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Animal biotechnology – past, present and future

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The evolution of biotechnology

According to Verma et al., Biotechnology is the use of engineering and biological science concepts to develop new goods from biologically derived basic materials, such as vaccines or food.[1] To put it another way, it's the utilization of living organisms or their products to alter or improve human health and the environment. If scientists want to understand how biotechnology works, they must first understand what the technology's starting point is: it's either a living material or a biological product that's utilized to create new items for pharmaceutical, medicinal, agricultural, and environmental purposes, intending to benefit humanity. Biotechnology may therefore be divided into three stages: ancient biotechnology, classical biotechnology, and modern biotechnology.[1]

Before 1800, most biotech developments might be regarded as discoveries.[2] Many instances exist but are not limited to the cheese we eat every day, which was manufactured by adding rennet to sour milk, which might be considered one of the first biotechnology by-products. Another old fermentation result is wine, which goes back to 3,500 BCE. Mules, which are the offspring of a male donkey and a female horse, were once used for transportation, carrying weights, and farming. Adding to this, vinegar was first made in France towards the end of the fourteenth century.[2]

According to Wolpert's study, Robert Brown discovered in 1831 the nucleus which is a huge membrane-bound organelle that contains genetic information in the form of numerous linear DNA molecules grouped into chromosomal configurations in cells. He is most known for his descriptions of cell nuclei and Brownian motion, which is the continuous motion of minute particles in a solution. In addition to that, Edward Jenner and Louis Pasteur created smallpox and rabies vaccinations.[3] Moreover, Barranco revealed that the live vaccinia virus in the smallpox vaccine is derived from vaccinia, a pox-like virus associated to smallpox.[4] According to Scheuerlein et al., Heinrich Wilhelm Gottfried Von Waldeyer-Hartz, a German scientist, created the name chromosome in 1888. He then split the word chromosome into two parts: chromo, which means color, and soma, which means the body. In the late 1800s, the scientist gave chromosomes their name because they easily accept dye and take on patterns of light and dark when exposed to different strains that help identify the different chromosomes.[5]

In consonance with Smith's paper, two major occurrences have come to be regarded as scientific watershed moments in the age that brought genetics and biotechnology together: The first one was Watson and Crick's discovery of the structure of DNA in 1953, and the second was Cohen and Boyer's discovery of a recombinant DNA technique in 1973, in which a segment of DNA was cut from an E. coli bacterium's plasmid and put into the DNA of another.[6] Furthermore, pray highlighted Watson and Crick's discovery of the double helix of DNA, which gave rise to contemporary molecular biology. In a nutshell, her finding revealed previously unknown details about the genetic code and the protein production. Later, this advancement aided in the development of recombinant DNA research, quick gene sequencing, and monoclonal antibodies, which are the foundations of today's multibillion-dollar biotechnology business.[7] Moving on, tan et al. discussed the first polio vaccine which was produced in 1955 by Dr. Jonas Salk.[8] Polio, which is a disease that has afflicted humans for as long as records have been kept, targets the nervous system, and can result in varying degrees of paralysis. Afterwards, in the early 1970s, several other breakthroughs were made, including the discovery of restriction enzymes; the use of DNA ligase to join Okazaki fragments; Cohen and Boyer's first successful recombinant DNA experiment; the development of hybridization and the use of southern blotting for diseases' diagnosis. Additionally, recombinant human insulin was created for the first time in the late 1970s.[9]

The Human Genome Initiative, the international scientific project that sequenced all the genes present in humans, was one of the major projects on which scientists collaborated in the early 21st century.[10] Hood et al. showed the project's importance, strength, and effectiveness of large-scale, integrated, cross-disciplinary initiatives aimed at complicated key goals. Many of the HGP's aims include sequencing the human genome, but it also included developing sequencing technology. Investigators also intended to find sequence variation to start creating the technology for functional genomics, which is the study of how genotype and phenotype are linked. They sought to sequence other genomes and undertake comparative genomics, as well as create computational biology and bioinformatics tools like blast and training procedures, to build up national manpower in fundamental biotechnology.

Animal biotechnology - a growing field

The Animal Biotechnology section is a subset of biotechnology in which molecular biology techniques are used to alter the genome of animals to increase their fitness for agricultural, industrial, or therapeutic purposes.[11] Livestock, poultry, fish, insects, companion animals, and laboratory animals are all included in animal biotechnology. Creating animals with one or more genes introduced by human intervention, employing gene knock out technology to create animals with a specific inactivated gene, and making virtually identical animals using somatic cell nuclear transfer or cloning are all examples of animal biotechnology.[12] This segment as it is done today is mostly based on genetic engineering, while other genetic engineering approaches, such as transgenics and cloning, are also used in this segment.[13]

The full genetic composition of an animal is defined and characterized through genomics. Animal genomics is a sub-discipline of the Animal Biotechnology industry.[13] Scientists can better understand the foundation for illness resistance, disease susceptibility, weight growth, and nutritional value factors by studying animal genomes. Another area of Animal Biotechnology is Animals Cloning. Researchers employ reproductive procedures to create many copies of mammals that are virtually exact clones of other animals, such as transgenic animals, genetically superior animals, and animals that generate large amounts of a desired feature. Transgenic animals, or those whose genomes have been transformed by the transfer of a gene or genes from another species or breed, are another segment of Animal Biotechnology. Transgenic animals are created to allow researchers to investigate how genes are controlled, how they impact the body's normal functioning and development, and how genes contribute to the development of illnesses, among other things.[13]

The animal biotechnology industry is one of the fastest-growing businesses, with chances to be had through 2028.[14] The research evaluates developing market trends, market size outlook, potential opportunities, market share by Animal Biotechnology kinds, and applications.[14] Furthermore, the report evaluates the top players participating in the worldwide Animal Biotechnology industry and forecasts market size by nation.[14] The Animal Health Biotechnology business is expected to earn $11.1 billion in sales in 2021, with a 2% increase in market size.[15] From 2020 to 2025, the worldwide animal biotechnology market is estimated to increase at a CAGR of 5% to 7%.[16] Increasing regulatory approvals and increased research and development activity connected to animal biotechnology are the main growth factors for this industry. Farmers were able to genetically improve animals, resulting in increased disease resistance and meat and dairy output to fulfill expanding demand for the global agribusiness economy, thanks to advances in biotechnology. Product Type (Diagnostic Tests, Reproductive & Genetic Products, Vaccines, and Drugs), Application (Animal Pharmaceutical Development, Food Safety and Drug Development, Other Applications), and Geography (North America, Europe, Asia-Pacific, Middle East and Africa, and South America) are all segments of the animal biotechnology market. Moving on, vaccine development is the fastest-growing application in the animal biotechnology business. Increasing incidences of animal illnesses, particularly infectious and zoonotic diseases, as well as increased pet adoption rates, have led to North America dominating the worldwide animal biotechnology industry. Due to an increase in animal illnesses and a huge livestock animal pool, Asia Pacific is expected to rise at a fast rate over the projection period. Growing public awareness of animal welfare and the implementation of government programs are also expected to boost the region's animal biotechnology sector. The animal biotechnology industry is relatively concentrated, with a few big competitors such as Bayer AG, Boehringer Ingelheim GmbH, Merck & Co., Zoetis Inc., Virbac, and others now leading the market. The chemical firm Bayer makes fungicides, herbicides, insecticides, and crop types. Boehringer Ingelheim, another pharmaceutical company, focuses on cardiovascular health, cancer, respiratory, metabolic, and immunological illnesses, as well as retinal health. Merck & Co. also manufactures a large range of well-known medications, vaccines, and animal health products, as well as providing novel health solutions.[16]

The future of animal biotechnology

Recent advances in molecular biology, immunology, and genetic engineering have expanded the scope of biotechnology study and use in farm animals. Meat and milk from farmed animals, such as cattle and poultry, are good sources of high-quality protein and necessary amino acids, as well as minerals, lipids, and fatty acids, easily absorbed vitamins, tiny amounts of carbs, and other bioactive components.[17] Biotechnology is being used in the livestock business to speed up breed development for better animal health and welfare, increased reproduction, and improved nutritional quality and safety of animal-derived commodities. Animal breeding stock is thus improved through a variety of biotechnological technologies including artificial insemination, in-vitro fertilization, and somatic cell nuclear transfer.[17]

First and foremost, artificial insemination is a fertility procedure that involves injecting sperm directly into the cervix or uterus in the hopes of conceiving. These sperm are sometimes prepared to boost the chances of a woman becoming pregnant.[18] This method first lowers many of the hazards associated with mating; males, especially in cattle, can be violent at times.. As a result, it eliminates the hazards associated with having a guy on the premises. Second, it boosts productivity. Because most males generate enough sperm, it could be delivered to various livestock farmers across the United States to artificially inseminate their herds. Consequently, many farmers will be able to avoid having to retain a male on the farm or maybe having to take their breeding animals to a male.

Next, in vitro fertilization is a complicated set of techniques intended to improve fertility, prevent genetic abnormalities, and aid in child conception. In IVF, mature eggs are extracted from the ovaries and fertilized in a laboratory using sperm. Not only is this procedure effective for obtaining children of endangered species, sterile animals, or animals with low reproductive performance, but it may also be used to examine fertilization mechanisms Embryo and sperm freezing methods are also critical for the care of a variety of experimental animals.[18] In the case of laboratory animals, mice are the most used species for IVF. The embryo transfer technique follows, which is the final step in the in vitro fertilization process.

Finally comes the somatic cell nuclear transfer procedure which involves transplanting the nucleus of a somatic cell into an enucleated, unfertilized egg. This will cause the genetic material in the nucleus to be completely reprogrammed, allowing the egg to begin dividing and becoming an embryo. Somatic cloning can be utilized to produce numerous copies of genetically elite agriculture animals, transgenic animals for pharmaceutical protein manufacturing, and endangered species preservation. Cloning has become an important method for investigating gene function, genomic imprinting and reprogramming, development control, genetic disorders, and gene therapy, among other areas.[19]

In animal biotechnology, the use of DNA markers to describe an animal's genetic composition and forecast its performance is a valuable tool. Marker-assisted selection is a method for selecting a genetic determinant of a characteristic of interest indirectly.[20] Many qualities are controlled by several genetic loci, each of which contributes to the trait's variance and is referred to as a quantitative trait locus.[20] Important quantitative characteristic loci, for example, might be detected in the embryo, giving the producer the choice of transferring or discarding the embryo. Only those genetic markers that are directly related to the genes or are closely associated with the objective qualities can give adequate assurance for practical breeding success.[20] Another approach is recombinant DNA technology, in which a recombined DNA molecule known as rDNA is put into a host organism to develop novel genetic combinations that are beneficial to animals. It allows to produce multiple copies of genes and the insertion of foreign genes into other species to confer new features such as antibiotic resistance, as well as the manufacture of animal vaccinations; hence, DNA vaccines can elicit robust long-term cellular immune responses.[21]

Conclusions

Advances in biotechnology have evolved at such a fast rate in the previous decade that even specialists have been taken aback. Aside from that, breakthroughs in farm animal genome sequencing, molecular marker technology advancements, and other biotechnology applications will provide new possibilities for research to improve and modernize the livestock industry. In the future, animal genetic composition will be available, allowing for the prediction of an animal's production capacity before birth, or even as a fetus, as well as the selection of animals best suited to a certain production setting. For animals to live, it is critical that the necessary knowledge is handed down through the generations. If a population's genetic information has enough diversity, it is more likely to adjust successfully to environmental changes.

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Conflicts of interest

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