

# From School to University and back again: Cus-Mi-Bio, an integrated approach to science education in Lombardy, Italy

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**Abstract.** High school science education is a complex task, requiring an integrated approach by all institutions dealing with science education, including University.

Here we presents the general organization and philosophy of Cus-Mi-Bio (Centre of the University and High School of Milan for Bioscience Education), together with the analysis of all initiatives developed for High school science teachers and students.

**Keywords.** Science education, High school, science teachers, High school students, university, bio-lab

## Introduction

While there has been an extraordinary acceleration in the comprehension of basic biological phenomena, which has so far brought Genetics and the Biosciences in the “Big Science” field, a lack in scientific culture among the general population can be observed. Terms as DNA, gene and genome are very common nowadays, but most of the people do not know their exact meaning. Terms as “organic” or “biological” have assumed a positive meaning, while others, such as “genetics” or “biotechnological” a

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negative one. This is the result of prejudices and of poor scientific culture and can have serious social and economic repercussions.

Moreover, according to a recent survey performed within the frame of the ROSE (Relevance Of Science Education) project [1], among students in many industrialized countries science is less popular than other subjects and young people, mostly girls, are ambivalent or negative as regard to get a job in technology. This tendency is worrying, because a country which is not developing science and know-how is a country lagging in international challenges in the High tech sectors and hence doomed to be left behind. As a consequence, all institutions dealing with science education, including University, should make efforts for raising interest in science. However, the diffusion of scientific culture is a complex and articulated task; there are a lot of movers and subjects to investigate and coordinate to reach this goal. A key step in this direction is to improve and stimulate science education in High schools.

### **Acting science education**

Acting science education means to give the students the instruments to understand and interpret the cultural and scientific evolution of modern society, to infuse enthusiasm and the will to know and interpret the research progresses, to increase and sharpen their critical sense and their capacity to make conscious choices.

Most of the undergraduate students will soon access University, making the two educational systems (i.e. High school and University) closely linked. In Italy, for instance, in 2005 more than 300.000 students were enrolled into the University [2], and University will have good freshmen, only if the High school provides the students with an adequate background. Moreover, it should also not be underestimated that students with a strong interest in biosciences will ensure, once graduated, a new generation of researchers.

At High school, students should acquire not only specific competences (i.e. knowledge in specific topics, such as maths, physics, biology or literature), but also aspecific competences in life and social skills, like team working, self management, autonomy, responsible behaviour (in terms of punctuality, attention, critical participation etc.). What is important is to "learn how to learn".

For these reasons, we strengthened the existing collaboration between High school and University, the two cornerstones of education and training in modern societies, in an attempt to promote cooperation and mutual exchanges.

### **Establishment of Cus-Mi-Bio**

In 2004, the University of Milan (Università degli Studi di Milano) [3] signed a collaborative agreement with the Educational School Office of Lombardy [4], the institution coordinating all public High schools (about 1.000 schools, over 1.500 life science teachers and over 320.000 students) in this Highly industrialized region of Northern Italy (9.475 .000 inhabitants, 21,861 m<sup>2</sup>).

The result was the establishment of a centre, called Cus-Mi-Bio (Centre of the University and High school of Milan for Bioscience education), specifically dedicated

to science education in High school [5]. This centre wants to be a bridge between the two educational systems, University and High school. In our opinion, a strong collaboration between High school system and other institutions, like University, research centres or museums, dealing with science education is crucial for the success of all science education initiatives.

The organization structure of Cus-Mi-Bio comprises a director (lasting three years) and a scientific committee composed by 5 members (University teachers and representatives of the Educational Office of Lombardy). An essential point to be underlined is that at Cus-Mi-Bio centre, two High school teachers (C.G. and A.C.) are working full time, therefore representing the needs of the High school within the University. Moreover, a dozen of University teachers working in the scientific faculties of the University of Milan (Faculty of Agriculture, Pharmacy, Medicine, Science and Veterinary) are collaborating with different roles, as project coordinators or supporting staff. The involvement of several University teachers with different cultural background should from one side guarantee the critical mass to this initiative and therefore its lasting over time, from the other side should allow a multidisciplinary approach to specific scientific topics for High school science education. Like in biology, diversity is essential and is an asset to be preserved! Finally, several young graduated people are collaborating as tutors for carrying out the hands on activities, as discussed in the paragraph “The role of tutors”.

Cus-Mi-Bio has also a collaborative agreement with EMBL (European Molecular Biology Laboratory) of Heidelberg [6] for delivering courses for science secondary school teachers under the support of ELLS (European Learning Laboratory for the Life Sciences) at EMBL.

### **General philosophy of Cus-Mi-Bio**

The general philosophy underlying all the initiatives developed by Cus-Mi-Bio is that High school teachers are the key elements in the process of diffusion of knowledge. Consequently, all activities towards High school students, the final recipients of the whole initiative, are discussed and organized in close collaboration with the teachers. Therefore, Cus-Mi-Bio organizes activities for both High school teachers and students, as illustrated underneath.

### **Activities for High school teachers**

According to the above presented general philosophy, we established a strong web of interactions with the teachers (Fig. 1), so that they become the main actors in the diffusion of scientific knowledge in the newest fields of Biosciences. Owing to their fundamental role, we deserve a lot of attention to High school teachers. They need updating (in average High school teachers graduated about 20 years ago); they need motivation (they are often depressed and bored); they need to recover a social role and to receive new stimuli for doing their work in a more participated, more creative and consequently more effective way; they need also a place where to meet, to exchange experiences and to establish contacts with their colleagues.

### *Collaborative High school/University groups*

Collaborative High school/University groups are groups, each composed by an University teacher and 5/7 High school teachers, which, under the supervision of university teachers, work on a given scientific topics with the goal of preparing work-packages and new teaching methods and tools for High school students. In these groups, High school teachers have a dual role: from one side, they become students again, since they are updated in their scientific knowledge by the University teachers, that are also a reference point for High school teachers as far as University expectancy on students' background knowledge is regarded. On the other side, the High school teachers are also a crucial component of the team with their professional skills and specific competences in dealing with teenagers, their knowledge in how to get their attention, in how to prepare suitable activities, in the language to use etc. In these High school/University groups, therefore, there is an osmotic exchange of competences.

As a result of the combined High school/University efforts, several activities for students have been produced on advanced biotechnological topics, such as GMO (Genetically Modified organisms) identification, DNA fingerprinting, simulation of a FISH (Fluorescent In Situ Hybridization) analysis, molecular markers in corn, yeast genetics, bioethics, bioinformatics, genetic counselling, etc. For each topic, the single collaborative group developed a handbook, freely available on our website [5].

Many High school teachers report how pleasant and rewarding is to study again as they used to do when they were at University. Simona Cadirola (teacher at the classic lyceum "Berchet", Milan), one of the most involved teacher, says: *"it has been an absorbing and cooperative experience, we had the pleasure to be students again...Also the collaboration among a lot of High school teachers has been important not to mention the exchanges with the University teachers. It has been a demanding job but rewarding for the goal reached both in the activities elaboration and in the relationship with students and colleagues of our schools who are enthusiastic about the project."*

### *Attending national or international meetings*

The efforts of High school teachers in the collaborative groups are acknowledged by Educational Office of Lombardy through the sponsorship of the teacher participation to updating meetings, both national and international. The latter are strongly favoured by Cus-Mi-Bio, owing to the fundamental role of establishing international contacts. In this regard, internationalization should be further increased.

Another key feature of the Cus-Mi-Bio philosophy is that all teaching experiences of teachers must become a common resource, shared by and available to all teachers. Accordingly, Cus-Mi-Bio organizes reports and publications of the experiences on the Cus-Mi-Bio web site [5]. This resulted to help very much in developing their sense of belonging.

### *Lead teacher*

The lead teacher is a new role we created for science teachers, in accordance with the Educational Office of Lombardy. A lead teacher is a High school teacher who worked

in the University/school collaborative groups in developing lab activities, and thereafter can run himself “Try the BioLab” (see corresponding paragraph), in place of the University teacher.

Hence, the lead teacher responds to another aspect of the general philosophy of Cus-Mi-Bio: High school teachers must perform a round trip. They go to the University or to a research lab, they pick up knowledge, but then they must “close the circle” in order to bring back their new competences and skills to the High school by updating students (Fig. 2).

That is what M. Teresa Oliveira (teacher at the vocational school “Ipsia Fiocchi”, Lecco, Como), one of our lead teachers, reports: “*it has been a unique experience ...I have improved a lot since I joined Cus-Mi-Bio activities, now I know much more than before, also my way of teaching is more dynamic, I feel more self confident when I face the audience..... I will always thank you to have made my path to knowledge so much easier...*”

#### *Updating courses*

Another activity of Cus-Mi-Bio for High school teachers concerns the planning and organization of updating courses, both theoretical and practical, attended up to now, by about 400 teachers. Some of these courses are run in Italian, others are run in English, and organized with ELLS. Updating course resulted to be the first step in allowing a contact with teachers for further activities.

#### *E-learning activities*

Cus-Mi-Bio developed and is developing e-learning activities for High school teachers to be used in the classroom teaching in the frame of the “Bioteach: tools and tips for science teachers” project [7]. Some modules (e.g., “From organism to genes” on zebrafish performed in collaboration with ELLS) are available in English.

However, this kind of teaching tool is not widely used by the teachers. In our experience, they prefer, in their updating process, a more direct relationship and interchange with the University teacher.

### **Activities for High school students**

Teaching in the classroom, although essential, cannot fully transmit the excitement of scientific research and discovery [8]. New initiatives and proposals, therefore, are necessary to support a more participatory, discovery-based instruction in undergraduate science education.

To this purpose, hands-on activities and experiences based on direct involvement in scientific research were developed by Cus-Mi-Bio, as discussed in the next paragraphs.

#### *“Try the Bio-Lab”*

“Try the Bio-Lab” is the main activity for High school students: third, fourth and fifth grade students can spend one morning in a fully equipped University lab (both

materials and equipments are usually not available in a school laboratory) where they can perform one hands-on activity on advanced biotechnological topics, elaborated by the collaborative groups of University/High school teachers (see paragraph “Collaborative High school/University groups”). Students of each class are divided in small groups (5 to 6 people). Subdivision in small groups is important to help them in developing sense of ownership and team work capabilities.

The students, with the help of lead teachers (see “Lead teacher” paragraph) and tutors (see “The role of tutors” paragraph) perform by themselves a simple experiment, comment their results and discuss conclusions. The lead teacher can explain in more depth some theoretical aspects and discuss with the students their results.

The class teacher also attends the activity. He/she has prepared the students during his/her lessons at school and has already performed the experiment in a preliminary rehearsal session for teachers.

Last but not least, from this experience our young students, mixing with University students who attend courses, take exams or work in the labs or simply having a drink at the coffee bar can have their first taste of the University environment.

#### *The role of tutors*

Tutors are newly graduated or PhD students (even though the latter are only occasionally involved due to their research activity), that cooperate as instructors in the “Try the BioLab” activities.

The involvement of the tutors results to be very important, as they act as role models for the students (high school student relates to a peer and not directly to the teacher, whose institutional role creates more barriers) and they can give careers advice, helping students in a more conscious and motivated choice of their future studies. The presence of tutors ensures also a cooperative and collaborative atmosphere.

#### *The annual students contest*

The research internship in a molecular biology research lab is a vital component of an advanced science education program. It allows students to see hands-on what biomedical research is all about—the ups, the downs, the excitement, the frustration, the challenging aspects of this activity.

Within this general frame, Cus-Mi-Bio organises a competition, reserved to all High school students who attended “Try the BioLab” activity, for about 10 stages in a research lab. The stages are both short (“A week as a researcher”) and long (“One-month stage in an international lab”) and are performed during holidays. The short stage is performed in one of the research labs of Milan University, the long one in an international lab [in 2006, it was at the Monterotondo (Rome) outstation of EMBL] and it is reserved to the first ranked student.

Therefore, at Cus-Mi-Bio we try to have a balance between non-selective (“Try the BioLab”) and selective (Stage in a research lab) activities and the general strategy can be summarized as “From many to few”.

This strategy raises the problem of the selection criteria to be used in order to avoid discrimination, both against or in favour of any kind of High school (classic, scientific lyceum or vocational school). Selection is mostly based on multiple choice test. There are different kinds of questions in the tests evaluating different skills and to be tackled

by different cognitive styles to give students with less theoretical knowledge but more method and logic (i.e. vocational school students) the same opportunities as Lyceum students.

The selection is performed through two successive selection steps (Fig. 3). A first selection step is performed in each class by the class teacher through a questionnaire which is the same for all classes and a second selection step performed at Cus-Mi-Bio, which is based on a computer test and an interview to assess motivation. The selection, being very hard (from 3.000 participating students to 12 winners), allows the identification of very talented young students, as confirmed also by the evaluation of the lab group leader where each student performed the research stage.

#### *“Attend a top science research project”*

We reasoned that Cus-Mi-Bio does not lose talented students selected through the annual students contest (see above paragraph). Therefore, a new project, “Attend a top science research project” was launched, for combining professional-quality research with a strategy for research-based undergraduate education.

The project, which will start in October 2006, will consist in involving, all school year long, the High school students who attended the lab stage in a real top science research. “Following the footsteps of evolution, looking for new genes” is the 2006 research project, which will consist in a bioinformatics analysis of the human genome, aimed at the discovery of novel and as yet unidentified genes. Hopefully, this new experience will end up in a positive way, like previous similar experiences [9].

#### **Evaluation instruments and feedback**

Cus-Mi-Bio has also planned some instruments to evaluate its activities both in quality and in quantity terms. At the end of all workgroups, meetings, training courses and lab activities, teachers and students are surveyed through a questionnaire assessing the effectiveness, the relevancy, the adherence to the expectations, the clearness of the exposition, the feasibility of hands on activities, the reproducibility of the activities; they can also express their opinion and comments and give suggestions.

After only 3 years of activities, it's too soon to have a feedback on their impact on High school science education. An extremely positive and encouraging observation is the substantial increase, year after year, of the number of teachers who join the different activities, who want to collaborate and of the High school students attending the lab activities.

#### **Concluding remarks**

As a consequence of the general philosophy underlying Cus-Mi-Bio and of the results of up to now experience, we draw the conclusion that University and scientific institutions dealing with Science education in High schools have to develop two main perspectives: first, they have to design a new role for their activities, and they have to establish tight links with the territorial and cultural background, involving other

institutions, like local government and civil society sharing the same mission, i.e. education. The second perspective is to create a network between European or non-European institutions dealing with science education for High school students and to implement the already existing collaborations.

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Figures

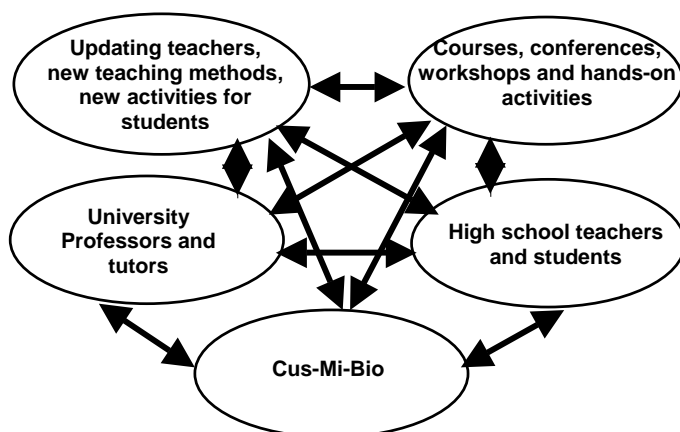


Fig.1.

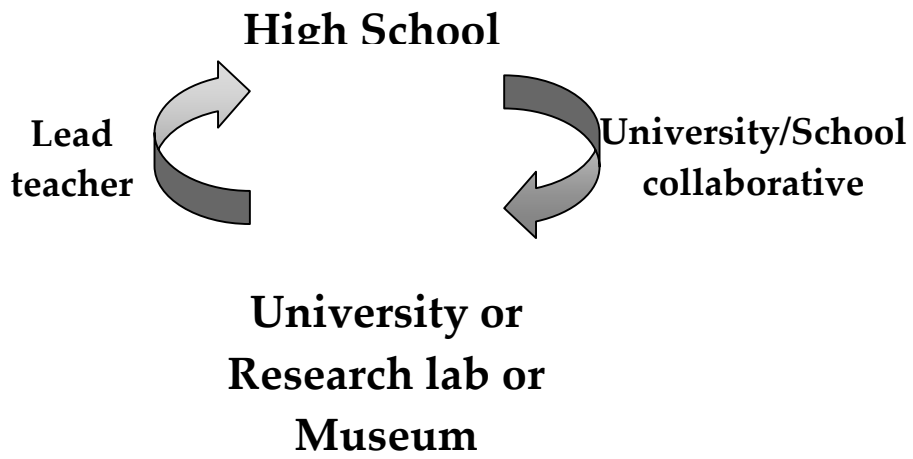


Fig. 2.

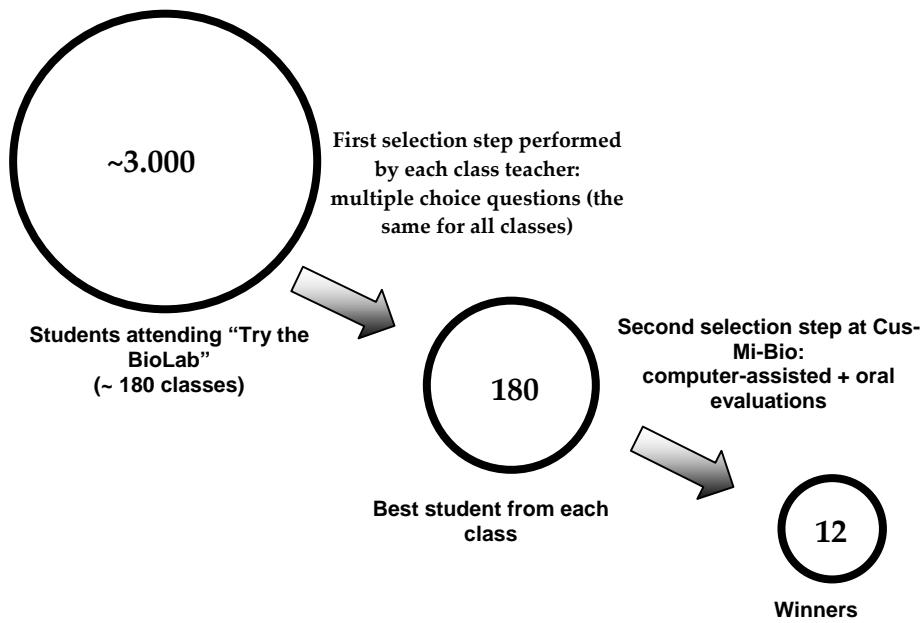


Fig.3.

**Legends to figures**

Fig. 1. Cus-Mi-Bio web of interactions.

Fig. 2. The lead teacher, a new role for High school teachers. A lead teacher makes a round trip: from School to University (where he was updated in the High school/University collaborative groups) and back again, from University to High school by collaborating to activities for High school students.

Fig. 3. Selection steps in “A week as a researcher” and “One-month stage in an international lab” prizes reserved to High school students attending Bio-Lab activities. Numbers refer to 2006 edition.

**Tables**

<b>Activities of Cus-Mi-Bio for High school teachers</b>		<b>students</b>
Collaborative groups	High school/University	“Try the Bio-Lab”
Attending meetings	national or international	Stage in a research lab: “A week as a researcher” and “One-month stage in an international lab”
Lead teacher		“Attend a top science research project”
Updating courses		

**Table 1.** Activities developed by Cus-Mi-Bio for High school teachers and students in the frame of science education. For details, see text.