ion has been stabilized or universalized in respect to these. What are and what should be the legal and moral positions vis-à-vis the following procedures, all but one of which have already been carried out in nonhuman organisms?

1. Artificial insemination with sperm from donors selected for particular qualities.

2. Artificial inovulation in which an egg produced by the wife and fertilized by the husband is transferred to a foster uterus.

3. Artificial inovulation by transfer of an egg produced by a donor, and fertilized either by the husband or a sperm donor, into the uterus of the wife.

4. Insertion of the nuclei of ordinary body-cells into eggs whose own nuclei have been removed, producing thereby any desired number of individuals with exactly the same genetic constitution as that of the donor of the nuclei—a procedure called cloning.

5. Cloning by causing ordinary body-cells to act as if they were fertilized eggs, thereby (again) producing any desired number of persons having the same hereditary makeup as the donor of the cells.

So little thinking has been done about the last two of these possibilities (outside the realm of science fiction, anyway) that we can hardly even list the individual or social advantages and disadvantages that might accrue from having a large number of genetically identical individuals. We are even less in a position to give these possibilities the calm and deliberate weighing that ought to lead to acceptable patterns of application.

Prospects and Challenges

The following general conclusions can be drawn:

1. Specific modification of individuals, by action on the genes or on the reproductive patterns and for individual or social purposes, is now possible and is increasingly and rapidly becoming feasible.

2. These techniques differ fundamentally from older approaches based on restricted breeding patterns–classical eugenics and Hitlerian eugenics, for example—in two critical respects: they are fast and they work. Even the insertion into man's heredity of what might be termed socially specific genes is a rather close—an uncomfortably close—probability.

3. We need to develop ways of adjusting these possibilities, of restricting their use within morally and socially acceptable patterns.

4. To do this will require a rejuvenation of the humanities and the social sciences and a reshaping of the relationship between them and the natural sciences.

Athelstan Spilhaus (1972) has said: "Just as technological invention cannot remove the need for social invention, neither should our slowness in changing outmoded social practices, institutions, and traditions be allowed to slow technological realization of potential benefits to all." Unless we rearrange our houses so that we can get to work immediately and unless we *do* get to work immediately, the genie (or gene) will be out of the bottle before we know the magic formulas that control it. And to permit this kind of genie to be out of control or to be misused is (to use the words in an unusual but meaningful combination) to *commit extinction*—first of freedom, and then of the species.

As teachers we have additional duties: to inform our students of these developments and to help them make the questions raised by these developments a prime order of business in their lives. We may confidently expect their lives to encompass the period during which most or all of the developments outlined here, as well as others, will be brought into practice. Those who are presently our students will be the ministers, the judges, the political scientists, the philosophers, the legislators, the teachers and, yes, the biologists, in charge. We and they had better start to think fast about how to handle that charge.

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Cell Energy System Duplicated

A part of the mysterious process by which cells produce energy has been duplicated in the laboratory by Efraim Racker, a Cornell University biochemist and molecular biologist.

The accomplishment is considered a breakthrough in the field of energy metabolism and membrane research. Scientists have been attempting for years to unlock the secret of the complex mechanism by which cells, the basic units of life, produce energy.

A major portion of the energy used in animal cells is produced in tiny "power plants," the mitochondria. The membrane of mitochondria contains enzymes that burn food and release an energy-storing molecule, adenosine triphosphate (ATP).

Three distinct enzyme systems cooperate to generate three molecules of ATP for each oxygen atom used in the burning process in which food is changed into energy. Racker isolated the third of these enzyme systems from mitochondria taken from beef hearts; and by combining the enzymes with phospholipids and membrane proteins Racker was able to reconstitute small round structures that produced ATP during the burning process.