Discovery-based Functional Genomics Laboratory for the Biology Program

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Background

What's in the teaching laboratory?
(Biology, Biochemistry, Chemistry, Physics, Engineering….)

- **An instruction manual**
- **Pre-run laboratory procedures**
- **Questions are pre-set**
- **Results are worked out ahead of time**
- **Students are provided with a pre-lab talk**
- **Execute the procedures in a defined period of time**
- **TAs and technicians all know the pre-set answers**
- **Be the experiment working or not, write up a report**

What is our university mission?

- **Knowledge, skill, communication, team building…**
- **To train our students to solve real life problems.**

Problems?
Are they reflecting real life situations in the teaching lab?
Do students receive the needed training?

Can we learn from others?

Lessons from US and UK

- **Discovery-based science education has been deemed as an effective approach in secondary and tertiary education.**

- **It concentrates on inquiry and discovery with lots of hands-on experience with undefined outcomes. ($\neq$ no outcomes)**

- **Students are solving novel and real life problems, not problems pre-set by the instructors.**

The educational process is more important than the experimental results.

- **Can we use this teaching approach to complement current traditional cookbook style large class laboratory teaching in the biology department?**

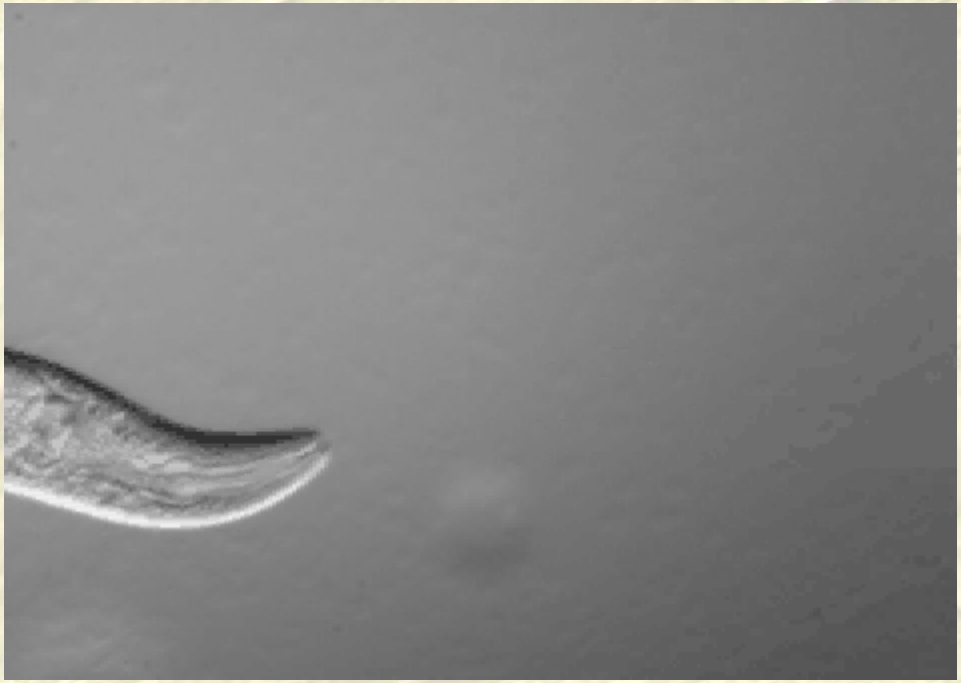
- **What does it take to make it work well?**

- **Can students with little experience handle it?**

So, we seek help from CELT.

OBJECTIVES OF THE PROJECT

- **Set up a discovery-based undergraduate course (BIOL200)**
- **With a small cohort of students**
- **Pilot run it for a year and a half with multiple sessions**
- **Based on a genetic screen for developmental defects in the round worm *C. elegans.***



***C. elegans* crawling**

LABORATORY / OPERATION

Space - a 45 square meter lab for 10-15 students
People - CELT support for hiring a part time research assistant
Equipment - Dean of Science Office support &
Biology Department
TA and technical support - volunteer postgraduate students
from my own laboratory
Consumables - CELT funding for a year's operation

Assembled in a period of 8 months!

EXPLICIT OBJECTIVES OF THE COURSE

- The course encourages *critical thinking*, *student initiated activities* and allows the students to develop their *own hypotheses*.
  - Briefing of the course
  - Evaluation of students' grades
  - Interviews
- It provides students who anticipate a research career to have a glimpse of the research lab operation.

- To give UG students a head-start in their research career.

- To learn the details of research including preparation, time management, plans of gathering data, documentation, and formal presentation.

INITIATION

- An introductory session about the whole project & the course

- A course lab manual was designed for the course containing procedures for various research techniques ranging from basic molecular biology, genetics, cell biology, neuroscience, physiology , behavioral studies and beyond.

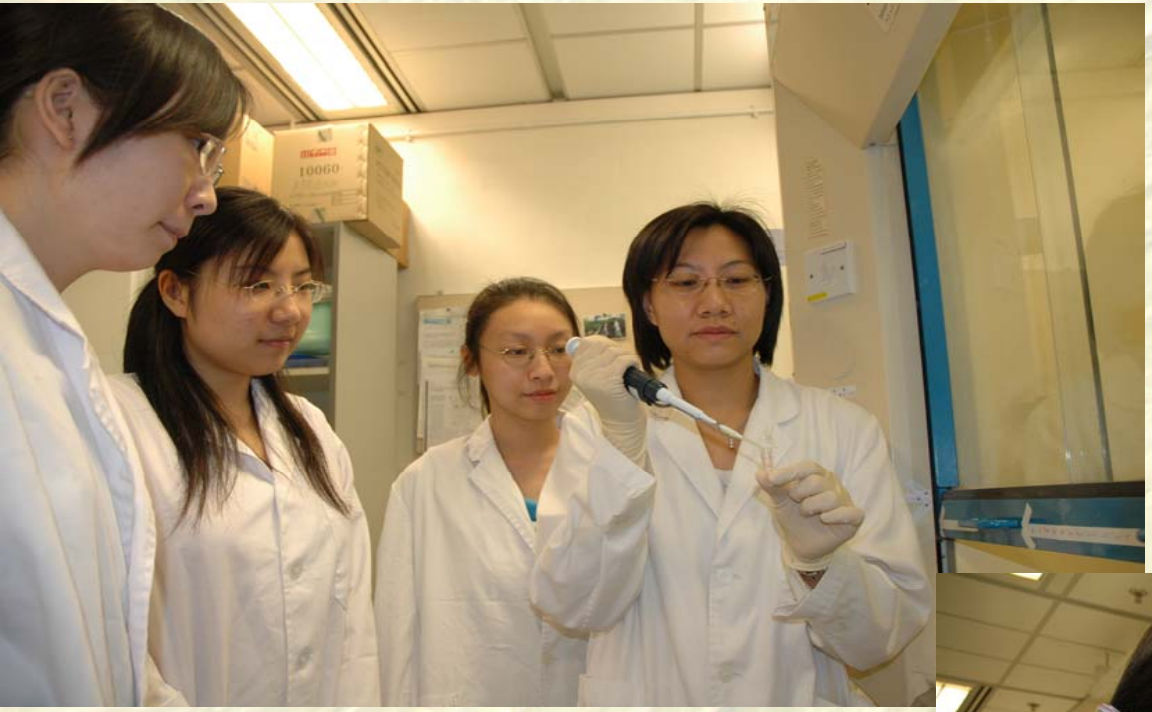
- Lab work started in the Biology teaching laboratory (4 - 8 pm, Mon. – Sat., on average 10-12 hours per week)

BIOL 200A

- Culturing worms
- Basic lab routines e.g., bacterial culture, seeding and pouring of worm plates

- Use of dissecting microscopes
- Sexing the animals
- Staging the animals
- Phenotypic recognition

BIOL 200A



- An EMS screen

- Use of DIC microscope (cell. biol.)
- Fixing of mutants (genetics)
- Stage synchronization (dev. biol.)

COURSE STRUCTURE

BIOL 200A first semester (2 credits), elective course
may be taken in first or second year
Isolate a mutant by genetic screen for each individual
bi-weekly journal club meetings
presentation attended by post graduates and faculty

may continue to 200B

BIOL 200B second semester (2 credits)
characterize mutant using genetic and molecular techniques
one to one mentoring from postgraduate TAs,
bi-weekly journal club presentations

may continue to 200C

BIOL 200C third semester (2 credits)
further characterization of mutant, genetics, molecular biology work, bioinformatics and others
bi-weekly journal club presentations
final written report and final presentation

COURSE SCHEDULE

BIOL 200A

- Photography under microscope
- Image capturing
- Image publication

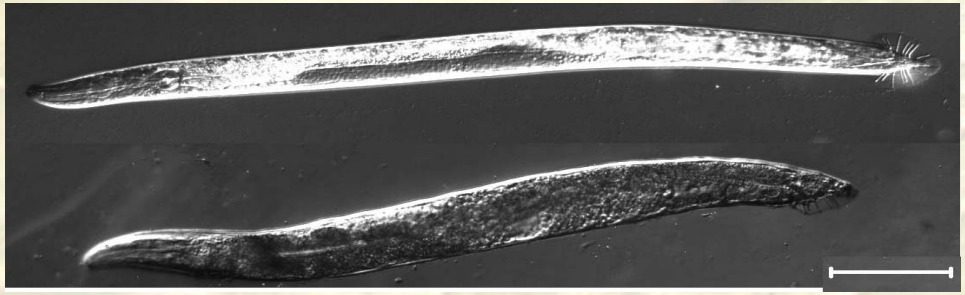
- Decontamination of worms
- Outcrossing of mutants
- Worm freezing – stock keeping

Results from a mutagenesis screen

- 50 mutants were obtained, e.g., body defects, co-ordination of movement and male tail sensory organ defects.

- It was aimed that each student could isolate at least one mutant, and therefore, experience the discovery of new mutant of interest and continue their characterization as an independent researcher with supervision from the instruction team

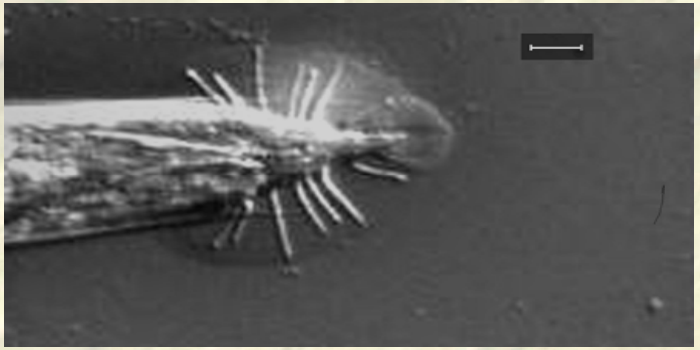
Examples of mutants from the EMS screen



body phenotype

WT

Dpy



male tail phenotype

WT

Ram

Others:

- **Organ defective**
- **Non-chemoattracted**
- **Blister formation**

Spun-off Projects

- Extensive linkage mapping
- Complementation experiments
- Genetic loci mapping
- Physical marker mapping (SNP)
- Molecular cloning of genomic fragments
- Lesion detection
- Mutant gene sequencing
- Phenotypic characterization
- Molecular marker examination for cellular defects
- Behavioral study of mutants

BIOL 200 COURSES

- The course is run by a PI.
- An instructor positioned full-time in the laboratory facilitates continuous guidance.
- Postgraduates are also part of the instruction team.

UNIQUENESS OF THE COURSE

- The course offers an integrated training ranging from genetics, cellular molecular biology, biochemistry, developmental biology, bioinformatics and behavioral science. (Content normally would have been covered in different lectures separately.)

- Students would have hands-on research experience with unknown outcomes.

- Done in their freshmen year, instead of waiting until their final year.

- Everyone is in charge of his/her own project.

- **There is no instruction but only facilitation.**

ENRICHMENT PROGRAM

- **Student initiated presentation on concepts of experimental techniques**

- **Instructor initiated journal club presentation of literature related to the projects**

- **Student initiated journal club presentation of literature deviated from the projects**

Benefits to the research/education community

- The screening results can be shared with the research community of developmental biology (of real purpose)
- Our experience was shared with other educators in conferences

Benefits to the students

- Early hands on experience in research setting
- Promote enthusiasm
- Develop an inquisitive mind
- Exposure to broad areas of biological sciences, including areas not covered by our existing curriculum
- Extensive literature search and experimental adaptation
- Polish their presentation and communication skills

Student Presentations

Is it working?

- **Evaluation was conducted in informal meetings with students throughout the project once every half a year.**

- **Comments were collected from the instructors, facilitators and graduate students who were involved in this project (by interviews).**

- **Meetings of the project team with staff from CELT for suggestions and advice throughout the project.**

From the evaluation report

Looking back to when you first applied this course, what were the main reasons for applying?

"This is a different lab course from all others ordinary university lab courses as this course provides students opportunities to learn something themselves without asking them to follow merely the instructions when doing experiments."

From an evaluation report

What have you learned?
Did things play out the way you anticipated?

- Patience and commitment.
- Ask the right questions, but not just taking instructions.
- To use time more efficiently
- Have learned how to face problems and frustration in research.
- Understand oneself much better about one's strength.
- Good communication is essential in science.
- Personal growth.
- Got more than I expected.

Major frustration

- Sometimes students would feel a bit lost as they were required to design their own experimental plan, manage their own working schedule, and to work independently. (TA and instructor felt bad, too, to see them struggling.)

- It was hard to ask questions at the very beginning because they were not sure about what to ask. They have never done it before.

- It was a big challenge to them.

Do you think this discovery-based science education course is helpful in arousing your interest in biological sciences?

- **Definitely, students are more eager to learn about sciences (i.e. the principles and rationale behind the concepts, about the application, the integration, not just the definitions, facts and examples).**

- **A better connection is then established between the real world practice and the content covered in the textbooks.**

A REVISIT

- **Can we use this teaching approach to complement current traditional cookbook style large class laboratory teaching in the biology department?** **YES!**
- **What does it take to make it work well?** **A LOT!**
- **Can students with little experience handle it?** **YES!**

SUSTAINABILITY / LOOKING FORWARD

- We have incorporated this course into the new BSc Molecular Biomedical Sciences program (5103).

- To create diversity of exposure, we will add other modules apart from worm, including yeast and zebrafish. Cross fertilization of ideas from different fields may come about.

Incorporating discovery-based teaching in other curricula at HKUST

- Resources- manpower, funding, teaching space

INSTITUTIONAL COMMITMENT

- Involvement of other faculty staff in designing discovery based courses - problems with overcoming inertia from faculty.

FACULTY COMMITMENT

- How to adapt it for larger classes?

INSTITUTIONAL & PROGRAM VISION

It’s time to show our commitment !

ACKNOWLEDGEMENTS

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