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*REVIEW ARTICLE*

# A REVIEW ON RECENT ADVANCES IN ANIMAL BIOTECHNOLOGY

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**ABSTRACT**

Animal biotechnology represents a cutting-edge field that has revolutionized our interactions with the animal kingdom. Recent advancements encompass various domains, including genetic editing techniques like CRISPR-Cas9, which allow precise genetic modifications for improved animal health and product quality. Cloning and reproductive technologies offer opportunities to preserve rare genetic traits and enhance livestock production, albeit accompanied by ethical and genetic diversity challenges. Transgenic animals, engineered with foreign genes, serve purposes from increased productivity to disease modeling, raising ethical and regulatory concerns. Disease resistance strategies involve selective breeding and gene editing to bolster animals' immunity, promoting sustainable farming practices. Biopharming utilizes genetically modified animals for large-scale pharmaceutical production, balancing potential benefits with containment and safety issues. Conservation efforts employ advanced genetic and reproductive techniques to protect endangered species, necessitating careful ethical and ecological considerations. Animal biotechnology promises transformative possibilities but underscores the importance of responsible progress and ethical frameworks.

**KEYWORDS**

Animal biotechnology, advancements, gene editing, transgenic

## 1. Introduction

In recent years, the field of animal biotechnology has witnessed remarkable and transformative advancements, reshaping our interactions with the animal kingdom across diverse domains. These breakthroughs have the potential to revolutionize agriculture, medicine, and scientific research. Central to these developments are cutting-edge techniques such as CRISPR-Cas9, which allows precise genetic modifications to enhance animal health and product quality (Doudna and Charpentier, 2014). Furthermore, cloning and reproductive technologies have opened doors to the conservation of rare genetic traits and the improvement of livestock production practices (keefer et al., 2015). Transgenic animals, engineered with foreign genes, serve a multitude of purposes, from increased productivity to disease modeling (Gordon et al., 1980). However, the ethical and regulatory aspects surrounding these engineered organisms raise complex questions (Wolff et al., 2020). Disease resistance strategies, employing selective breeding and gene editing techniques, are paving the way for more sustainable farming practices (Lillico et al.,2003) . Additionally, biopharming, utilizing genetically modified animals for large-scale pharmaceutical production, has the potential to revolutionize the pharmaceutical industry (Gomis et al., 2017). Conservation efforts have also been significantly bolstered by advanced genetic and reproductive techniques aimed at protecting endangered species (Comizzoli et al,., 2010). Yet, these endeavors necessitate meticulous ethical and ecological considerations to ensure responsible progress in the field.

This review aims to explore these recent advances in animal biotechnology, shedding light on their potential benefits, ethical implications, and regulatory challenges. As we delve into these transformative possibilities, we must also emphasize the importance of establishing robust ethical frameworks to guide responsible innovation in this rapidly evolving field.

## 2. Methodology

The methodology for this review on recent advances in animal biotechnology involved an exhaustive and systematic search of peer-reviewed literature using electronic databases such as PubMed, Scopus, and Web of Science. Search terms and keywords, including "animal biotechnology," "genetic engineering," "gene editing," "cloning," and "transgenic animals," were employed to identify relevant articles published between January 2010 and September 2023. Inclusion criteria were set to encompass research articles, reviews, and meta-analyses discussing innovative techniques, applications, and ethical considerations in animal biotechnology. Following the identification of eligible articles, data extraction and synthesis were conducted to summarize key findings and trends in the field. Quality assessment, when applicable, was performed using established evaluation tools. This comprehensive methodology facilitated the compilation of a thorough and up-to-date analysis of recent advancements in animal biotechnology, providing valuable insights into its current state and future prospects.

## 3. Recent Advances in Animal Biotechnology

### 3.1 Genetic Editing Techniques

Recent breakthroughs in genetic editing techniques, particularly the development of CRISPR-Cas9(Clustered Regularly Interspaced Short Palindromic Repeats - CRISPR-associated protein 9.) technology, have revolutionized the field of animal biotechnology. Researchers can now precisely modify genes within animals to introduce desirable traits or

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remove genetic disorders. This advancement holds immense potential for improving animal health, increasing resistance to diseases, and enhancing product quality. Example: Hornless cattle, cattle naturally have horns, which can pose safety risks to animals and handlers. Researchers used CRISPR-Cas9 to edit the DNA of cattle embryos, disrupting the gene responsible for horn growth. The resulting cattle were born without horns, eliminating the need for painful horn removal procedures. These techniques have immense potential in agriculture, medicine, and beyond, offering precise genetic modifications to enhance desired traits and mitigating genetic disorders (Mali et al., 2013; Doudna and Charpentier, 2014).

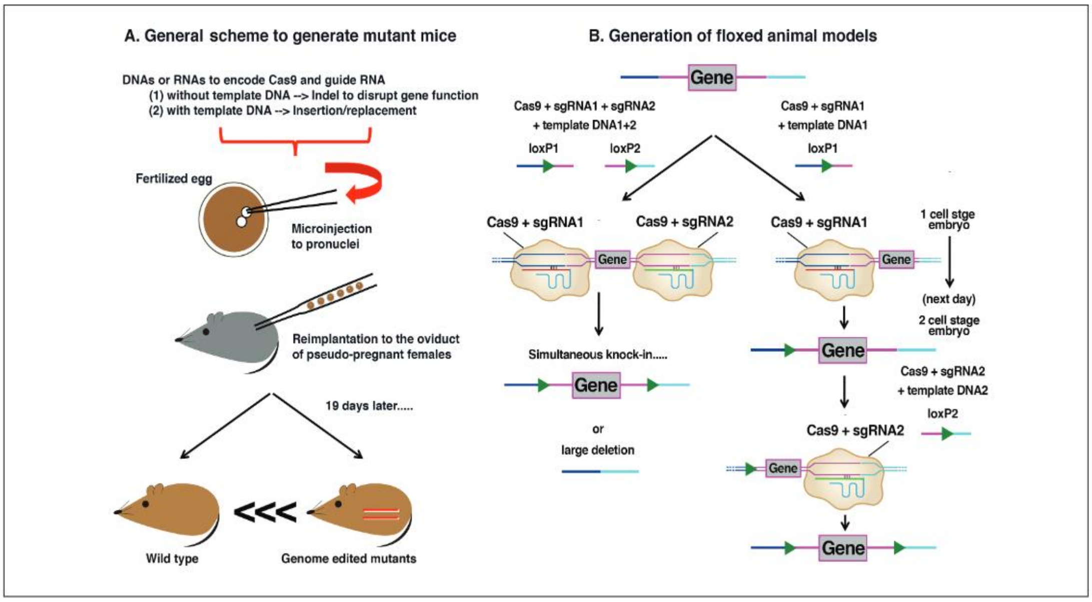


**Figure 1:** Applications of CRISPR/Cas9 to generate mutant animals. (A) General scheme to generate mutant mouse models. DNAs or RNAs encoding Cas9 and single-guide RNA (sgRNA) with or without template DNA are microinjected into the pronuclei of the fertilized egg. These modified zygotes are reimplanted to the oviduct of pseudo-pregnant surrogate mice. After 19 gestational days, mutant mice offspring are born. (B) Generation of floxed animal models. The left arm represents the simultaneous method. This method involves coinjecting nucleotides encoding Cas9, 2 sgRNAs, and 2 individual loxP template DNAs to zygote. It simultaneously knocks in 2 loxP alleles to flank the target exon gene. However, large deletions can occur as a result. The right arm represents the sequential method. This method involves coinjecting Cas9, first sgRNA, and first loxP template DNA at 1-cell stage embryo to knock in the first loxP allele. On the next day, the second group of Cas9, second sgRNA, and second loxP template DNA are injected into 2-cell stage embryos, leading to knock-in of the second loxP allele. (Source: Ning et al., 2018)

### 3.2 Cloning and Reproductive Technologies

Cloning and Reproductive Technologies in animal biotechnologies encompass a range of innovative methods aimed at manipulating animal reproduction. Cloning involves creating genetically identical organisms through somatic cell nuclear transfer, where the nucleus of a somatic cell is placed into an egg cell, resulting in a clone with identical DNA. Reproductive technologies like in vitro fertilization (IVF) enable controlled fertilization outside the body, while artificial insemination aids controlled mating. These techniques hold potential for preserving rare and valuable genetic traits, enhancing livestock production efficiency, and advancing research, but ethical concerns, technical challenges, and genetic diversity issues remain subject to ongoing debate and refinement (Wilmut et al., 1997).

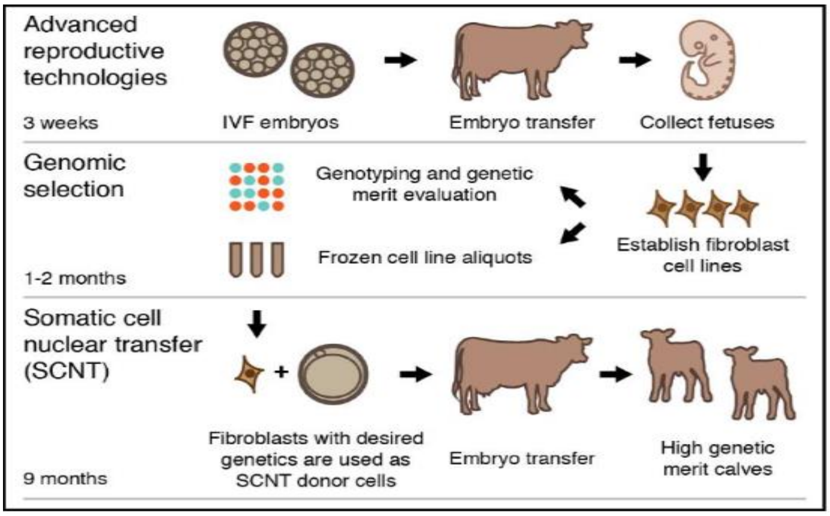


**Figure 2:** Production of high genetic merit calves using a range of biotechnologies. Image taken from (Kasinathan et al., 2015)

### 3.3 Transgenic Animals

Transgenic animals play a pivotal role in animal biotechnology by harboring genes from other species, thus endowing them with specific desired traits. This process involves the insertion of foreign genes into an animal's genome, often utilizing techniques like microinjection or gene editing tools like CRISPR-Cas9. These modified animals can be engineered for various purposes such as enhanced agricultural productivity, pharmaceutical production through bioengineered livestock, and serving as disease models to study human ailments. Despite their potential benefits, transgenic animals also raise ethical and regulatory concerns related to animal welfare, environmental impact, and potential unintended consequences. Therefore, their creation and utilization necessitate careful consideration of both scientific advancements and ethical considerations. For instance, transgenic cows producing human antibodies in their milk have been developed, showing potential for treating various diseases (Gordon and Ruddle, 1981; Houdebine, 2000).

**Table 1:** Example of transgenic animals for agricultural application. Adopted from Lievens et al. 2015.

| ***species*** | ***transgene*** | ***origin*** | ***Effect/goal*** |
|---|---|---|---|
| Cattle | Lysosome | Human | Milk composition |
| | PrP | Knockout | Animal health |
| | α−,κ-Casein | Bovine | Milk composition |
| | Omega-3 | Nematode | Milk composition |
| | Lysostaphin | Bacterial | Mastitis resistance |
| Goat | Lysozyme | Human-Bovine | Animal health |
| | Monosaturated fatty acid | Rat-Bovine | Mastitis resistance |
| | Lactoferrin | Human | Prophylactic treatment |
| | Human beta-defensin 3 | Human | Milk composition |
| Pig | Phytase | *E. coli*-Mouse | Feed uptake |
| | Growth hormone | Human-porcine | Growth rate |
| | cSKI | Chicken | Muscle development |
| | Unsat. fat. acid | Spinach | Meat composition |
| | Mx1 | Murine | Influenza resistance |
| Sheep | IGF-1 | Ovine | Wool growth |
| | CsK | Bacterial | Wool growth |
| | Visna resistance | Viral | Disease resistance |
| Chicken | alv6 envelope glycoprotein | Viral | Disease resistance |
| | Short hairpin RNA | Viral | Disease resistance |
| | LacZ | Bacterial | Animal Health |
| Carp | Growth hormone | Piscine | Growth rate |
| | Lactorferrin | Human | Disease resistance |
| Salmon | Lysozyme | Piscine | Animal health |
| | wflAFP-6 | Piscine | Cold tolerance |
| Silkworm | eGFP, DsRed, or mKO | Cnidarian | Silk color |
| | A2S814 | Arachnid | Silk strength |
| Trout | Follistatin | Piscine | Muscle development |
| Catfish | Ceropin B | Insect | Disease resistance |

### 3.4 Disease Resistance and Management

Disease resistance and management are pivotal aspects of animal biotechnology, encompassing strategies to enhance animals' ability to combat diseases while minimizing their impact. These approaches involve selective breeding to identify and propagate genetic traits that confer resistance to specific diseases, thereby creating more resilient livestock populations. Additionally, advanced techniques like gene editing enable the direct modification of animals' genetic makeup to bolster their immune responses and resist diseases. Furthermore, the implementation of biosecurity measures, vaccination protocols, and monitoring systems play a crucial role in preventing disease outbreaks and managing their spread within animal populations. The synergy of these techniques within animal biotechnology offers promising avenues to address disease challenges and promote sustainable and healthier animal farming practices (Whyte and Prather, 2011).

### 3.5 Biopharming

Biopharming, a pivotal aspect of animal biotechnology, involves the use of genetically modified animals to produce valuable pharmaceuticals and proteins. Scientists can harness their natural ability to synthesize complex molecules like antibodies, hormones, and enzymes by introducing specific genes into animals, usually livestock. This approach offers several advantages, including cost-effective large-scale production, reduced dependency on traditional manufacturing methods, and the potential to create therapeutic proteins for treating various human diseases. However, biopharming also raises ethical and regulatory concerns due to the need for stringent containment to prevent unintended environmental release and potential impacts on food safety. Despite these challenges, biopharming holds promise as a transformative field that bridges biotechnology and medicine, offering innovative solutions for producing vital medical compounds (Ebert et al., 2019).

### 3.6 Biopharmaceutical Products

Biopharmaceutical production is the process of using genetically modified organisms, such as transgenic animals or microbial systems, to produce valuable therapeutic proteins, monoclonal antibodies, and vaccines for human and veterinary medicine. This approach offers a scalable and cost-effective means of manufacturing complex biologics. For example, transgenic animals, like goats and chickens, have been engineered to produce high-value biopharmaceuticals such as recombinant proteins in their milk or eggs, offering a reliable source for the production of essential medical products (Van Eenennaam and Young, 2014). This method not only reduces production costs but also ensures a consistent supply of biopharmaceuticals, contributing to advancements in healthcare.

### 3.7 Conservation Efforts

Conservation efforts in animal biotechnologies involve the application of advanced genetic and reproductive techniques to safeguard endangered species and preserve biodiversity. These technologies include artificial insemination, in vitro fertilization, cryopreservation of gametes and embryos, and cloning. By utilizing these methods, scientists can manage genetic diversity, assist in breeding programs, and prevent the extinction of endangered species. However, ethical considerations, potential risks to ecosystems, and the need for comprehensive monitoring and research highlight the complex nature of integrating biotechnologies into conservation strategies (Raddatz and Deem, 2019).

### 3.8 Environmental Sustainabilitys

Genetic engineering can be used to reduce the environmental footprint of animal agriculture, such as through the development of low-emission livestock and animals that require less feed to produce meat or dairy products (Capper, 2011).

## 4. Conclusion

Based on the study recent advances in animal biotechnology have paved the way for significant improvements in livestock productivity, disease management, and biomedical research. While offering tremendous potential benefits, these advancements also come with ethical and regulatory challenges that need to be carefully addressed. As the field continues to evolve, it is essential to strike a balance between innovation and responsible use to harness the full potential of animal biotechnology for the betterment of society.

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