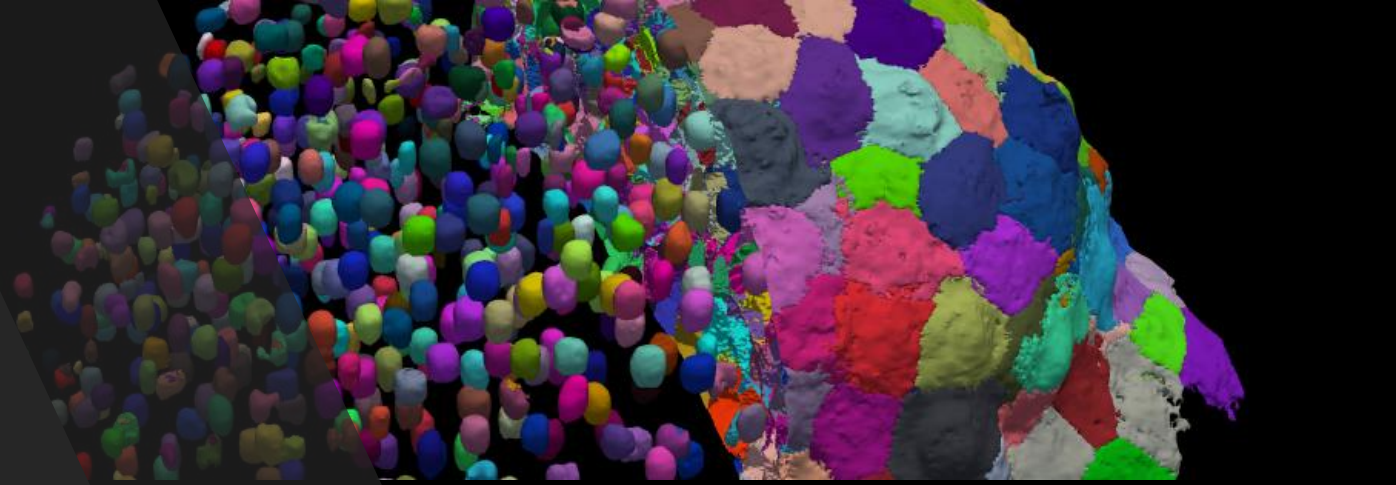
Image segmentation

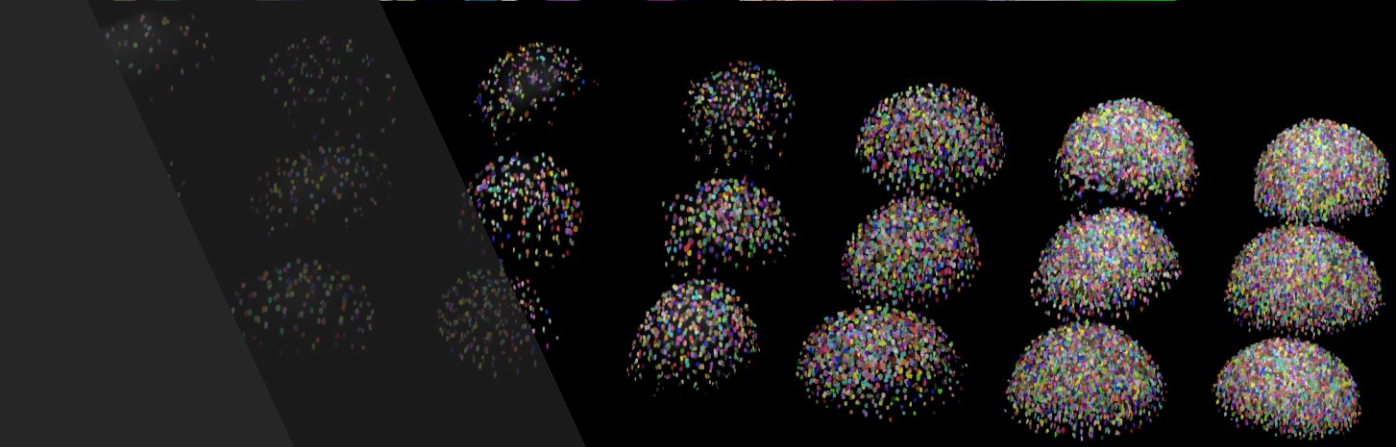
- The output of image segmentation typically is a **«label image»**
- Background pixels of a label image usually have the value 0
- All pixels assigned to a distinct object have the same value
- Basic measurements can directly be extracted from label images with the help of image-processing libraries

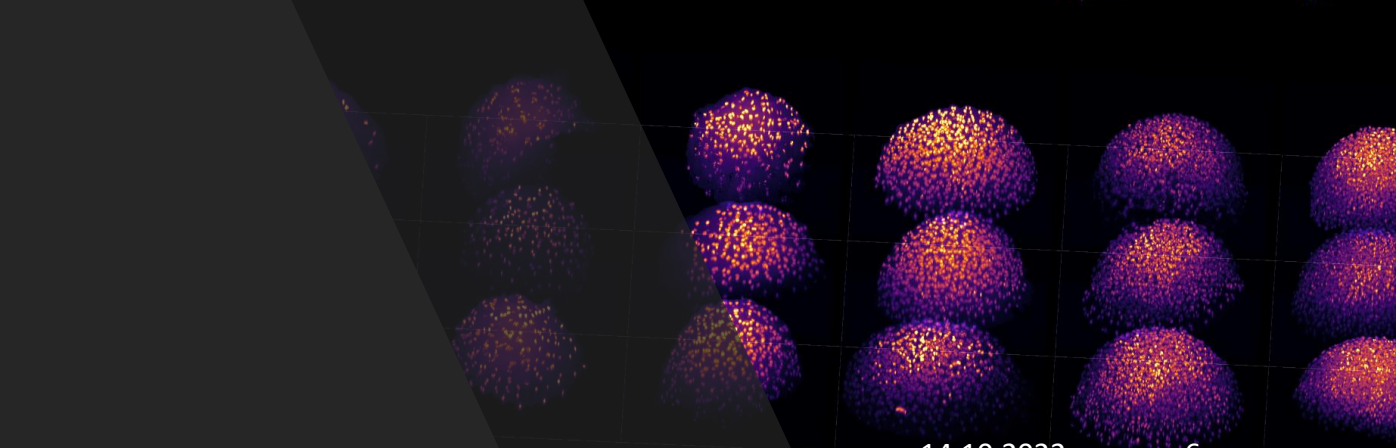
- Typical measurements could be:
  - Area of the object (in pixels)
  - Roundness of the object
  - Mean intensity of all pixels of an intensity image contained in the object











Data exploration and plotting

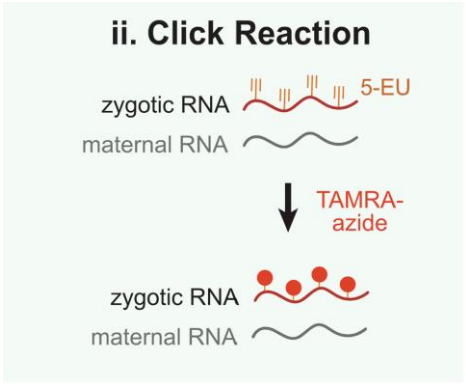
IT introduction

5-EU injection in zebrafish embryos

ZGA

Kimmel et al. 1995

Injection



Chen et al. 2019

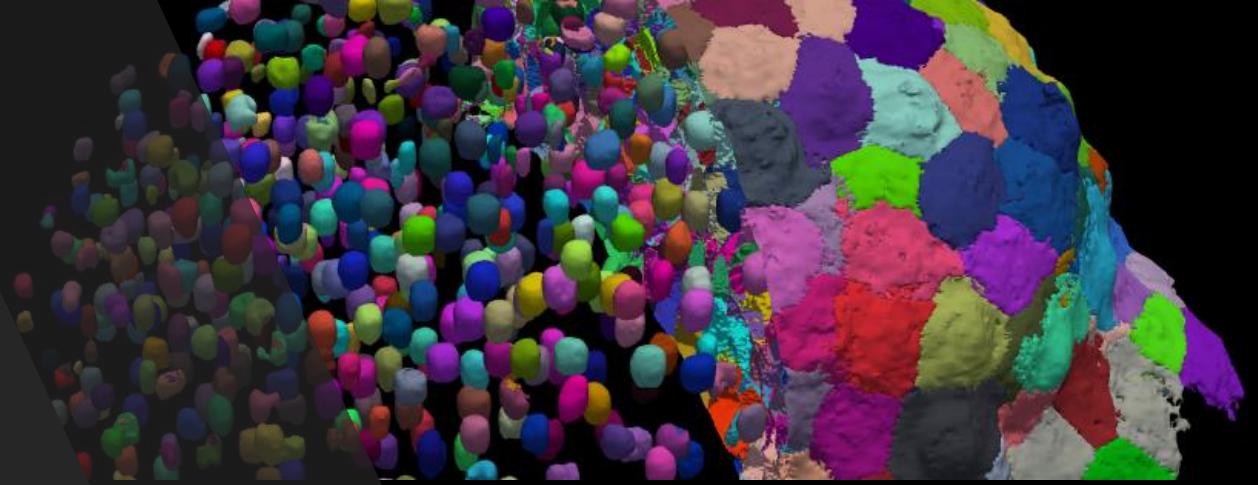
fixation 2-4 hpf based on time point of laying
~10 embryos per time point

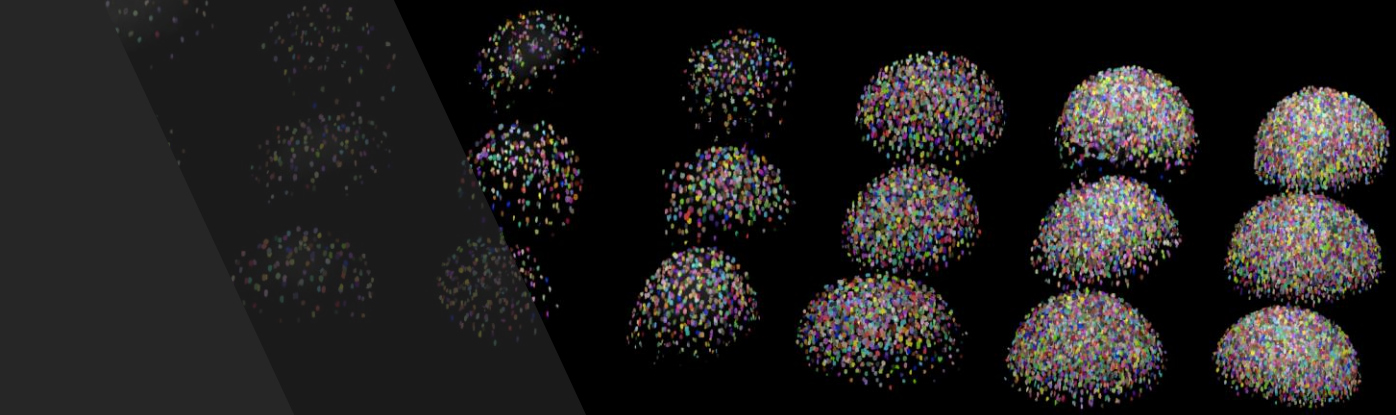
Click-it and IF staining

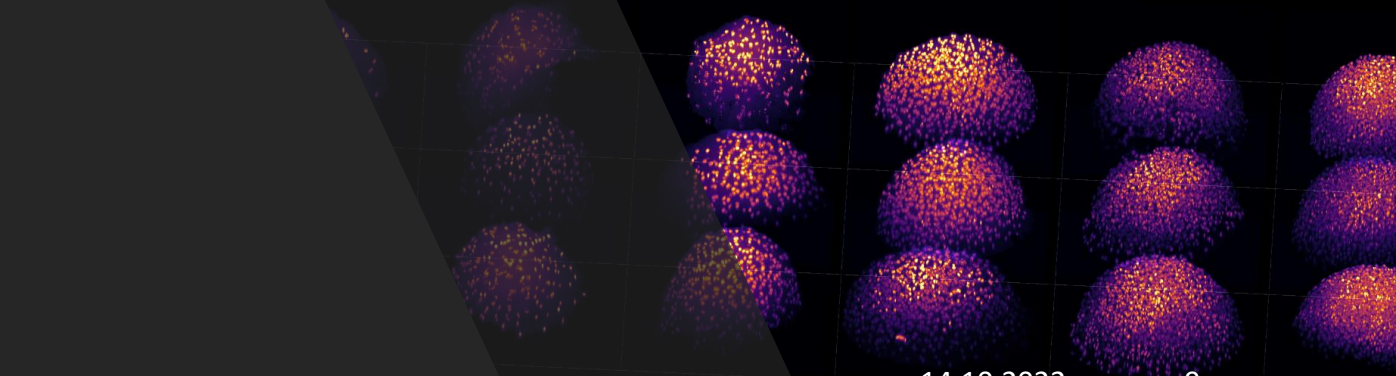
- Pool embryos across timepoints in an Eppi
- Click-it staining with **AF647-azide**
- IF against **β-Catenin (568)** and **PCNA (405)**
- **SYTOX-488** to stain DNA
- 2 replicates

Installation of basic components for BIO325

IT introduction







Installation of basic components for BIO325

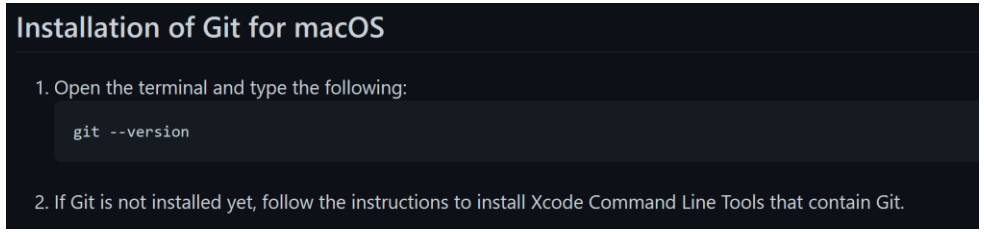
https://github.com/adrtsc/bio325_2022

Follow the Read Me instructions

Installation of Git

Windows

macOS



Installation of Miniconda

https://docs.conda.io/en/latest/miniconda.html

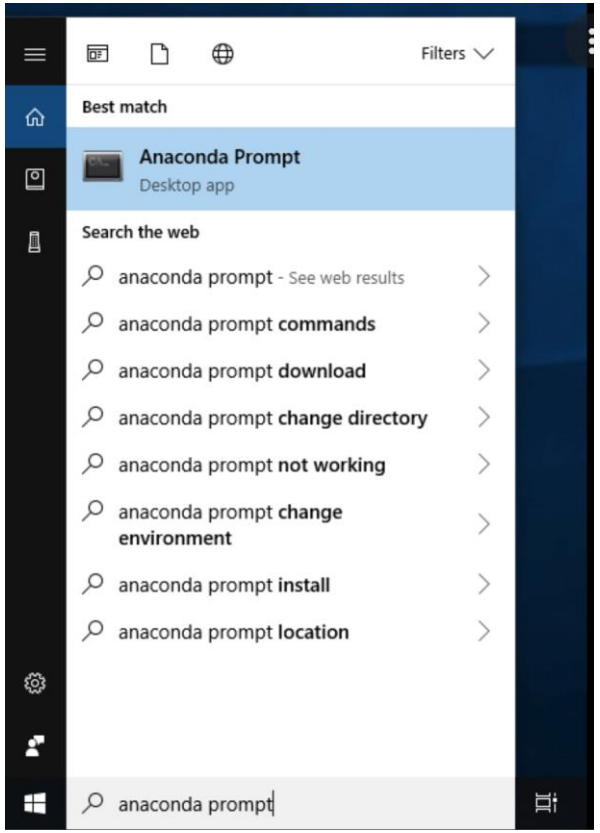
Latest Miniconda Installer Links

Latest - Conda 4.10.3 Python 3.9.5 released July 21, 2021

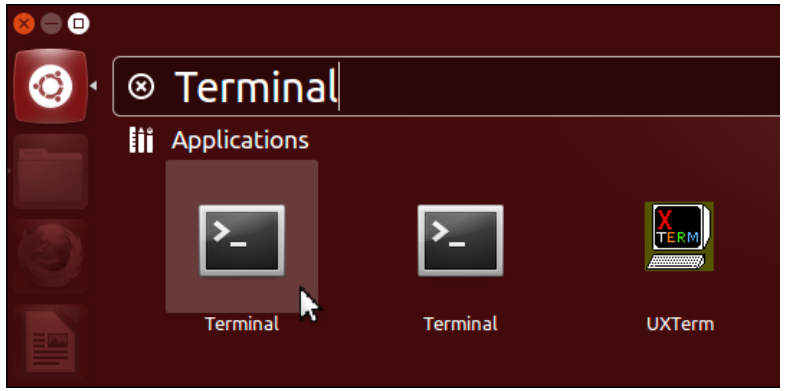
Platform	Name	SHA256 hash
Windows	Miniconda3 Windows 64-bit	b33797064593ab2229a0135dc69001bea05cb56a20c2f243b1231213642e260a
	Miniconda3 Windows 32-bit	24f438e57ff2ef1ce1e93050d4e9d13f5050955f759f448d84a4018d3cd12d6b
MacOSX	Miniconda3 MaxOSX 64-bit bash	786de9721f43e2c7d2803144c635f5f6e4823483536dc141ccd82dbb927cd508
	Miniconda3 MaxOSX 64-bit pkg	8fa371ae97218c3c005cd5f04b1f40156d1506a9bd1d5c078f89d563fd416816
Linux	Miniconda3 Linux 64-bit	1ea2f885b4dbc3098662845560bc64271eb17085387a70c2ba3f29fff6f8d52f
	Miniconda3 Linux-aarch64 64-bit	4879820a10718743f945d88ef142c3a4b30dfc8e448d1ca08e019586374b773f
	Miniconda3 Linux-ppc64le 64-bit	fa92ee4773611f58ed9333f977d32bbb64769292f605d518732183be1f3321fa
	Miniconda3 Linux-s390x 64-bit	1faed9abecf4a4ddd4e0d8891fc2cdaa3394c51e877af14ad6b9d4aadb4e90d8

Create a virtual environment for Python

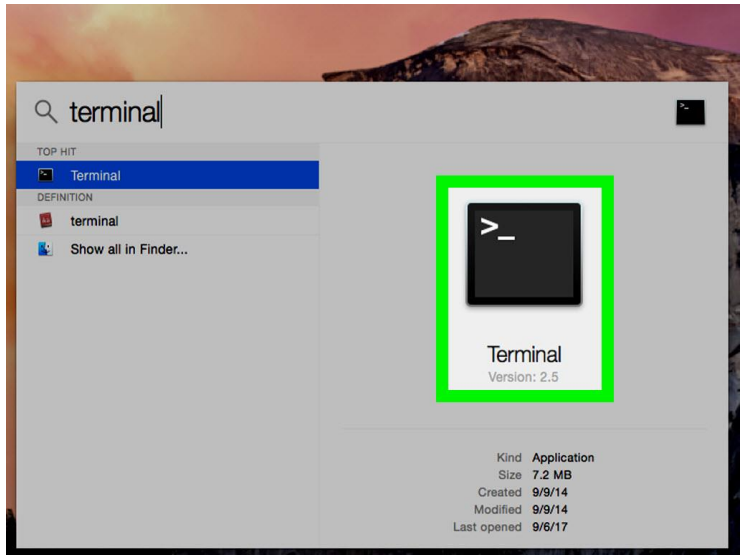
Windows



Linux



macOS




```
conda create -n bio325_2021 python=3.9
conda activate bio325_2021
```

Clone the bio325_2021 github repository and install the requirements

```
git clone https://github.com/jluethi/bio325_2021
cd bio325_2021
pip install -r requirements.txt
```