

Chronological development avenues in biotechnology across the world

Abstract

Biotechnology is expected to be a great technological revolution followed by information technology. It is an application of scientific and engineering principles to the processing of material by biological agents to provide better goods and services to mankind. Commercially its techniques are applied long back in 6th century in the art of brewing, wine making and baking. It has progressed there after crossing different land marks. Modern biotechnology has developed significantly in the late 19th century with groundbreaking discoveries applicable in medicine, food, agriculture, chemistry, environmental protection and many more industries. It is widely used in the development of high-yielding, disease-resistant, better quality varieties by applying tissue culture and recombinant DNA techniques. It has wide application in animal breeding using techniques such as artificial insemination, *in vitro* fertilization and embryo transfer. Specific enzymes used in laundry, fuel and leather industries for better quality, economically feasible and environmental friendly production. Biotechnology in healthcare system uses body's own tools and weapons to fight against diseases, manufacturing of targeted therapeutic proteins, gene therapy and so on. Novel approaches such as proteomics and structural biology are contributing to understanding the chemistry of life and diseases. Malfunctioning gene replaced with correctly functioning gene by using gene therapy. Tissue engineering has opened up the use of *in vitro* developed tissue or organ in repairing wounded tissue and system biology which is a computer-based approach to understand cell functions. Although every new discovery related to biology and its implications is significant and has taken the technology ahead. This includes applications, commercialization, controversies, media exposure and so on. Hence, we have enlisted some of the chronological development avenues in biotechnology across the world.

Key words:

Avenues, biotechnology, chronological

Introduction

The field of biotechnology has moved very fast all over the world in the last decades. Biotechnological applications have great potential for developing countries for creating jobs through value-added products and for generation of nonpolluting environment friendly technologies. Biotechnology has the technical breadth and depth to change the industrial community because of its potentials such as to give products, which were never available before, to give products those are currently in short supply, to give

new methods that will reduce costs substantially, to give safer, better quality products, to give products that will use cheap raw materials, which are plentifully available but not used.^[1] As we move into the 21st century, biotechnology has become thrust to the centre of public conciseness by many groundbreaking spectacular discoveries and development in the field through biochemists, geneticists and cell biologists for providing better health care to humanity. Disease itself is now being understood, diagnosed, prevented, and treated without considering its symptoms, made possible by higher

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Prashant Y. Mali, Shital J. Panchal¹

Department of Pharmacology, Radharaman College of Pharmacy, Ratibad, Bhopal, Madhya Pradesh, ¹Department of Pharmacology, Institute of Pharmacy, Nirma University, Ahmedabad, Gujarat, India

Address for correspondence:

Mr. Prashant Y. Mali
Department of Pharmacology, Radharaman College of Pharmacy,
Ratibad, Bhopal - 462 044, Madhya Pradesh, India.
E-mail: pymali2008@rediffmail.com

order of genetic information. Recombinant therapeutic proteins, diagnostics, monoclonal antibodies, recombinant vaccines, gene therapy in the sphere of healthcare system have improved human health and atmosphere. Biotechnology is a collection of technologies that capitalize on the attributes of cells such as their manufacturing capabilities and put biological molecules such as DNA and proteins to work for us. There are some newer approaches and achievements of biotechnology in the field of medicine such as novel and more powerful antibiotics, cheaper steroid drugs and hormones, improved more effective and safer vaccines for disease prevention and so on. Therefore, we have highlighted some chronological development avenues in biotechnology across the world, which will help to all persons relates too life science. They are as follows:

- 2010 Researchers at the J. Craig Venter Institute created the first synthetic cell.^[2]
- 2009 Master gene switches on disease fighting cell that is, the master gene that causes blood stem cells to turn into disease fighting “Natural Killer” (NK) immune cells was identified by scientists, in a study published in *Nature Immunology* today. The discovery could one day help scientists boost the body’s production of these frontline tumor killing cells, creating new ways to treat cancer.^[3]
- 2008 Chemical boosts blood flow to brain that is, a team at the Weill Cornell Medical College in New York City reports that, the human brain contains its own store of a powerful enzyme called tissue plasminogen activator (tPA), which appears to be a key regulator of blood flow to brain cells.^[4]
- 2007 In April, Henrik Clausen, a professor at the University of Copenhagen in Denmark, published research in *Nature* describing a way to convert any kind of blood into Type O that is, the type that almost anyone can tolerate.^[5]
- 2006 Researchers develop biotech pigs that produce high levels of omega3 fatty acids. The biotech pigs were developed by inserting the “fat1” gene that comes from the roundworm *Caenorhabditis elegans*. The biotech pigs were cloned and 6 of the 10 clones produced increased levels of omega3 fatty acids, which are believed to ward off heart disease.
- 2006 The genetic test, Oncotype DXTM was developed by the biotech company Genomic Health and was already commercially available.
- 2005 Researchers at the University of Georgia successfully produce a cow cloned from the cells of a carcass.
- 2005 Scientists at Harvard University report success in converting skin cells into embryonic stem cells through fusion with existing embryonic stem cells.
- 2005 The Energy Policy Act was passed and signed into law, authorizing numerous incentives for bioethanol development.
- 2004 The FDA approves the first antiangiogenic drug for cancer, Avastin (bevacizumab).
- 2004 The FDA clears a DNA microarray test system, the AmpliChip Cytochrome P450 Genotyping Test, to aid in selecting medications for a wide variety of common conditions.
- 2003 Researchers find a vulnerability gene for depression and make strides in detecting genetic links to schizophrenia and bipolar disorder.
- 2003 The U.S. Environmental Protection Agency approves the first transgenic root wormresistant corn, which may save farmers \$1 billion annually in crop losses and pesticide use.
- 2003 Japanese researchers develop a biotech coffee bean that is naturally decaffeinated.
- 2003 China’s State Food and Drug Administration grants the world’s first regulatory approval of a gene therapy product, Genticine, developed by Shenzhen SiBiono GenTech. The product delivers the p53 gene as a therapy for squamous cell head and neck cancer.
- 2002 Researchers announce successful results for a vaccine against cervical cancer, the first demonstration of a preventative vaccine for a type of cancer.
- 2002 Japanese puffer fish genome was sequenced. The puffer fish sequence was the smallest known genome of any vertebrate.
- 2002 The draft version of the complete map of the human genome was published and the first part of the Human Genome Project comes to an end ahead of schedule and under budget.
- 2001 The sequence of the human genome was published in *Science* and *Nature*, making it possible for researchers all over the world to begin developing treatments.
- 2001 Researchers with China’s National Hybrid Rice Research Center report developing “super rice” that could produce double the yield of normal rice.
- 2000 Golden Rice, modified to make vitamin A, promises to help third world countries alleviate blindness.
- 2000 A rough draft of the human genome was completed by Celera Genomics and the Human Genome Project.
- 2000 Pigs are the next animal cloned by researchers, hopefully to help produce organs for human transplant.
- 2000 First biotech crop fieldtested in Kenya: virusresistant sweet potato.
- 1999 The complete genetic code of the human chromosome was first deciphered.
- 1998 University of Hawaii scientists clone three generations of mice from nuclei of adult ovarian cumulus cells.
- 1998 Human skin was produced *in vitro*.
- 1998 Embryonic stem cells are used to regenerate tissue and create disorders mimicking diseases.
- 1998 The first complete animal genome for *C. elegans* worm was sequenced.
- 1998 The Biotechnology Institute was founded by BIO as an independent national, 501(c)(3) education organization with an independent Board of Trustees.

- 1997 Scottish scientists report cloning a sheep, using DNA from adult sheep cells that is, Dolly born.
- 1997 A group of Oregon researchers claim to have cloned two *Rhesus* monkeys.
- 1997 A new DNA technique combines PCR, DNA chips, and a computer program, providing a new tool in the search for disease causing genes.
- 1996 Scottish scientists clone identical lambs from early embryonic sheep.
- 1996 Discovery of gene associated with Parkinson's disease provides an important new avenue of research into the cause and potential treatment of the debilitating neurological ailment.
- 1995 The first baboon to human bone marrow transplant was performed on an AIDS patient.
- 1995 The first full gene sequence of a living organism other than a virus was completed for the bacterium *Hemophilus influenzae*.
- 1995 The threedimensional structure of a catalytically active fragment of murine RT was elucidated.
- 1994 Genentech's Nutropin was approved for the treatment of growth hormone deficiency.
- 1994 The first breast cancer gene was discovered.
- 1994 Flavrsavr™ tomato the first genetically engineered whole food approved by the FDA was on the market.
- 1993 Chiron's Betaseron was approved as the first treatment for multiple sclerosis in 20 years.
- 1993 FDA approves bovine somatotropin (BST) for increased milk production in dairy cows.
- 1993 The FDA declares that genetically engineered foods are "not inherently dangerous" and do not require special regulation.
- 1993 The Biotechnology Industry Organization (BIO) was created by merging two smaller trade associations.
- 1992 The threedimensional structure of HIV reverse transcriptase was elucidated.
- 1992 American and British scientists unveil a technique for testing embryos *in vitro* for genetic abnormalities such as cystic fibrosis and hemophilia.
- 1991 Amgen develops Neupogen, the first of a new class of drugs called colony-stimulating factors, for the treatment of low white blood cells in chemotherapy patients.
- 1991 Immunex's Leukine, used to replenish white blood cell counts after bone marrow transplants was approved.
- 1991 Genzyme's Ceredase was approved for the treatment of Gaucher's disease.
- 1990 The first federally approved gene therapy treatment was performed successfully on a 4 year-old girl suffering from an immune disorder.
- 1990 Human Genome Project launched.
- 1990 ChyMax™, an artificially produced form of chymosin, an enzyme for cheese making was introduced. It was the first product of recombinant DNA technology in the U.S. food supply.
- 1990 First transgenic dairy cow used to produce human milk proteins for infant's formula was created.
- 1989 First approval for field test of modified cotton: insectprotected (Bt) cotton.
- 1989 Plant Genome Project begins.
- 1989 Amgen's Epogen is approved for the treatment of renal disease anemia.
- 1989 The gene responsible for cystic fibrosis is discovered.
- 1988 Congress funds the Human Genome Project, a massive effort to map and sequence the human genetic code as well as the genomes of other species.
- 1988 Harvard molecular geneticists are awarded the first U.S. patent for a genetically altered animal A transgenic mouse (first mammal patented in U.S.A.).
- 1988 Fluorescence *in situ* hybridization by Lawrence *et al.*
- 1988 A patent for a process to make bleachresistant protease enzymes to use in detergents was awarded.
- 1987 Humatrope was developed for treating human growth hormone deficiency.
- 1987 Advanced Genetic Sciences' Frostban, a genetically altered bacterium that inhibits frost formation on crop plants, was field tested on strawberry and potato plants in California, the first authorized outdoor tests of an engineered bacterium.
- 1987 Genentech's tissue plasminogen activator (tPA), sold as Activase, was approved as a treatment for heart attacks.
- 1987 Reverse transcription and PCR are combined to amplify mRNA sequences.
- 1987 Cloned murine RT was engineered to maintain polymerase and eliminate Rnase H activity.
- 1986 The first field tests of genetically engineered plants (tobacco) are conducted.
- 1986 Ortho Biotech's Orthoclone OKT3, used to fight kidney transplant rejection, was approved as the first monoclonal antibody treatment.
- 1986 The first biotechderived interferon drugs for the treatment of cancer, Biogen's Intron A and Genentech's Roferon A, are approved by the FDA. In 1988, the drugs are used to treat Kaposi's sarcoma, a complication of AIDS.
- 1986 The first genetically engineered human vaccine, Chiron's Recombivax HB, was approved for the prevention of hepatitis B.
- 1985 Fully active murine RT was cloned and over expressed in *E. coli*.
- 1985 NIH approves guidelines for performing experiments in gene therapy on human.
- 1985 Genetic markers found for kidney disease and cystic fibrosis.
- 1985 Transgenic plants resistant to insects, viruses and bacteria are field tested for the first time.
- 1984 The DNA fingerprinting technique was developed.
- 1984 Discovery of pulsed field gel electrophoresis by Schwartz and Cantor.
- 1984 The entire genome of the human immunodeficiency virus was cloned and sequenced.

- 1984 The first genetically engineered vaccine was developed.
- 1984 Chiron clones and sequences the entire genome of the HIV virus.
- 1983 The Polymerase Chain Reaction (PCR) technique was conceived. PCR, which uses heat and enzymes to make unlimited copies of genes and gene fragments, later becomes a major tool in biotech research and product development worldwide.
- 1983 The first genetic transformation of plant cells by TI plasmids was performed.
- 1983 The first artificial chromosome was synthesized.
- 1983 The first genetic markers for specific inherited diseases were found.
- 1983 Efficient methods were developed to synthesize doublestranded DNA from firststrand cDNA involving minimal loss of sequence information.
- 1982 Humulin, Genentech's human insulin drug produced by genetically engineered bacteria for the treatment of diabetes, was the first biotech drug to be approved by the Food and Drug Administration.
- 1982 Applied Biosystems, Inc. introduced the first commercial gas phase protein sequencer, dramatically reducing the amount of protein sample needed for sequencing.
- 1982 Establishment of Gene Bank.
- 1982 First recombinant DNA vaccine for livestock developed.
- 1982 First biotech drug approved by FDA: human insulin produced in genetically modified bacteria.
- 1981 Scientists at Ohio University produce the first transgenic animals by transferring genes from other animals into mice.
- 1981 Chinese scientist cloned a fish (A golden carp).
- 1981 The first genesynthesizing machines are developed.
- 1981 The first genetically engineered plant was reported.
- 1981 Mice were successfully cloned.
- 1980 US patent for gene cloning was awarded to Cohen and Boyer.
- 1978 North Carolina scientists Hutchinson and Edgell showed that it is possible to introduce specific mutations at specific sites in a DNA molecule.
- 1978 Recombinant insulin first produced using recombinant DNA technology.
- 1977 Genetically engineered bacteria were used to synthesize human growth protein.
- 1977 Methods for reading DNA sequence using electrophoresis are discovered.
- 1977 First expression of human gene in bacteria.
- 1976 The tools of recombinant DNA are first applied to a human inherited disorder.
- 1976 Molecular hybridization was used for the prenatal diagnosis of alpha thalassemia.
- 1976 Yeast genes are expressed in *E. coli* bacteria.
- 1976 First guidelines for recombinant DNA experiments released: National Institutes of Health Recombinant DNA Advisory Committee.
- 1975 First monoclonal antibodies produced.
- 1975 Discovery of Southern analysis by Southern.
- 1974 The National Institute of Health formed a Recombinant DNA Advisory Committee to oversee recombinant genetic research.
- 1973 Cohen and Boyer performed the first successful recombinant DNA experiment, using bacterial genes.
- 1972 DNA compositions of humans were discovered to be 99% similar to that of chimpanzees and gorillas.
- 1971 Reverse transcriptase was shown to have ribonuclease H (Rnase H) activity.
- 1971 First complete synthesis of a gene.
- 1970 Specific restriction nucleases were identified, opening the way for gene cloning.
- 1969 Enzyme synthesized *in vitro* for the first time.
- 1967 First automatic protein sequencer perfected.
- 1966 Genetic code was cracked, demonstrating that a sequence of three nucleotide bases (codon) determines each of 20 amino acids.
- 1965 Harris and Watkins successfully fused mouse and human cells.
- 1964 The existence of reverse transcriptase (RT) was predicted.
- 1963 New wheat varieties developed by Norman Borlaug increase yields by 70%.
- 1961 The genetic code understood for the first time.
- 1960 Messenger RNA discovered.
- 1960 Exploiting base pairing, hybrid DNARNA molecules are created.
- 1959 Discovery of interferons.
- 1958 Sickle cell anemia was shown to occur due to a change of a single amino acid.
- 1958 DNA was made in a test tube for the first time.
- 1957 Sickle cell anemia was shown to occur due to a change of a single amino acid.
- 1956 Kornberg discovered the enzyme DNA polymerase I leading to an understanding of how DNA is replicated.
- 1955 Enzyme involved in the synthesis of nucleic acid was isolated for the first time.
- 1954 Cell culturing technique was developed.
- 1953 Watson and Crick revealed the threedimensional structure of DNA.
- 1951 McClintock discovers transposable elements or "jumping genes" in corn.
- 1951 Artificial insemination of livestock using frozen semen was accomplished.
- 1949 Pauling shows that sickle cell anemia was a "molecular disease" resulting from a mutation.
- 1946 Discovery that genetic material from different viruses can be combined to form a new type of virus, an example of genetic recombination.
- 1944 Waksman isolates streptomycin as an effective antibiotic for tuberculosis
- 1944 DNA was shown to be the material substance of the gene.

- 1943 Discovery of streptomycin by Selman Waksman.
- 1943 Avery demonstrated that DNA is the “transforming factor” and is the material of genes.
- 1942 The electron microscope was used to identify and characterize a bacteriophage virus that infects bacteria.
- 1941 The term genetic engineering was first used by a Danish microbiologist.
- 1938 The term Molecular Biology was coined.
- 1930 The U.S. Congress passed the Plant Patent Act, enabling the products of plant breeding to be patented.
- 1928 Fleming discovers penicillin, the first antibiotic.
- 1927 Muller discovers that X-rays cause mutation.
- 1920 Human growth hormone was discovered by Evans and Long.
- 1919 The word Biotechnology was first used by Hungarian agriculture engineer.
- 1916 Development of fermentation process for acetone and nbutanol by Chain Weizmann.
- 1915 Phages, or bacterial viruses, are discovered.
- 1914 Bacteria are used to treat sewage for the first time in Manchester, England.
- 1911 The first cancer-causing virus was discovered by Rous.
- 1909 Genes are linked with hereditary disorders.
- 1907 The first *in vivo* culture of animal cells was reported.
- 1906 The term Genetics was first introduced.
- 1902 The term Immunology first appeared.
- 1900 Drosophila (fruit flies) were used in early studies of genes.
- 1888 The chromosome was discovered by Waldyer.
- 1883 The first rabies vaccine was developed.
- 1883 Francis Galton, a cousin of Charles Darwin, coined the term eugenics.
- 1879 Fleming discovered chromatin.
- 1878 First centrifuge developed by Laval.
- 1877 A technique for staining and identifying bacteria was developed by Koch.
- 1869 Discovered DNA in sperm of trout.
- 1863 Mendel, in his study of peas, discovers that traits were transmitted from parents to progeny by discrete, independent units, later called genes. His observations lay the groundwork for the field of genetics.
- 1855 *E. coli* bacteria discovered.
- 1856 Separation of brewer’s yeast from lactic acid bacteria by Louis Pasteur.
- 1833 The cell nucleus was discovered as well as first enzymes were isolated.
- 1830 Proteins were discovered.
- 1824 Dutrochet discovers that tissue is composed of living cells.
- 1802 The word biology first appeared.
- 1797 Jenner inoculated a child with viral vaccine to protect him from smallpox.
- 1675 Leeuwenhoek discovered protozoa and bacteria.
- 1663 Cells were described first by Hooke.
- 1650 Preparation of vinegar from ethanol.
- 1590 Janssen invents the microscope.
- 1322 Arab chieftain first uses artificial insemination to produce superior horses.
- 100 A. D. Powdered *Chrysanthemum* was used in China as an insecticide.
- 250 B.C. The Greeks practice crop rotation to maximize soil fertility.
- 500 B.C. The Chinese use moldy soybean curds as an antibiotic to treat boils.
- 40002000 B.C. Biotechnology first used to leaven bread and ferment beer, using yeast (Egypt) and production of cheese and fermentation of wine (Sumeria, China and Egypt).
- 8000 B.C. Potatoes were first cultivated for food.^[2,6]

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