Serial No	ISSN:
Author 1	OBITTE, N. C.
Author 2	OBITTE, B. C. N.
Author 3	
Title	Application of Science and Technology to Biotechnological Development in Nigeria
Keywords	
Description	Application of Science and Technology to Biotechnological Development in Nigeria
Category	Pharmaceutical Sciences
Publisher	Nijoster
Publication Date	2007
Signature	

Application of Science and Technology to Biotechnological Development in Nigeria

Obitte, N.C [1]. and Obitte, B.C.N [2]

Department of Pharmaceutical Technology and Industrial Pharmacy
Faculty of Pharmaceutical Sciences
University Of Nigeria, Nsukka.

Science Technology Department
Federal Polytechnic, Offa

Abstract

The development of Biotechnology in Nigeria is an emerging area of interest that owes its success to the manner and extent science and Technology are applied to it. An introduction of basic principles of genetics was presented. Definition, procedure/techniques and applications of Biotechnology were discussed. Biotechnology has a wide application in such areas as, Pharmacy, Electronics, Medicine, Industrial Microbiology, Nanotechnology and Agriculture. Certain factors were pointed out, that affect (the use of science and Technology) in the development of Biotechnology in Nigeria. These include funding, standard of education, establishment of Biotechnology institutes, Biotechnology researchers, and strong emphasis on science and technology at secondary school level and awareness on Biotechnology.Key words: Biotechnology, Science & Technology and Recombinant DNA Technology.

Introduction

Biotechnology is the field devoted to applying the techniques of Biochemistry, cellular biology, biology, biophysics and molecular biology to addressing practical issues related to human beings, agriculture and the environment. It is the use of recombinant DNA or hybridoma technologies for production of useful molecules or for the alteration of biologic processes to enhance some desired property (Stedman's Med.Dict.2000). It is the employment of molecular biology to effect transformational modification of microorganisms. It deals with the technology of constraining microorganisms to perform specific tasks or yield such desired products (through alteration of the genetic materials) as hormones antibiotics, steroids, chemicals, feedstocks, amino acids, enzymes, biopolymers, nanoparticles, quantum dots etc.

The genetic material

Genetics is the study of heredity and variation. DNA is a polymeric molecule composed of four monomeric deoxynucleotide units – deoxyadenylate, deoxyguanylate, deoxycytidylate and thymidylate. These are organized into genes, the units of genetic information. In 1944 Avery Macleod, and Mccarty showed that DNA contained the genetic information. These information reside in the sequence / ordering / arrangement of its monomers – purine and pyrimidine doexyribonucleotides. Any distortion in the arrangement in the purines (Adenosine and Guanosine) and pyrimidines (Cytidine and Thymidine) is the source of mutation and other genetic changes and functional variations. Their paring pattern in the DNA is as follows; Thymidine and Adenosine paired by 2H bonds while,

deoxycytidine (cytosine) and deoxyguanosine (guanosine) are paired by 3H bonds.

Specifically, the double stranded DNA has the genetic information locked within the nucleotides sequence on one of the stands called the template strand (i.e. the strand which is copied during the synthesis of nuecleic acid) or non -coding strand. But the strands opposite it is called coding strand due to the fact that it matches the DNA transcript responsible for encoding the protein.

Separation of the double DNA strands is crucial in biotechnology. This is accomplished by increasing the temperature of DNA solution at a low salt concentration, which causes the purine and pyrimidine bases to unlock or disengage while still attached to the polymer by the phosphodicster backbone. The biotechnologist will use the best techniques to separate the base pairs for the purpose of genetic manipulations (recombinant genes), thus ensuring that it is done at a low mid temperature (Tm) to reduce strand breakage. In recombinant DNA technology, Formamide is used to ease DNA strand separation. However at the optimum temperature (Tm) and salt concentration, renaturation of the DNA strands do take place.

Apart from DNA, many yeasts and bacteria contain extra smaller genetic materials called Plasmids (very common in Prokaryotic cells). Genes for bacterial growth are carried in the DNA while plasmids contain genes for specialized functions such as transfer of plasmids from one organism to the other; and this is how antibiotic resistance is transferred. The replication of plasmids in bacteria usually occurs independent of the bacterial DNA. Due to probably its size, the sequence of the DNA of plasmids is known, as a result it is not difficult locating sites where restriction enzymes can act on to make room for foreign /external DNA to be inserted.

Bacteriophages are viruses that live in or are associated with bacteria. Unlike eucaryotic DNA, which is membrane-bound, bacteria and virus DNA, are not; rather, viral nucleic acids are covered by protein coats. While, some viruses have double stranded DNA, others are single stranded DNA or RNA. E.g. E. Coli phage M13 are filament-bearing viruses possessing single strands of DNA surrounded by or complexed with protein. The application of biotechnological techniques to engineer DNA into phage M13 has yielded single strands that remain valuable sources to manipulate and analyze DNA (Jawetz 1995).

Phages contain linear molecules of nucleic acids (DNA) with restriction enzymes sites for foreign DNA attachment (or insertion). Phages' vectors enjoy advantage over plasmids in that while phages can accommodate DNA fragments 10 – 20Kb long, plasmids can only accept DNA pieces about 6 – 10 kb (Kilobasc) long. However more DNA fragments can be cloned in cosmids that possess the dual best characteristics of phages and plasmids.

Recombinant DNA Technology / Combinatorial Biology

Recombinant DNA research involves two major enzymes – exonucleases and endonucleases – which were formally known as restriction enzymes. While exonucleases are capable of severing DNA at specific sequences, endonucleases digest DNA from its end. The name restriction enzymes were so called because of their capacity to inhibit or restrict the growth of phage in bacteria. They function majorly to lyse foreign DNA from other microorganisms that invade a cell. At the same time, it also possesses methylase enzyme that buffers or shields it from being lysed by the restriction enzyme. This is why restriction enzyme and site-specific DNA methylase occur in pairs.

Restriction enzymes lyse DNA at specific sites while some chemical, physical or other enzymatic means rather sevcre DNA at random. The restriction enzymes found in E. Coli is ECORI and that of Bacillus amylolequefaciens is BamHI. The segments of an enzyme-digested DNA can be isolated

using agarose or polyacrylamide by electrophoresis.

Examples of other enzymes used in recombinant DNA research that act on DNA or RNA are reverse transcriptase and terminal transferase (Emery 1984).

Recombinant DNA segments can be analyzed for the type of nucleotide sequence they have, in a large number of similar DNA molecules using the manual/ enzymatic or automated / chemical method.

The manual method uses particular dideoxynucleotides that stop or terminate the synthesis of DNA strand at specific nucleotides in the course of its synthesis on purified template nucleic acid. The reaction is deliberately manipulated to produce fragments that terminate at every nucleotide. Size separation of fragments using polyacrylamide gel by electrophoresis and image production with an autoradiograph will reveal the DNA sequence.

The automated method of synthesizing fairly long oligonucleotides having very precise sequence, involves initial syntheses of short nucleotides, which are then joined or legated together to give rise to the oligonucleotides. The latter are frequently used in DNA sequencing, the polymerase chain reaction, DNA mobility shift assays, library screening etc

Biotech procedures

Microorganism Hunt/Isolation

Industrial microbiologists and biotechnologists actually go for microbial hunting, i.e. in search of the right microorganisms that possess some preconceived minimum characteristics. This search and identification process is scientifically carried out. Some organisms would not give maximum yield in their natural environment unless under a controlled environment. Therefore the challenge for the biotechnologist is that of bio-prospecting, that is being in search of, to identify, isolate, characterize and grow these special organisms in the appropriate environment (medium).

Fusion

This is the bringing together or cleavage of two organismic protoplasts to form a hybrid. The laboratory procedure begins with the culturing of the different cells in an isotonic solution, with the inclusion of beta-galacturonidase and cellulase enzymes. This medium removes the cell walls, and upon the addition of an osmotic stabilizer like sucrose the protoplasts are regenerated. A successful occurrence of fusion to yield hybrid is a preceding step to selecting the desired recombinants through the usual technique of plating.

Short DNA Sequences Insertion

Genetic information is stored as a sequence of bases in DNA. DNA sequences can be synthesized in the laboratory through chemical means. The short lengths of such synthetic DNA sequences could be introduced into another microorganism through he process of site-directed mutagenesis. In this process the gene is altered, amino acid/s change/s and new products (enzymes) probably with environmental resistance and catalytic properties are produced. Some of such products have enzyme-active sites capable of facilitating the transformation or biodegradation of materials or substances that are not of natural origin.

Mutation

Mutation is believed to be an evolutionary tool organisms wield to promote habitational adaptability. In biotechnology, scientists are more concerned with looking for the most valuable microorganisms. To impart desirable optimum characteristics they set out to distort the genetic equilibrium. This is done using mutagenic chemicals or U.V light. Penicillium notatum is cultured to produce penicillin antibiotic. But because its penicillin yield was low, in 1943 a strain of penicillium chrysogenum (strain NRRL 1951) was isolated. This was subjected to mutation under aerobic stirred fermenters with a 55-fold higher yield of penicillin than the earlier

static culture. When irradiated with x-ray, U.V and mustard gas, penicillin yield was improved from 120 I.U to 2,580 I.U (a 20 fold increase)

Interorganismic Genetic Information Transfer

This involves taking a gene responsible for the synthesis of a product and transferring it from one organism into the other. By so doing the receiver organism is endowed with additional functional capabilities.

Alteration of Genetic expression /information transfer

Apart from transferring or expressing genetic information from one organism to the other, the gene transferred can further be an agent of modification or alteration (for instance) of the metabolic part ways, which can either inactivate or deregulate specific genes.

Natural Genetic Engineering

Natural genetic engineering involves the use of environmental conditions to constrain microorganisms to undergo mutation and adaptation in what is called forced evolution. This process imparts into microorganisms new metabolic or biological capabilities or potentials, since it involves DNA rearrangement.

Applications Of Biotechnology

Application in electronics

Biotechnology has been applied to electronics and physics. If properly explored it is believed that the future of electronics will owe much of its inventions to engineered propensity of viruses (Whaley, 2000) and bacteria to manufacture nano-components such as quantum dots, carbon nanotubes and nonowires that can be assembled into such complex structures as nanocircuits (Fairley, 2003).

Biosensor Production

Biotechnology has also been applied to the production of biosensors. In this field of bioelectronics living organisms, organelles or enzymes are linked with or connected to electrodes. The resultant biological reaction is converted to an electrical signal. Biosensors can be employed to quantify certain beer components, detect flavors in food and monitor pollutants. This procedure offers the research opportunity to measure the concentration of different source samples e.g. glucose, ethanol etc.

Application In Pharmaceutical Drug Production

3 Vaccine Production (Tortora,et al. 1989; Johnston 2003).
4 Antibiotic production (Enzyme Inhibitors, penicillins, Streptomycin
5 Others: Uterocontractants, Antitumour agents, Immunosuppressants

(Demain 2000; Lancini, 1999)

Application in medicine

1 Cloning (Stedman's Medical Dictionary, 2000; Okoye, 2004)
2 Diagnoses (Mckusick 1983)

Application in agriculture/fuel production

1 Gibberellin, fuel production, etc.

Application in Food Science and Technology

2 Production of Amino acids, Vitamins, Nucleotides,etc.

Application in Nanotechnology

Albert Franks defined Nanotechnology as that area of science and technology where dimensions and tolerances in the range of 0.1nm – 100nm play a critical role. (Chemistry in Britain, 2003). Ultra-tiny bionano motors composed of molecular derivatives of viral protein, are being created by some researchers for propelling devices through a patient's blood stream (IEE spectrum, 2003).

Application in industrial microbiology.

3 Production of Alcohol, yogurt, etc.

Factors Affecting Biotechnology Development In Nigeria

Before we go ahead, we would define Science and Technology. Science is knowledge about the structure and behaviour of the natural and physical world, based on facts that you can prove, for example by experiments (Oxford Advanced Learners Dictionary, 2001). It is knowledge ascertained by observation and experiment, critically tested, systematized and brought under general principles (Okonta, 1996). Therefore for any body of knowledge to be tagged scientific, it must follow such general principles as observation, collection of data through experimentation and analyses of the data for the establishment of a trend. The backbone of science is the word "systematic" more than the word reproducibility. Systematic order in science includes the sequence of observation, hypothesis, experimentation, data collection, formulation of theory, comparison of theory with hypothesis and (if theory and hypothesis differ reasonably) progressive change or reframing of theory when proven facts reveal its weakness.

The relationship between knowledge and wisdom is Akin to that between Science and Technology. While wisdom is the fruitful and positive application of knowledge, Technology is the application of Science to industry, civilization, production, invention and urbanization. It is a tool or instrument, which employs science to organize and accomplish specific tasks and goals. All technologists are scientists but not all scientists are technologists or have the potentials to become one by age or experience. Biotechnology has an aim geared towards satisfying areas of human need by combining relevant aspects of biology and / or other sciences and employing appropriate technological techniques. Therefore Biotechnology development in Nigeria must involve the application of the essentials of Science and Technology.

Since our focus is on Biotechnology development we must set the stage for establishment and then provide enabling environment for development. Stakeholders in its development in Nigeria are government, parents/guardians, teachers, lecturers, heads of institutions and students. It is a grassroots- and upstream involving project, which demands concerted participation. They must contribute their quota individually and collectively for a credible and viable outcome. Government must make positive and supportive policies, and establish well-funded Biotechnology Schools/Institutes etc.

Strong emphasis on science and technology at secondary school level

Most schools do not have well equipped laboratories. Students pass out of secondary schools without sufficient practical experience. This kills the morale for the pursuit of science/technology-based courses.

It is sad to note here that many unqualified science teachers have helped to frustrate the efforts of aspiring science students. The dependence on malpractices by teachers and students have been perceived as an alternative way for crossing the hurdles and overcoming the challenges of diligent study. However we recommend that teachers should know how to counsel and encourage science inclined students. It should be emphasized that ability and desire are two different ball games. Ability is inborn; desire is "outborn".

Laboratories should be well equipped with both chemicals and materials/instruments. High-spirited teachers should be preferred to mere job seekers.

Establishment of standard biotech institute in Nigeria

To some people, Biotechnology is undoubtedly at its inchoate stage in Nigeria. To others, it is in a fallow state. Some do not even know that some of the special plant breeds ranging from Mango, Coconut, Palm fruit, Guava, Pawpaw, etc are transgenic crop products of biotechnology. In fairness to our government, Nigerians have been enjoying some of the dividends of biotechnology, albeit

unknown to them. Nevertheless it appears to be more favorable to Agriculture.
At present we have zonal Biotech institutes and centres established by the Federal Government. States in Nigeria should also establish and invest in Biotechnology institutes.

Multidisciplinary approach to biotechnology

Biotech is a dynamic discipline with a traceable ancestry to genetics and molecular biology. But it is no longer limited to biology, but encompasses such discipline as physics/electronics and material science. To catch up with the present integration capacity of biotechnological disciplines, it is expedient that an aspiring biotechnologist be vast in those relevant science and technology-based courses. Alternatively it is advised that the staff mix of any biotechnology-based research or institute in Nigeria should as much as possible embrace biochemists, pharmacists, chemists, agriculturists, electronic engineers, physicists, biologists, material scientists, etc.

Biotech awareness.

Seminars and lectures should be organized in secondary schools and tertiary institutions to enlighten students on biotechnology. All science students should be exposed to rudiments of biotechnology, sufficient enough to ignite their interest. Biotechnology can be made an elective course for all science and technology students in higher institutions. Comprehensive instructional (Means et. al. 1995; 1993) materials should serve as teaching aid.
The Genome Society of Nigeria is not doing badly, but they should extend their frontiers to non-biologists and geneticist. They should go into joint, interdisciplinary biotechnology researches, e.g. they should go into combined researches with engineers etc. Some researchers are vast, possessing biological science and engineering degrees. However, in place of this, joint research efforts are the ultimate in biotechnology advancement. Researchers from Northwestern University have shown a fabrication process that permits them to pattern and align molecular structures that consist of more than one molecule type on silicon surfaces with atomic precision (MIT enterprise technology Review,2004). This method enables the construction of prototype molecular electronic devices relevant to technologies of the future such as biomedical diagnostics, electronics etc. these researchers are versatile and/or authorities in areas where their co-biotechnology researchers are not.

Funding

Third world research has suffered so much set back because of poverty and gross insufficient research funding. Many researchers who found their way outside the country have performed enviably well under optimum research conditions (funding, equipment etc). Research grants in universities are rare and when available are sometimes conceded not on merit basis. The biotech departments in universities and institute in Nigeria should be adequately funded by the government and stake holders.

Biotechnology Researchers

It will be ridiculous for Nigeria to establish a biotechnology institute which is only a place where imported transgenic plants and seeds are exhibited. Our researchers should be involved in the technologies proper. They should upgrade and improve through further continual intensive researches. That means gene library, electron microscopes etc should be at their disposal.
The Nigeria recombinant genetic disease factor of, "man-known man," which keeps square pegs in round holes should not be allowed into research institutes. Gifted researchers should be sourced and employed to be able to come up with tangible progressive inputs to biotechnology development in Nigeria.

Conclusion

The vision and task of biotechnological development in Nigeria requires thorough knowledge of genetics and recombinant genc technology. Upon this foundation we can erect a virile Nigeria-friendly biotechnological structure. To have such a sustainable structure Science and Technology must play inevitable applicational roles. Thesc we have compressed and congealed in preceding sections under the factors that affect biotechnological development in Nigeria.

References

Applied physics today (2004) September 27th in MIT enterprises technology Review (2004) October 25th Big Bucks from small science, chemistry in Britain, (2003) April p. 24. –m 26

Demain A. L. (2000), Microbial Biotechnology, Tib Tech, 18 : 26 – 31

Demain A. L., (2000), Pharmaceutically active Secondary Metabolites of Microorganisms, App. Microbial Biotechnol. 52 : 455-463

Emery A, E. , (1984), An introduction to Recombinant DNA, Wiley, P. 41

Fairly P., (2003), Germs that build circutss IEEE spectrum, Nov 2003, vol 40, No 11, PP 37 – 41.

Jawetz E., Melnick J. L., Adelberg, E. A. (1995), Medical Microbiology, 20th Edn, Appleton and Lange, PP 86 - 88

Johnston, A. S. (2003) Nature Biotechnology Chambers, Sept., 2003, in The Punch, Wed., Aug. 27, Vol. 17, pp 49.

Lancini, G. Demain A. L., (1999) Secondary Metabolism in Bacteria: Antibiotic Pathways regulations, and function. In Biology of the Prokaeyotes, lengeler, J. W.; Drews, G., and schlegel, H.G. (eds) New York: Thieme,: 627 – 651.

Means B., Olson K., Singh R., (1993/1995), Kappan, Sept; SRI Report for OERI. April.

Mckusick V. A. (1983), Mandelian Inheritance in man 6th ed. Univ. Press Johns Hopkins, quoted in Harper's Biochemistry, Appleton and Large.

Nanotechnology and Smart materials for medical Devices, (2003) Our Dynamic Earth, Edinburgh, Dec 1 & 2,

Okoye,S.E (2004)The great Stem Cells, human cloning debate 2,The Guardian,Thurs.,vol.21,p.21.

Okonta,A.A (1996) Productivity Indigenous Technology as an alternative to Technology Transfer. Paper presented at the 14th Annual National Conference of the Nigeria Institute of Science Technology(NIST)at Offa, Kwara State 26th-30th Nov.1996.

Oxford Advanced Learners Dictionary, 6th Edn., (2001). P. 1051.

Stedman's Medical Dictionary (2000), 27th Edn., Lippincott Williams and Wilkins, 351 West Canada St., Maryland, USA. P. 364.

Stedman's Medical Dictionary (2000) 27tech,Lippincott Williams and Wilkins, 351 West Canada St., Maryland, USA. P. 207.

Tortora G. J., Funke, B. R. and Gase C. L. (1989). Microbiology:- An introduction, The Benjamin/Cummings publishing company, inc. Redwood city California, U. S. A, P. 435.

Whaley, S. R. et al, (2000). "Selection of peptides with semi conductor binding specificity for directed nanocrystal assembly." Nature, 8 June. Vol. 405, No 6787, P. 665 – 668.