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Anchal Singh

# Animal Biotechnology

Models in Discovery and Translation



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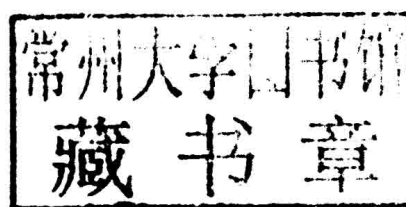
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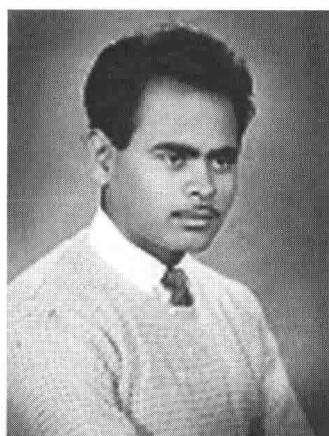
# **Animal Biotechnology**

Models in Discovery and Translation

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**This book is dedicated in fond memories of  
Dr. Har Swarup Verma**



**(1941–1995)  
Loving Father,  
Admirable Professor,  
&  
Compassionate Physician.  
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Animal biotechnology is one of the eight disciplines – along with environmental, food, plant, aquaculture, industrial, molecular, and medical studies – of biotechnology. This volume, drawn together by Professor Ashish Verma and Dr. Anchal Singh, is a comprehensive overview of animal biotechnology from a diverse set of perspectives. The volume is comprised of 32 chapters divided into three main sections: (1) *in vivo* and *in vitro* models of human disease, (2) tools and techniques, and (3) applications and concerns.

The term animal biotechnology is broadly applied when the production or the processing of products derived from animals or aquatic species is subjected to a particular set of scientific and engineering principles in order to enhance accessibility and services. Some classic examples are the development of transgenic animals or aquatic species, the use of cloning techniques to generate nearly identical animals, and various gene knockout strategies. Transgenic animals, including cattle, pigs, and poultry, have been developed to enhance the production of human pharmaceuticals and proteins such as enzymes, antibodies, clotting factors, and albumin. Somatic cell nuclear transfer has been used to clone several important mammalian species, including sheep, pigs, goats, cattle, rats, and mice. Because success rates for implanted embryos are often quite low, this offers opportunities for research and development. It is critical that this stimulating and wide-ranging progress be assembled, assessed, and considered in a timely manner, for the development of future initiatives, and to provide appropriate and accessible background for agricultural and health regulators. This treatise does just that. From a societal perspective, there are two main questions: (1) How is animal biotechnology addressing the needs of human agriculture and health? (2) Are products from the technology safe for human consumption and not detrimental to the environment? This volume does not shy away from those tough discussions, and anchors the responses in science.

Section I of the volume offers 10 chapters on *in vivo* and *in vitro* model systems that have been developed for animal biotechnology research. It includes discussions on the applications of *Drosophila*, and the use of animal models for tuberculosis, human neurodegenerative diseases, and aging, as well as work on cancer, HIV and other anti-retrovirals, HPV diagnosis, and DNA tumor viruses.

Section II assembles 11 chapters on the basic tools and techniques that are being used in contemporary animal biotechnology. These include the use of multicellular spheroids in cancer research, animal tissue culture and tissue engineering, and the applications of nanotechnology, antibodies, and molecular markers. The techniques and uses of gene expression and ribotyping are discussed, and the future of sequencing strategies presented. Finally, the importance of biomolecular displays and *in silico* modeling of networks and complex diseases in contemporary research are delineated.

Section III, which also consists of 11 chapters, focuses on applications and societal concerns. It provides summaries of the development and applications of transgenic animals, the saga of stem cells in medical research and therapy, the role of cytogenetics in medicine, and the applications of antibodies and vaccines. The importance of safety assessment of crop-derived foods is presented, together with the use of nanotechnology for the detection of pathogens, the development of marine animal biotechnology, and discussions on how the phytochemistry and pharmacology of herbal medicine biotechnology are linked to animal health. Finally, there are two chapters that provide an overview of the human genome and its relationship to animal biotechnology, and a consideration of the ethical issues that are fundamental to many aspects for the future evolution of animal biotechnology.

This volume makes clear both the vibrant diversity of the field of animal biotechnology, and the ethical and societal concerns that must be addressed. It is therefore an important volume for a wide audience, including researchers, veterinarians, physicians, agricultural and developmental economists, and policy regulators. The next few years are likely to see major breakthroughs in this field, which will be necessary to meet the nutritional and health care needs of a burgeoning global society.

**Geoffrey A. Cordell, Ph.D.**

Professor Emeritus, University of Illinois at Chicago  
Adjunct Professor, University of Florida  
President, Natural Products Inc.



Lately, “biotechnology” has become a buzz-word in both the academic arena and in day-to-day life. It is still debatable as to when and where the term originated. Who is its originator? Was biotechnology always known to the world in its present form? The answers to these questions are not known. The scientific literature tells us that Karl Erkey, a Hungarian Engineer, coined the term biotechnology in 1919. The next question is, did nature sire biotechnology or is it human beings that have created it in its present form? Again, it is difficult to come to any conclusion about the current state of knowledge. Let us go back and review the evolution of life from the most primitive form of organisms (i.e. viruses) to the most evolved form of life (i.e. human beings).

Certainly, one of the most important and advanced aspects of biotechnology and biotechnological tools is the manipulation of the genome of an organism. These manipulations can have either good or bad implications, but the answer lies in the final outcome. The most primitive form of life (i.e. viruses: bacteriophages) infects bacteria and replicates in bacterial hosts due to the integration of the viral genome into the bacterial genome. Is it Nature’s biotechnological experiment to integrate genomes of two entirely different organisms? It is probably a natural need of life to compete and evolve with selection of better traits to survive against adversaries. It can be easily concluded that the present state of biotechnology has evolved due to the in-depth understanding of some of these natural processes and biological phenomenon.

There is no doubt that the life sciences have seen tremendous improvements by virtue of keen observations and discoveries made by numerous great scientists. Antibiotics and vaccinations are two of the most pronounced examples. During previous years, knowledge gained through various branches of science, namely biochemistry, molecular biology, virology, and recombinant DNA technology, etc., has tempted scientists to imitate Nature’s experiments in laboratories. For successful and useful manipulations, there are three essential requirements: (1) to understand the mechanism of the biological process, (2) to replicate the same process exactly in an experimental model, and (3) to have a logical hypothesis. If these manipulations are successful, we may be able to find solutions to many prevailing and unresolved problems, namely famine, malnutrition, infectious

diseases, new and emerging infections, genetic disorders, aging, debilitating diseases, etc. No doubt advancements in biotechnology, with reference to the animal sciences, have already provided solutions for some of these issues. Some issues are even partially resolved, while others are still in experimental stages.

The explosion in the knowledge of biotechnology is attributed to two important discoveries: (1) the structure of DNA, and (2) the Polymerase Chain Reaction (PCR). Advancements and applications of biotechnology have become so fascinating that it is almost difficult to confine it to the domain of scientists and high-end laboratories. This information has to be passed to the general public in order to increase awareness and to reap the benefits of these discoveries. With the explosion of biotechnology, numerous large and small companies dealing with the production and commercialization of biotechnology products have come into existence. To survive and thrive in the biotech market, companies are in a perdurable search for trained manpower.

That’s how biotechnology as an educational course found its niche in the university curricula. The demand for trained biotechnologists led to the development of undergraduate and postgraduate courses in biotechnology at various universities and academic institutions. Realizing the needs of industry, some institutions developed management courses pertaining to biotechnology. In the last couple of decades it was realized that biotechnology education had to be imparted even to younger students, and that is the reason biotechnology was also included in the curricula of 10th and 12th Standard. Biotechnology itself is an amalgamation of various disciplines in the life sciences. Some of these disciplines are well evolved and have numerous good books to cater to the needs of audiences: biochemistry, molecular biology, genetics, microbiology, etc. However, animal biotechnology as a subject is still in its infancy, and has yet to develop and evolve as a full discipline in academic departments at universities. As such, it is difficult to find books in animal biotechnology that can fulfill the need of biotechnology students.

We teach animal biotechnology to undergraduate and postgraduate students. We have had a tough time teaching this course because of major limitations like an ever-evolving curricula and unavailability of reasonable textbooks on the subject. The only available resources are



research publications and books semi-related to research topics. On the one hand it's hard for students to find a place to start when learning the subject, and on the other hand instructors have a difficult time locating and organizing materials and resources for the classroom. The ultimate resource for instructors and students is the World Wide Web (WWW). In our teaching experience, we come across curious students who ask numerous intelligent questions almost every day. Their quest for information and knowledge remains insatiable due to the limitation of consolidated sources of information. Not only this, but we routinely face questions from students about where they can get more information on a specific subject or topic, and to their utter disappointment, it's hard for us to pinpoint one book or a good resource to answer all their questions. We frequently discuss the issue of the lack of applicable literature, almost every day over coffee with our colleagues. Discussing various options and trying to narrow down our search to fill this void of content in the area of animal biotechnology was not getting us anywhere.

After numerous deliberations, it was Dr. Anchal Singh who came up with the idea to explore the possibility of developing a book on animal biotechnology to partially (if not completely) fill this void. Then we deliberated on our *modus operandi* to develop this book. Finally, we decided to develop a book by inviting chapters from experts in the field who have relevant research experience and an understanding of the intricacies of the subject. We had in mind a book that would help to alleviate most of the worries of both students and instructors. We discussed, argued, and disagreed until we came up with the thought that a resource book would be a reasonable format, as it could provide sufficient

information and literature for instructors to teach the subject, while providing students with ample information to gain better insight about the subject. Once we formulated these thoughts to develop a resource book, the ball started rolling, and we identified various experts and convinced them to contribute chapters.

Bringing this book to completion was a joint effort. We could not possibly assemble all subjects together in one book, therefore we tried to bring together some of the important topics that usually interest students and instructors of animal biotechnology. The subject matter of this book varies from the basics of animal biotechnology, to animal tissue culturing, to the production of antibodies against infectious agents like HIV. Included are chapters dealing with animal models of important diseases like cancer and tuberculosis, and also *in silico* models, to emphasize their importance in understanding disease pathogenesis. An attempt was made to include the latest tools and technology related to the subject, namely, ribotyping, epigenetics, cytogenetics, bimolecular display technologies, next generation sequencing, and many more such topics not listed here.

This is our maiden effort to produce a book to help students and instructors of animal biotechnology. We hope that we will get support from the readers of this book. We are always open to criticism, suggestions, and recommendations that can help to improve the content and presentation of the book. Your suggestions and criticisms will give us an opportunity to explore other aspects of animal biotechnology in our future ventures and endeavors.

**Ashish S. Verma**  
**Anchal Singh**

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