

Falk, H., Piontkovitz, Y., Brill, G., Baram, A., and Yarden, A. (2003). *Gene Tamers: Studying Biotechnology Through Research*. (A student text, a teacher guide and an internet site <http://stwww.weizmann.ac.il/g-bio/biotech>, The Amos de-Shalit Israeli Center for Science Teaching, grades 10-12, 2nd edition 2005).

Short summary of the main features

This curriculum in biotechnology was designed for 11th and 12th-grade biology majors. The student book contains an Introductory Unit and three Adapted-Primary-Literature (APL) articles. The teacher guide contains guiding questions to the research articles, elaborations on the developers' aims and rationale and suggested instructional strategies. Those materials are accompanied by an internet site, designed for students and teachers that use the materials. Among other things the site include animations of various biotechnological methods that were used in the APL articles, a close forum for teachers as well as numerous suggestions for enactment and evaluation of those unique materials.

The Introductory Unit to the student book lays the groundwork for learning the APL articles. It presents basic concepts and processes in molecular biotechnology. To avoid a systematic presentation of biotechnological methods, its contents were organized around three main case studies: genetically engineered human erythropoietin, the cloning of human growth hormone in bacteria, and genetic engineering of transgenic plants that are resistant to insects. Each case study gradually describes several biotechnological processes. Throughout the Introductory Unit, a large number of questions and assignments are distributed. Some of them ask the students to find relevant information toward solving a certain transfer problem and suggest a solution. Others require finding additional applications for a given method or analyzing the possible social implications of a biotechnological process. In parallel to presenting biotechnology as a practically oriented, problem-solving endeavor, we stress the fact that many biotechnological solutions, although beneficial, raise new problems and students are often invited to expose the possible drawbacks of present solutions and to suggest theoretical designs of better ones.

The three adapted research articles, all from leading peer-reviewed professional literature, deal with three different topics: 1) Detection of genotoxic materials in water by bacterial biosensors (Davidov et al., 2000); 2) Promotion of plants' resistance to pests by expressing a bacterial toxin (De Cosa, Moar, Lee, Miller, & Daniel, 2001); 3) Gene therapy of an immunodeficiency in humans (Aiuti et al., 2002). The abstracts of

the three adapted articles, translated back to English from the Hebrew version of the original APL articles, appear below. The articles were chosen for several reasons: 1) variety of the organisms used; 2) variety of stages in the biotechnological process, from basic research to field and clinical applications; 3) presentation of biotechnological principles which can be used toward understanding other articles and can be transferred to the design of other biotechnological products; 4) adaptability of the original research article to the APL genre, i.e. clear presentation of results, possibility of choosing a limited number of figures without altering the main meaning of the research, scientific background which is compatible with students' prior knowledge; 5) leading-edge, high-impact subjects that are broadly covered in the popular scientific literature and in the public media; 6) articles based on research by local scientists.

The abstracts of the three adapted articles, translated back into English from the Hebrew version of the original APL articles that appear in the student book, are presented below.

Expression of the Bt bacterium toxin in chloroplasts of tobacco plants imparts resistance to insects (following De Cosa et al., 2001)

The problems created in engineered plants into whose nucleus a toxin-encoding gene, isolated from the Bt bacterium, was introduced, led us to study how to engineer the operon encoding the toxin into the chloroplasts of tobacco plants. The operon integrates into, and is expressed in, the chloroplast genome of the transgenic plants. The toxin protein expressed in the plant cells forms crystals, in the same way that the toxin forms crystals in the Bt bacterium. The quantity of the toxin in these engineered plants is a hundred times higher than that in engineered plants into whose nucleus the toxin gene is introduced, and it is one of the highest levels reported, so far, in engineered plants. The quantity of the toxin remains constant even after the leaves turn yellow. When various moth larvae were fed with the engineered plants, they stopped feeding and died shortly afterwards. These results have paved the way to a new biotechnological method for creating transgenic plants.

The development of a biosensor for the detection of genotoxic materials

(following Davidov et al., 2000)

The danger of environmental pollution calls for the development of sensitive, fast and cost-efficient methodologies for the detection of pollutants in the environment. One way to detect pollutants in potable water is by using genetically engineered *E. coli* bacteria that emit light in the presence of genotoxic materials. The aims of the present investigation were to characterize the bacterial biosensor's performance in the presence of genotoxic materials, investigate its activity when linked to a gel matrix, and improve its sensitivity using different strains of bacteria. The results of our research attest to the potential use of the biosensor for the detection of genotoxic materials, and to the possibility of engineering additional biosensors that will detect warfare toxins, biological contaminants and heavy metals.

Correction of ADA-SCID by bone-marrow stem-cell gene therapy (following Aiuti et al., 2002)

ADA-SCID is an inherited blood disease caused by a mutation in the ADA gene that impairs immune-system activity. Treatment of ADA-SCID involves bone-marrow transplantation or life-long dependency on ADA enzyme injections, and it does not cure all cases. First trials of gene therapy for ADA-SCID, performed by introducing the normal ADA gene into the cells of sick people, did not yield positive results. The present research describes the gene therapy of two ADA-SCID sick infants for which bone-marrow transplantation or enzyme injection were not possible. Return of the bone-marrow cells, in which the normal gene had been inserted, into the infants resulted in increased white blood cell counts and improved activity of the immune system. Both patients are currently at home and clinically well, exhibiting normal growth and development. These results demonstrate, for the first time, the efficacy of gene-therapy treatment for ADA-SCID patients.

References

Aiuti, A., Slavin, S., Aker, M., Ficara, F., Deola, S., Mortellaro, A., Morecki, S., Andolfi, G., Tabucchi, A., Carlucci, F., Marinello, E., Cattaneo, F., Vai, S., Servida, P., Miniero, R., Roncarolo, M. G., & Bordignon, C. (2002). Correction of ADA-SCID by stem cell gene therapy combined with nonmyeloablative conditioning. *Science*, 296, 2410-2413.

- Davidov, Y., Rosen, R., Smulsky, D. R., Van Dyk, T. K., Vollmer, A. C., Elsemore, D. A., LaRossa, R. A., & Belkin, S. (2000). Improved bacterial SOS promoter: lux fusions for genotoxicity detection. *Mutation Research*, 466, 97-107.
- De Cosa, B., Moar, W., Lee, S. B., Miller, M., & Daniel, H. (2001). Overexpression of the Bt cry2Aa2 operon in chloroplasts leads to formation of insecticidal crystals. *Nature Biotechnology*, 19, 71-74.