FUNDAMENTALS IN BIOTECHNOLOGY

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Summary

Biotechnology, since the commencement of 1980, has become an integral feature of the public's consciousness, hopes and fears. Issues such as novel diseases, genetically engineered foods, cloning, bioterrorism and biosafety impact and interact with the public's feelings and instincts, which, in turn necessitate the comprehension and conveyance of the fundamentals of biotechnology in an easy and simplistic manner.

Often seen as a single technology, biotechnology, in reality, is a collection of a set of techniques that involves the use of a variety of organisms that lend themselves to a wide range of applications in generating bioenergy, and in improving healthcare, food production, environmental quality, and consumer choice.

An understanding of cell identity and nature (i.e. either prokaryotic or eukaryotic), its characteristics, its cultivation, and its biodiversity, etcetera, is fundamental to its handling in the laboratory, and later for application in the environmental, health, industrial, and medical sectors that contribute to human progress and welfare. The different articles covered by this topic focus on these basic issues, and on the cultivation of microorganisms, plants and animals. Moreover, a concise insight into genetic engineering and recombinant DNA technology is provided. The utilization of genetic information in microbial, plant and animal cells is contributing to disease prevention and cure, gene therapy, production of biopharmaceuticals, edible vaccines, etc. These in turn raise new concerns that involve ethics and biosafety. With the proclamation of the new Biosafety Protocol, losses in biodiversity, insecurity in the food and health

domains, and, mismanagement and pollution of the environment will be tackled as a result of the basic research findings coming from incisive fundamental research in cell structure, cell physiology, and cell nutrition - the key ingredients of basic biotechnology.

1. Introduction

A deep interdependence between the human and nature remains the fundamental fact of life. Health, growth and subsistence of a human society are therefore intimately linked to those of natural systems. Biotechnology is a technology involving whole or parts of the foundation of life, the cell. The performance of the individual cell forms the basis for our food, possible exploitation and sustainability of life. Each cell performance, on the other hand, follows the natural laws of thermodynamics (see also Cell Thermodynamics and Energy Metabolism) as well as its inherited genetic code. It is finally the genetic code, which determines the optimal physical or biochemical characteristics of each cell. In the past, present and future, biotechnological approaches involve cells of many kinds, belonging to bacteria (prokaryotic microorganisms), yeast, fungi (see also Microbial Cell Culture) and algae (see also Algal cell culture) (eukaryotic microorganisms), plants (see also Plant cell culture) and animals (see also Mammalian cell culture) including humans (eukaryotes). Depending on the specific purposes and needs, wild-type cells, naturally occurring mutants, or genetically manipulated cells and organisms are employed. The interest in bioresource potentials reflects our growing awareness that the sun is the source of nearly all energy and what we call “biomass” is the storehouse of solar energy. The amount of raw energy stored in our bioresources is enormous. It has been estimated that 10 percent of the world’s current yearly production of biomass could readily meet the year 2000 requirements for food and energy, if used efficiently.

The first topic of this theme therefore deals with the characteristics of all types of cells, their nutrient requirements, thermodynamics, cultivation techniques, the gene technologies available for changing the genetic code as well as the preservation of this biodiversity in culture collections and gene banks.

2. Cell Characteristics

Biotechnology with prokaryotic cells makes use of an intimate knowledge of the general and detailed rules governing the life of these cells. Cellular reactions are linked to the cell structures, which in principle are common to most bacteria irrespective of the various degrees of complexity, which are used for taxonomic purposes. All bacteria have an envelope consisting of a cytoplasmic membrane and, in most cases, a cell wall. This envelope encloses the cytoplasm and interacts with its exposed layers, with the environment. In contrast to the eukaryotic cell, the cytoplasm contains nucleic acids, ribosomes, enzymes (proteins), storage materials and low molecular weight compounds without any compartmentalization. Additional features of the prokaryotic cell are its small size and its relatively large surface compared to its volume. This organization allows a high and fast exchange between cell and environment as the distances are short and the absolute masses are low. These features enable the bacterial cell to grow and duplicate fast, an advantage taken for biotechnological processing (see also Microbial cell culture).

One of the major differences regarding the structural organisation between a prokaryotic and an eukaryotic cell is the fact that the latter contains so-called compartments within the cytoplasm, eg chloroplasts, mitochondria, vacuoles, Golgi apparatus etc. In many cases, a compartment is also an organelle, but the two terms do not always denominate the same structure. Whereas a nucleus can be both, the polysome is an organelle and not a compartment.

Algae are a heterogeneous group of organisms (see also Algal cell culture). They are aquatic or live in damp habitats on land. Some are prokaryotic but most are eukaryotic. It would be a great mistake to underestimate the diversity of life that can be defined as algae, ranging from simple spherical cells to a highly differentiated plant.

Properties typical only for plant (see also Plant cell culture) and animal cells (see also Mammalian cell culture) are that they do differentiate to form tissues and to carry out specialized functions within an organism. Cells of plant and animal cells exhibit therefore an enormous variety of specialization depending on their function within a tissue or an organism. An obvious plant-specific aspect is their potential to perform photosynthesis similar to the algae and some bacteria. Furthermore, typical plant cells are enclosed by a rigid cell wall functioning as a mechanical stabilizer.

Compared to plants, animals have an extended range of specialised cells and tissues with very specific functions, eg muscles, nerves, sensory systems, blood, the immune system and many more. Cell walls comparable to those of prokaryotic or plant cells are missing in animal cells. The shape of the cell is rather determined and maintained by the so-called cytoskeleton. The spectrum of interactions of bacterial cells with their environment is large, ranging from contact with partner cells of the same and of different species, with solid surfaces and can also be the target of activities of eukaryotic organisms. These interactions involve a diversity of chemical and structural features of components, such as slime, capsules, exoenzymes, pili and fimbriae.

Higher plants show a typical differentiation into roots, stems, and leaves. The stem supports leaves and flowers and contains the elements for water and nutrient transport into the above ground parts of the plant as well as for the translocation of photosynthetic products. The shoot is anchored in the ground by the root system which is also responsible for the uptake of mineral nutrients, whereas the leaves are attached to the shoots in such a way that they can capture the light they need for their photosynthesis.

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Biographical Sketches

Horst W. Doelle, born in 1932, studied biology at the University of Jena [1950-1954]. He studied for his doctorate at University of Goettingen [1955-1957] on antibiotic production. After receiving his doctorate, he worked in the Wine and brewing industry in Germany before taking up an appointment with CSIRO in Australia in 1960. After 4 years wine research, he took up the challenge to build up microbial physiology and fermentation technology at the Department of Microbiology at the University of Queensland in Brisbane. He received his Doctor of Science in 1976 and his Doctor of Science honoris causa in 1998. He participated and conducted numerous training courses in developing countries. After 29 years teaching he retired in 1992. His research area was regulation of anaerobic/aerobic metabolism, microbial technology [*Zymomonas* ethanol technology] and socio-economic biotechnology using microorganisms for waste management.

Edgar DaSilva, a graduate of the University of Bombay in microbiology and chemistry, was awarded, in 1962, the Bachelor of Science Degree (First Class with Honours). In 1966, he obtained the Master of Science Degree, and in 1969 his doctorate in 1969 for research studies on the cyanobacteria. As a NORAD Fellow, his research study, on the marine algae at the Norwegian Seaweed Research Institute, Trondhein, Norway, in 1970, was followed by a teaching assignment at the University of Helsinki, Helsinki, Finland. Two years later, he joined the Institute of Physiology, University of Uppsala, Uppsala, Sweden as a UNESCO fellow. A former Vice-President of the World Federation for Culture Collections (WFCC), author of several scientific publications, and member of well-known microbiological societies, Dr. DaSilva, since 1977, has been instrumental in the planning and implementation of programmes within the framework of the UNESCO global network of microbial resources centres (MIRCENS), and other allied biotechnologies. Currently, he is the Director, Division of Life Sciences.