



UNIVERSITÀ  
DEGLI STUDI  
DI MILANO



# Centre of the **U**niversity and **S**chool of **M**ilan for **B**ioscience Education

Responding to the high-school teachers' need to receive training and swap advice in the latest scientific developments, the University of Milan in May 2004 has founded CusMiBio (Centre of the University and School of Milan for Bioscience Education), a new project to improve Bioscience Education in High Schools. CusMiBio works in close collaboration with the Lombardy Educational Office (Lombardy is a large area in the North of Italy with 991 public High Schools, over 1500 life science teachers and over 342.000 students). This center wants to be a bridge between the two educational systems, High School and University, with the main goal to increase knowledge and interest in Biosciences in High School students and to help their science teachers in keeping up with the rapid pace of advances in life sciences and in biotechnology.

CusMiBio organizes training activities and updating courses directed to High School teachers and laboratory activities for High School students with the final goal to ensure a new generation of researchers.

CusMiBio is a member of NYEX (Network of Youth Excellence) and has signed a collaborative agreement with the Gläsernes Labor-BBB Management GmbH Campus Berlin-Buch in Berlin.



## Major initiatives directed towards High School Teachers:

- High School Teachers attend education groups and meet regularly under the supervision of a Faculty member who provides them with constant scientific and cultural updating (so far, more than 300 High School Teachers have taken part in these groups). The practical products of these educational groups are the development of laboratory activities to be offered to their students together with handbooks and “tools and tips” that can be used by the teachers during their work at school.
- Lead teachers: a group of selected science teachers trained to run themselves the "Try the Biolab" activities, coordinate students groups and give the introductory lecture supporting the lab activities.
- Training courses in molecular biology and genetics combining cutting-edge science with simple activities easily transferable to the classroom;
- Workshops (such as the annual series "New frontiers in biology") on advanced topics in biosciences;
- Happy Science, where scientists and science teachers meet to approach and discuss in an informal way (aperitifs are served!) some hot themes in biosciences
- Training courses in Bioinformatics (basic and advanced)
- From School to University: a return trip (see below).
- - BioTeach, tools and tips for science teachers (<http://bioteach.ariel.ctu.unimi.it/v1/home/PreviewArea.aspx>) is a website (in italian and english) where High School science teachers can find constant scientific and cultural updating, infos about the latest scientific discoveries in hot topics of genetics and biotechnology and suggestions for doing their work in a more motivated, creative and effective way.

This site is a collection of molecular biology teaching modules designed for teachers and students, materials and useful resources for combining cutting-edge science with simpler activities easily transferable to the classroom



<p>Training courses</p>	<p>2004: “Genetic Engineering and its applications”</p> <p>2006: “Genes and diseases” in collaboration with EMBL</p> <p>2005-2006-2007-2008: “From organism to genes: what Zebrafish can tell us”, in collaboration with EMBL</p> <p>2010: “Molecules and cells in colors”, in collaboration with EMBL/ELLS</p> <p>2011: “Proteins: where, when and why” two replicas in Milan and in Genoa</p>
<p>Seminars “<b>New frontiers in Biology</b>”</p>	<p>2007: “Stem cells: from research to clinical applications”</p> <p>2008: “microRNAs”</p> <p>2009: “Epigenetics”</p> <p>2010: “New applications of Biotechnologies and Nanotechnologies in Biomedicine”</p> <p>2011: “Life Sciences: education and communication”</p> <p>2012: “Fascination of Plants Day”</p>
<p><b>Happy Science</b></p>	<p>2007/08: “DNA Repair mechanisms”</p> <p>2008/09: “Model organisms in research”</p> <p>2009/10: “Neurodegenerative diseases”</p>

### Major initiatives directed towards High School students are:

- “**Try the BioLab**”, “hands on” activities in some hot topics of genetics and molecular biology. Students run these activities under the supervision of a lead teacher and of young tutors, Ph.D. students and post-docs whose presence strongly facilitates productive interactions and helps in breaking the intimidating “teacher-student” barrier.



**“Try the Biolab”  
activities**

**DNA profiling**, on DNA analysis performed to obtain molecular identikit, i.e. for human genotypic identification (DNA fingerprinting)

Healthy or affected?, a simulation of genetic counseling and prenatal diagnosis of genetic diseases by means of RFLP (Restriction Fragments Length Polymorphism) analysis.

Genetically Modified Organisms, what, how and why. Analysis of corn flour to detect the Bt transgene from the bacterium *Bacillus thuringiensis*, coding for a protein which confers the GM plant protection against most insects pests.

Identification of meat species: analysis of a mitochondrial gene, cytochrome b, to identify the species origin in a meat sample.

DNA cloning: white or blue? recombinant or not?, two genetic engineering activities on DNA cloning in bacterial cells and on the identification of recombinant DNA molecules.

Molecular markers in corn, on Mendelian segregation of R gene, which regulates anthocyanin pathway in several tissues.

Chromosome analysis, optical microscope observation to compare human and mouse metaphase chromosomes; cytogenetic analysis of human normal and pathological karyotypes.

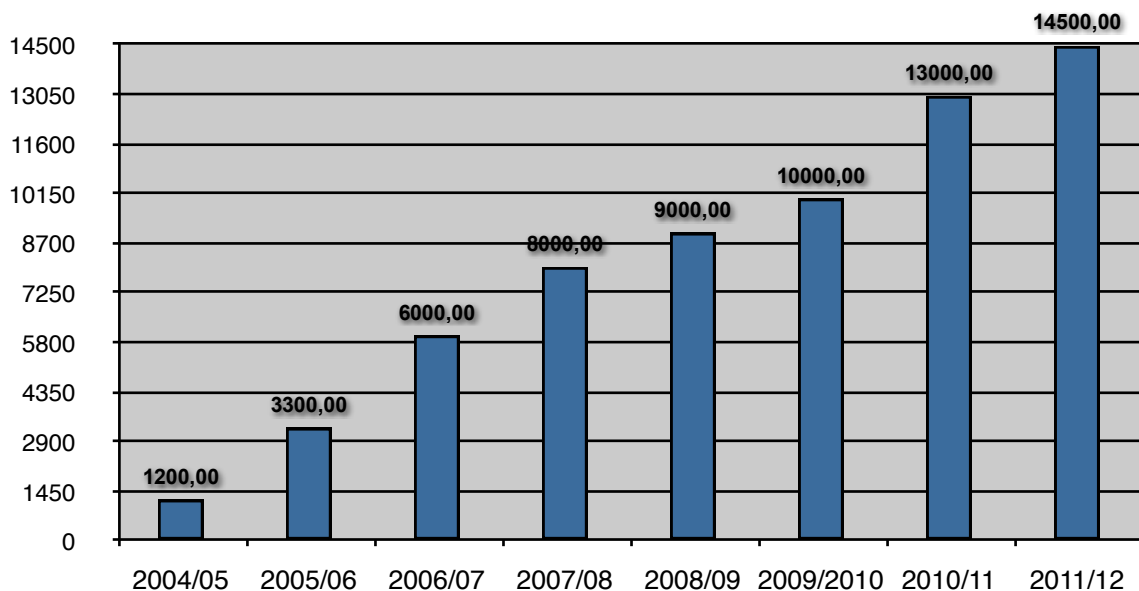
DNA fingerprinting: DNA extraction from buccal mucosa, PCR amplification of microsatellites regions to obtain a DNA fingerprint

SOS environment: a reporter gene in transgenic plants (*Arabidopsis thaliana*) becomes an environmental bioindicator able to detect the presence of heavy metals in soil.

Invisible forms, lysozyme crystals can be obtained in short time and observed at light microscope; in a parallel bioinformatics module, students visit one of the major protein 3D structure database and experiment how 3D models of proteins are used to design molecules of medical relevance.

	<p><b>Virtual microarrays.</b> To visualize gene expression students use a custom-made mat, Velcro and torches, following step by step microarrays technology and learning about its possible future applications.</p>
<p><b>Bioinformatics laboratories</b></p>	<p>NanoYOU. simple experiments to approach the world of nanotechnology</p>
	<p>Surfing among genomes, a bioinformatic module to discover how scientists use genetic information in databases and to learn how to ask (and answer) questions about the human genome.</p>
	<p>Gene Hunting, online searching for genes, proteins and mutations associated with genetic disorders.</p>
	<p>Proteins in 3-D, use of dedicated softwares to study major protein features and to visualize the 3-D structure of proteins.</p>
	<p>DNA barcode.</p>

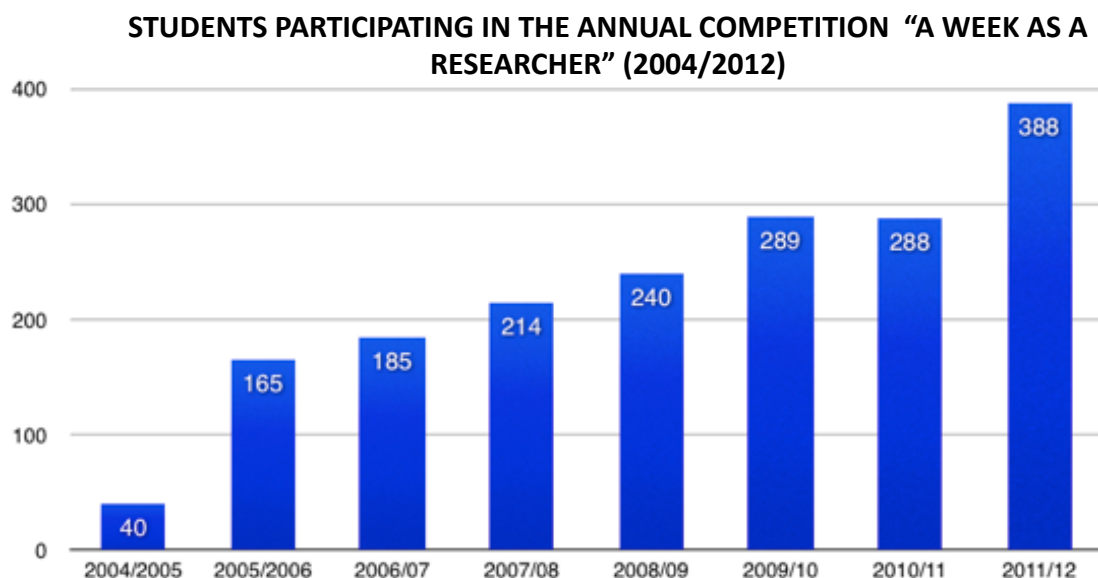
**STUDENTS ATTENDING “TRY THE BIOLAB” ACTIVITIES (2004/2012)**



Every school day, one or two classes attend these hands-on activities; in 2011-2012 more than 14.000 students have participated.

- **A week as a researcher:** the most motivated and skilled students participate in a competition that selects each year 30 of them to attend a 'week as a researcher' in a national or international research laboratory at the end of the school year. This contest represents a real scientific challenge for the participants and invariably selects very talented young students.

-The project "**Wannabe a researcher**". In 2006 CusMiBio launched the first "Wannabe a researcher" project, a program aiming to combine professional research with research-based undergraduate education. Since 2006, the 30 best ranking students each year are invited to contribute to a research project throughout the entire school year.



Since 2006, we choose every year a new project in Bioinformatics. We strongly believe in the effectiveness of this discipline as a new tool to teach the basics of molecular biology and evolution. With the support of bioinformatic tools, the new fields of genomics and comparative genomics can be appealingly introduced to the students and molecular evolution can be shown in "in silico experiments", such as aligning human proteins against the mouse genome, and vice versa. The choice of this discipline is also dictated by practical reasons, since the time-consuming part of the project can be carried out by the students in part at CusMiBio and in part on their own computers at home.

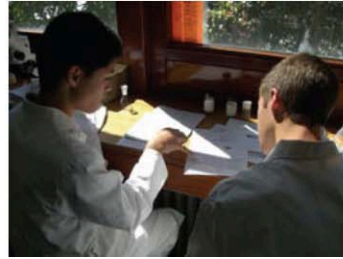
The 2006/07 project "Following the footsteps of evolution, looking for new genes", carried out by 35 High School students under the supervision of university researchers, led to new annotations of a new human exon. The results were published in EMBO Reports (Pavesi G, Siccardi A, Viale G, Grazioli C, Calciolari T, Tenchini ML, Plevani P. Hedgehogs, humans and high-school science. The benefits of involving high-school students in university research. EMBO Rep. 2008 Mar;9(3):208-11).

2007/08 project: "Study of gene structure dynamics during evolution with a particular focus on intron sequences".

2008/09 project "Comparative analysis of alternative splicing molecular mechanisms in mouse and man".

2009/10 project: "Fishing for genes: regulatory networks in man".

2010/11 project: "It's only a matter of splicing: sex related differential gene expression in Drosophila".



- The project "**Wannabe a tutor**", started in 2011/12, stems from the CusMiBio project "From school to university: a round trip", aimed at the assembling of Kits (materials, handbook, protocols, teacher's guide etc..) that teachers can "hire" from CusMiBio and take to their school. Some among the Try the Biolab activities have been adapted to be transferred to schools as teaching kits. In the "Wannabe a tutor" project, the most motivated and skilled students are invited together with their teachers to practice and become familiar with these teaching modules. Teachers and students, together, attend a training course to acquire the theoretical basis and become expert in presenting the practical activities to their peers at school.

Goals and Results of the "Wannabe a tutor" project from the teacher's side:

- acquisition of additional knowledge to manage the topics with the required competence;
- design of Lab activities suitable for being performed at school;
- creation of the most favorable conditions for cooperation within and between schools and between teachers and students;
- exchange of materials and experiences.

Goals and Results from the student's side:

- talented students returning to their schools share their knowledge with fellow students through a combination of experiments and dialogue. This approach facilitates productive interactions within peers while breaking the intimidating "teacher-student" barrier;
- students have an opportunity to develop a wide range of complementary skills, such as work in groups, peer exchange abilities, communication with an appropriate language.

## CusMiBio Labs

CusMiBio laboratories are University spaces dedicated to High School, fully equipped with high-tech materials and instruments, usually not available in a school laboratory. The Biosciences laboratory has 48 work stations, the Bioinformatics laboratory has 32 stations, each with computer and internet connection.

### CusMiBio permanent staff:

- Director Paolo Plevani and co-Director Giovanna Viale are Faculty members of the University of Milan;
- two High School teachers, Cinzia Grazioli and Livia Pirovano in charge of the Lombardy Educational Office, work full-time at CusMiBio;
- about two dozen University researchers and professors from different Biosciences disciplines at the University of Milano (Biomolecular Sciences, Medicine, Agricultural Sciences, Pharmacy and Veterinary) collaborate with CusMiBio in seminars, updating courses, and setting-up of new hands-on activities for students;
- several Ph.D. students and post-docs act as tutors during the hands-on activities in the lab. This is extremely important because the presence of motivated young people strongly facilitates productive interactions and dialogue with high school students, breaking the intimidating "teacher-student" barrier.

## CUSMIBIO STUDENTS IN EUROPE AND IN THE WORLD

CusMiBio collaborates with various international organizations to promote initiatives designed to identify attitudes and possible scientific excellences among young people in secondary schools:

- 2007: The winners of the first two editions of the contest "A week as a Researcher" won a FEBS (Federation of European Biochemical Societies) scholarship to participate in the 7th Young Scientist Forum in Vienna.
- 2008: At the annual conference of the NYEX (Network of Youth Excellence) in Goettingen, three students among those who participated in the 2nd edition of the "Trainees researchers" were chosen by the European Commission to participate in an international internship in biotechnology, held in part at the Explo, Heidelberg and partly at Xlab, Goettingen.
- 2008 and 2009: in 2008, according to the agreement between CusMiBio and the Glaesernes Labor of the Science & Technology Campus Berlin Buch, two students attended the laboratory activities of the Bio-Olympiade Summer Academy in Berlin.
- In 2009, 2010 and 2011 CusMiBio students participated in the Summer Schools organized by the Freie Universitaet Berlin.



- In the year 2011 and 2012 two talented students were selected to participate in the "Eilat-Eilot International Renewable Energy Conference", held in Israel on energy issues. In the months preceding the conference, groups of students of different nationalities, coordinated by a tutor, are asked to develop a project on one of the topics of the conference, and to present it in a dedicated session of the conference. In 2011 edition, the project by the group including the student selected by CusMiBio received the second prize (<http://renewable-energy-eilat.org/conference/>).
- CusMiBio students also distinguished themselves (first prize, 2010 and 2011) in the international competition "DNA DAY" organized by the American Society of Human Genetics.

## CUSMIBIO INTERNATIONAL SUMMER SCHOOL

### **Diving into molecular biology**

CusMiBio seeks to increase the participation of students in biological research and to encourage them to prepare for careers in research in the broad spectrum of the biological sciences from medicine, to biotechnology, ecology and bioinformatics. To this end CusMiBio organizes an International Summer School through which students receive training and research experience in a university setting.

The students admitted (20) will receive a week intensive hands-on experiments and seminars at the CusMiBio laboratories on the University of Milan campus. Lab activities will be supervised by scientists of Milan University, post-doc tutors and CusMiBio teaching staff. Seminars will be given by University faculty members or affiliated research organizations active in the fields of Biotechnology and Biomedicine.

At the end participants will have gained a broad up-to-date and experimental overview of nowadays biological research and they could be inspired and encouraged to take an interest in research and to consider careers in bioscience and technology.

## THE CITY BARCODE PROJECT

Science education is traditionally accomplished in the context of "canned" labs with known outcomes. Increasingly, science educators are looking for ways to implement open-ended, "authentic" research projects that engage students in all aspects of scientific inquiry. At the apex of authentic science are large-scale, "distributed" research projects in which students from different schools collaborate to fulfill different parts of a large project. Distributed projects typically make use of cyberinfrastructure and accentuate collaborative skills that are increasingly important in science – and any profession.

In launching the City barcode project, CusMiBio believes that it will provide a much needed opportunity for the bright and diverse High School students to “explore the science around them” in their urban backyard. We also hope that this competition will help students engage their curiosity for nature without being limited by an urban setting.

City barcode project (CBP) will engage students in studies of biological diversity in their urban environment. This project will encourage students to consider the diversity of other living things and products in their parks, homes, restaurants, and stores. CBP will provide an infrastructure to involve large numbers of students in distributed, collaborative experiments using DNA barcoding. This project is in the vein of “citizen science,” where non-scientists contribute data that is potentially useful to scientists.

To date, educational use of DNA barcoding has been limited to isolated projects that involved relatively few students. Although DNA isolation and amplification methods have been standardized for scientific use, they have not been adapted for widespread classroom use. Thus, CusMiBio will lend its expertise in providing educational kits, Internet sites, and teacher training to support student investigations using DNA barcoding.

CBP is a pilot project to demonstrate the feasibility of implementing large-scale, distributed experiments in DNA barcoding within the context of a major urban school system. By organizing the CBP, large numbers of students underrepresented in science will have a meaningful experience with scientific research. Students will also have the opportunity to submit to barcode records for species that have not yet been described in the iBOL database. The infrastructure and dissemination mechanisms developed by this project can potentially be elaborated to other regional and national projects on student DNA barcoding.