



YALE NATIONAL INITIATIVE

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Curriculum Units by Fellows of the National Initiative

2018 Volume V: Manipulating Biology: Costs, Benefits and Controversies

Introduction

by Paul E. Turner, Elihu Professor of Ecology and Evolutionary Biology, and Acting Dean of Science

Humans are ever more capable of manipulating biology; but are we fully aware of our actions and their possible consequences? We are increasingly able to ‘design’ babies with preferred traits; but are we mistaken in believing that human perfection is (or should be) a possibility? We are improving technology that links human genetic-testing with better estimates of future risks of developing Alzheimer’s and other diseases; but how valuable is this information and the resulting mental anguish if many such diseases remain incurable? Gene-drive technology can be used to force the extinction of disease-transmitting mosquitoes and other ‘unwanted’ organisms, and genetic engineering can revive woolly mammoths and other extinct species. However, is it fine for humans to gain increasing power to control which species thrive alongside us on earth, or does this cross an ethical boundary? Very many technologies can make our lives more comfortable and disease-free, but these efforts are controversial because the pace of developing them is happening faster than research to fully examine their broader consequences. Examples include artificial intelligence and the creation of cyborgs; pros/cons of widespread vaccine-use; and using nanotechnology and microbes such as viruses as novel therapies to treat disease. These discoveries are truly amazing. But they offer the possibility for students to examine the potential costs and benefits to society, and to consider the overarching controversy of whether humans may be manipulating biology ‘too much’ without fully acknowledging or understanding the consequences of our actions.

The seminar “Manipulating Biology: Costs, Benefits and Controversies” explored historical and modern-day efforts by humans to change the biology of organisms, including ourselves. The seminar was designed to appeal to biology/science teachers at all grade levels. We read and discussed book chapters and magazine and online articles that concerned manipulating biology. In addition, we examined the many ways that these biotechnologies are presented (accurately and inaccurately) to the lay public, particularly on TV and in the movies. The overarching goal was to empower teachers in their knowledge of past and current technologies to manipulate biology, with the expectation that this understanding would enrich the classroom experiences of their students. The resulting units are diverse, reflecting the varied interests and backgrounds of the Fellows. Cristobal Carambo develops a unit for high school students concerning the possibilities, perils, and unintended consequences of newly-emerging technologies for genetic engineering, where students conduct independent research and present their findings on the impacts of these manipulations. The focus of Pierre Clark’s unit for 6th graders is the science of genetically modified organisms (GMOs), allowing students to weigh the pros and cons of engineering crops to feed our expanding human population size. Similarly, Michael Doody’s unit for Advanced Placement (AP) high schoolers examines the considerable public resistance to developing GMO plants that increase agricultural yields in the face of climate change and can better resist crop pests. Nancy Ibarra’s unit for 7th graders looks at gene-drive technology to eradicate mosquitoes that spread malaria, and asks students to consider the ethics of purposefully driving species to extinction. Sheila Lacanaria’s unit for AP

Chemistry high-school students concerns the rise of antibiotic resistant bacteria, and emphasizes the structure and function of enzymes as students consider the consequences of banning growth-promoting and prophylactic uses of antibiotics in animal agriculture. Patricia Moncrief's unit for 7th graders allows students to learn about pesticides, as well as hormones and other food additives, which help in food production but increasingly enter human bodies and may be toxic to our health. The unit by Eual Phillips explores gene-drive technology intended to treat mental illness, especially schizophrenia, relating this idea to familiar themes of comic books where medical therapy unintentionally leads to super powers. Valerie Schwarz develops a unit for 4th graders that concerns technology to resurrect extinct species, and challenges students to think critically about the consequences of altering genes and whether we should counter extinction versus use resources to preserve current-day species. Thomas Teague's unit for 7th graders examines the ability for students to weigh conflicting information and sources of evidence, in the context of medical technologies such as vaccination that have saved countless lives but are still viewed with skepticism by many people.

Paul E. Turner

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