

Escherichia coli or another microbial species such as baker's/brewer's yeast, *Saccharomyces cerevisiae*⁷. While the success stories with this approach are few, this picture may change with adequate support and funding. It is of interest to highlight the potential value of this approach, as it would broaden the scope and success for natural products-based drug discovery.

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Teaching biotechnology at college level – need to balance ethics and science

Biotechnology is one of the technologies available to us 'off the shelf'. It can improve our quality of life in many ways. Among the many uses of biotechnology, application of biotechnology in the fields of food and agriculture is of particular interest to humankind¹. The 'modern' part of biotechnology shows a high potential for solving various problems of our modern world, but at the same time it is accompanied by ethical questions and problems. The aim of biotechnology education and R&D is to find solutions to identified problems like pest control, nutritional enhancement, an improved drug, a vaccine or an antibody. Over the last decade, a plethora of biotechnology courses have been started at the post-graduate level by the government and non-government organizations².

When students study biotechnology in science or biology courses at college, they get to know a technology that is on the one hand old – like techniques of making bread or wine – and on the other new – like genetic engineering. The biotechnology course should teach the students the scientific and technical aspects of biotechnology.

From a pedagogical and a didactical point of view, the course must deal with the basic knowledge and the effects of biotechnology. In addition, its aim should be to improve the student's ability of reasoned decision making. The course should lead the students to a basic under-

standing of the methods, achievements of biotechnology.

As the knowledge in the life sciences has exploded during the last two decades, it is necessary for science teachers to restrict to the main fields of biotechnology while teaching. However, the central application fields of biotechnology (pharmaceutical industry, medicine, farming, nutrition and environmental technology) as well as the procedures (i.e. genetic engineering, cell-culture techniques, cultivation of microorganisms) should be taken into account. Out of the variety of procedures that are summarized under the term biotechnology, genetic engineering is still one of the most discussed regarding ethics.

As many research studies in biology, chemistry, and physics, didactics have shown, pre-educational student's conceptions have an important influence on the learning outcome of the students. Besides this, cognitive aspect, the motivational aspect of learning processes must also be considered. Especially interest in a particular topic that must be learned is important for the learning outcome. One important characteristic of biotechnology in college education is the fact that it is such a complex issue and hence should be taught in an interdisciplinary way. Ethical questions cannot be excluded when teaching gene technology, for example. Therefore, a tool for discussing ethical problems in a structured way – ethical

analysis – should be described and illustrated using specific examples.

When teaching biotechnology, the topic cannot be restricted to pure science aspects only. Especially social and ethical questions related to the topic are aspects that the students are mostly interested in and occupied with. We therefore must differentiate two dimensions: the descriptive–explicative dimension, which deals with scientific facts and methods and that can be judged as right or wrong; and the normative dimension which deals with the moral judgement of human actions that can be judged as morally good or bad. The second dimension should aim at improving the students' ability of moral judgement – the ability to decide when in a dilemma, i.e. the health of a human being versus the health of an animal. To give the students a structure for their argument we define two higher categories: the category of welfare of man and/or nature, and that of human dignity.

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