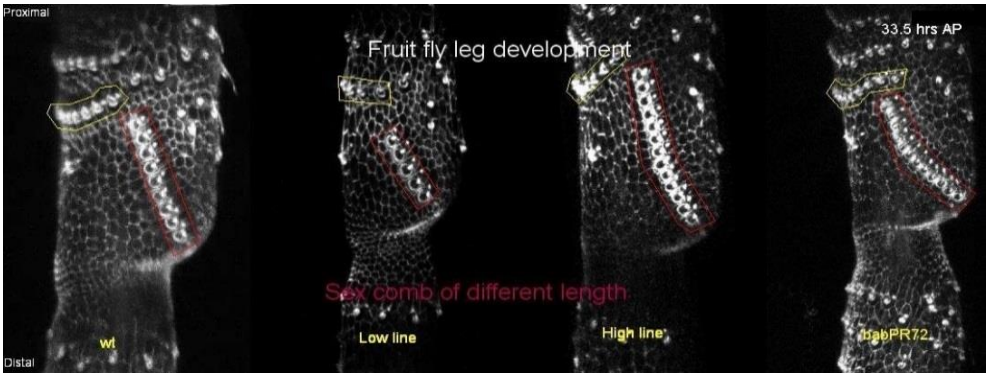
Juan Nicolas Malagon

EXAMPLE OF LABORATORY INVESTIGATIONS: DEVELOPMENTAL BIOLOGY COURSE



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Summary of laboratory investigations

The following laboratory investigations can be tailored to factors including 1) student numbers, 2) currently material and lab equipment, and 3) budget allocated to the developmental biology course.

Approach: In the lab component of this course, the process by which multicellular organisms develop will be covered by using a descriptive and experimental perspective. Examples will be drawn using the most intensively investigated organisms, including both invertebrates and vertebrates**.**

In addition, the laboratory investigations will constantly ***make connections*** between ***developmental biology*** and its implications for ***bio-medicine*** and ***evolution***. To do so, I will stress how deviations from normal morphogenesis, and cell differentiation can lead to diseases or morphological variation in populations.

Methodology: Where appropriate live organisms will be used where possible. As fruit flies are relatively inexpensive and there is a range of techniques to describe and perturb development, this model system will be used extensively in laboratory exercises. Other model systems and techniques will also be included in the lab using videos as well as using the existent lab material (slides, preserved samples). Depending on equipment available additional living organisms will be introduced such as planaria, hydra, zebra fish and chick eggs.

Educational goals

Analytical skills: Laboratory investigations suggested will develop evidence-based thinking, problem solving, and ability to synthesize information.

Technical skills: Laboratory investigations will focus on descriptive and experimental techniques used to study developmental biology including the utility of fluorescent proteins, the way genetic mutations and breeding programs (UAS-GAL4 methods in fruit flies), can advance our knowledge. Computer technology will be used in cell analysis using powerful and free imaging software (Image J) and basic statistical tools will be taught to aid in data analysis.

Brief descriptions of developmental biology laboratory topics

Topic Summary of the	Summary of the laboratory	Teaching objectives
1) Introduction	**Introduction: How to write a lab report** Describe laboratory objectives and expectations.	Explicit guidelines to write lab reports. (write-ups will be discussed). Review of use and care for lab equipment (microscopes and stereoscopes) will be stressed
2) Model organisms as a tool for studying developmental biology	**Introduction to developmental biology:** Comparing macroscopic and microscopic developmental changes in various model organisms including fruit fly, frog, Zebra fish, and plants. **Techniques:** Macroscopic observations will be done in samples preserved in alcohol Microscopic observations will use prepared slides and available time-lapse movies.	To show the importance of model organisms to study developmental biology and human diseases such as cancer (advantages and disadvantages).
3) Techniques to study developmental biology	**Descriptive and experimental techniques to study developmental biology** To show different techniques to describe and perturb morphogenetic mechanisms. **Descriptive techniques:** Fluorescent proteins. **Perturbations techniques:** ablations (laser, dissection) and genetic perturbations. **Computer simulations**: Cellular automata, Compu-cell.	To show students current techniques employed by developmental biologists to observe and interpret the changes that occur in an organism during development**.**
4) Differential gene expression	**Effect of perturbing of gene expression in development:**	To familiarize students with the critical role of gene expression in influencing

	Genetically perturbing gene expression to modify normal morphogenesis. **Techniques:** Mutations and the UAS-GAL4 system (RNAi lines and overexpression) will be used to produce abnormal morphogenesis.	morphogenesis. and the implications for understanding disease and evolution
5) Organogenesis	**Developmental mechanism involved in tissue elongation:** Comparing various developmental mechanisms leading to tissue elongation including multiple invertebrate and vertebrate systems. **Techniques:** Fruit fly movies including germ band extension, tracheal elongation, wing, and leg development. Convergent extension in vertebrate systems (Zebra fish and frogs)	To familiarize students with fundamental morphogenetic mechanisms widespread during evolution. To acquaint students with the use of imaging software (ImageJ) to analyze image and time-lapse movies
6) Evo-devo	**Evolution of developmental mechanisms:** To show how changes in few genes such as HOX genes can lead to changes of developmental mechanisms, which mimic changes observed during evolution **Technique:** Mutations and the UAS-GAL4 systems will be used to phenocopy the evolution of fruit fly system.	Option 2: To allow students to use their knowledge of developmental biology and the scientific process to design and execute a research project to modify morphogenesis to mimic phenotypes observed during evolution.

LABORATORY EXAMPLE

MACROSCOPIC ANALYSIS

Teaching goal:

- *Familiarize students with several kinds of macroscopic change during development.*
- *Encourage students to compare and contrast developmental differences between humans and model organisms*

Exercise 1a: Macroscopic observations of fruit fly metamorphosis

On the laboratory tables, there are small jars containing fruit fly eggs, larvae, pupae, and adults.

Fruit fly eggs[1]

Fruit fly lavrae[2]

Fruit fly pupae[3]

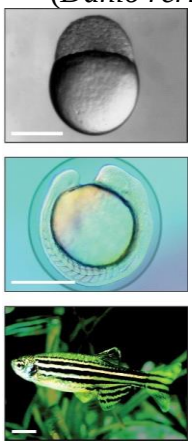
Fruit fly adult[4]

Questions: How many stages and "sub-stages" do you observed? What are the main morphological differences between the stages? What morphogenetic processes could take place in each developmental stage?

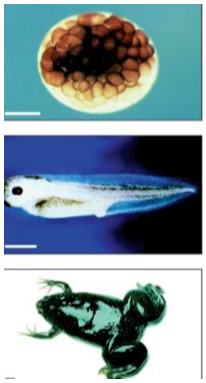
Exercise 1b: Macroscopic observations of other model organisms

On the laboratory tables, there are small jars containing preserved model organisms including zebra fish, frogs, among and others. Those jars will also have organisms arrested at different stages of development.

Zebra fish development[5]
(*Danio rerio*)



Frog development[5]
(*Xenopus Laevis)*



Plant development[6]
(*Arabidopsis taliana*)

Questions: 1) What is a model organism? 2) Why do we study more than one? 3) How many stages do you observe? 4) What are the main morphological differences between the stages? 5) How similar are the different organism during development?

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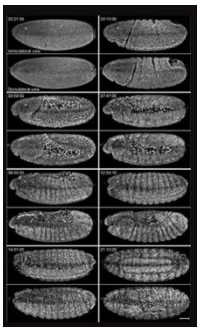
MICROSCOPIC ANALYSIS

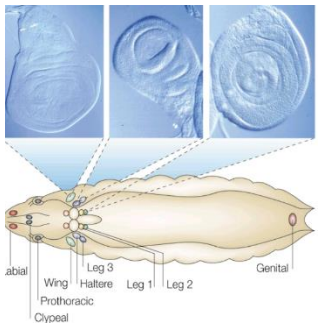
Teaching goal: *Make students aware that despite the seeming highly diverse morphogenetic processes observed during development and great differences in adult morphology, the cellular processes are the same: cell division, cell death, changes in cell size and shape, and in animals, cell movement.*

Exercise 2: Microscopic observations of fruit fly metamorphosis

Students will see slides to see cellular basis of developmental changes observed during development. If there is no slides available, students can see images and videos (embryos and imaginal discs).

Embryonic development[7] Larval development (Imaginal discs)[8] Pupal development (Wing)[9]



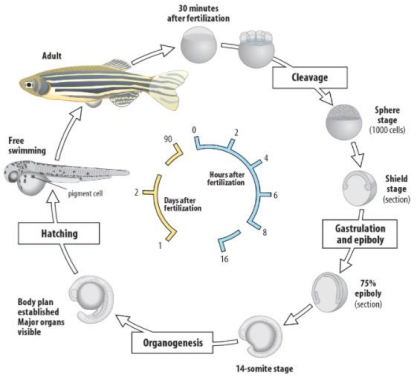


Questions: What the cellular and tissue dynamics observed during development? What cellular processes are you able to observe? Cell proliferation, cell death, cell movement.

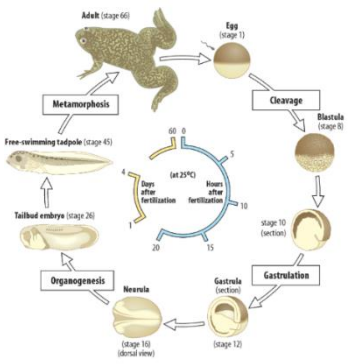
Exercise 2b: Microscopic observations of other model organisms

Students will examine slides to examine the cellular basis of developmental changes during development of various model organisms (zebra fish, frogs, among others). If there are no slides available, students can see images and videos of embryos and organogenesis.

Zebra fish development[5]
(*Danio rerio*)



Frog development[5]
(*Xenopus laevis*)



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Questions: What cellular and tissue processes are observed during development? What are the differences and similarities between different systems?

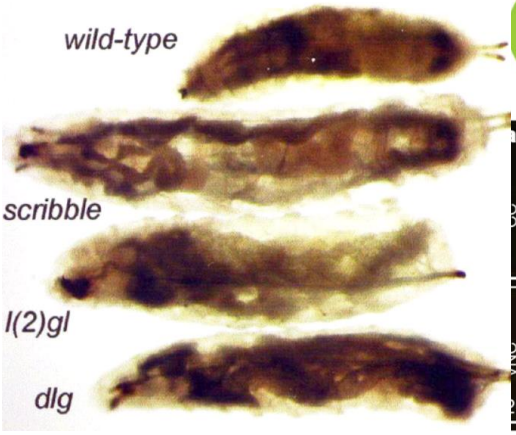
BIO-MEDICAL COMPONENTS

Teaching goal: *Students will understand that although fruit flies and other model organisms may seem very different from humans morphologically, as living organisms they share many morphogenetic mechanisms and cellular processes, so that, for example, fruit flies are used to understand disease mechanisms in cancer.*

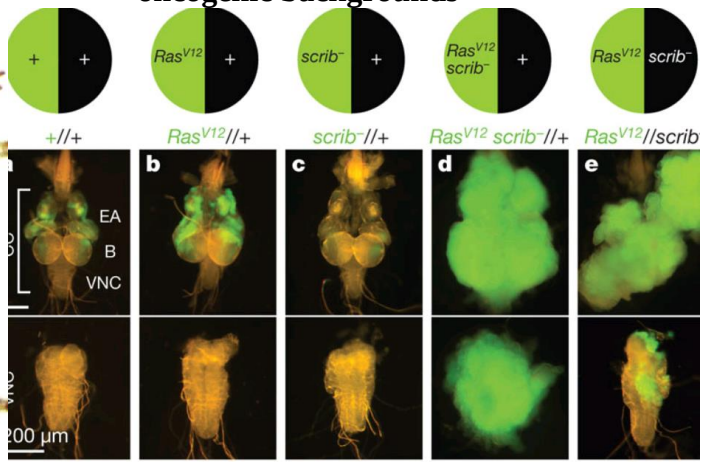
Exercise 3. Fruit fly oncogenic genes (Ras^{V12}, $Scrib^{-1}$) expression

On the laboratory tables, there are small jars containing fruit fly in the following stages: eggs, larvae, pupal, and adults.

Larval stage expressing oncogenic backgrounds[10]



Larval development oncogenic backgrounds[11]



Questions: What are the morphological and developmental differences seen when comparing normal development and fruit fly lines expressing oncogenic backgrounds? What are the advantages and disadvantages of using model organisms to study human diseases?

Study Questions

1. What are the differences between an egg, zygote, embryo and larval stages of development?
2. Why are there numbered developmental stages from egg to hatchling? Are the stages really compartmentalized or is change continuous?
3. On what basis would you agree or disagree with the idea of spending tax money studying model organisms rather than humans in disease research.

References for figures

1) https://www2.gov.bc.ca/assets/gov/farming-natural-resources-and-industry/agriculture-and-seafood/animal-and-crops/plant-health-images/drosophila4.jpg

2) https://www.researchgate.net/profile/Dr_Anand_Krishna_Tiwari/publication/263486191/figure/fig2/AS:296494939820034@1447701310132/Figure-2-Feeding-assay-of-D-melanogaster-larvae-a-Oregon-R-th-control-larvae-fed-on.png