Nanotechnology and its applications in Veterinary and Animal Science

S.S. Patil *, K.B. Kore[1] and Puneet Kumar[2]

Centre of Advanced Studies in Animal Nutrition,
Indian Veterinary Research Institute, Izatnagar 243 122
*Corresponding author email: drsrpatt@yahoo.co.in

Abstract

Nanotechnology has a tremendous potential to revolutionize agriculture and livestock sector. It can provide new tools for molecular and cellular biology, biotechnology, veterinary physiology, animal genetics, reproduction etc. which will allow researchers to handle biological materials such as DNA, proteins or cells in minute quantities usually nano-liters or pico-liters. Nanotechnology tools like microfluidics, nanomaterials, bioanalytical nanosensors, etc. has the potential to solve many more puzzles related to animal health, production, reproduction and prevention and treatment of diseases. It is reasonable to presume that in the upcoming year's nanotechnology research will reform the science and technology of the animal health and will help to boost up the livestock production. Nanotechnology will have a profound impact, but not in the immediate future as it is in the early stages of its development and needs to equip scientists, engineers and biologists to work at the cellular and molecular levels for significant benefits in healthcare and animal medicine. But It is reasonable to presume that in the upcoming year's nanotechnology research will revolutionize animal health and help to boost up livestock production.

Keywords: Nanotechnology, Livestock, Agriculture, Biotechnology.

Introduction

Nanotechnology is no more being a concept or theory of the new world, but has turned into a new enabling technology over the years, with tremendous potential to revolutionize agriculture and livestock sector in India as well all over the globe. Nanotechnology can provide new tools for molecular and cellular biology, biotechnology, veterinary physiology, reproduction and many more. It can be used for pathogen detection, so there are several areas in which nanotechnology could be applied to the science and engineering of agriculture, animal and food systems (Scott and Chen, 2002).

Nanotechnology is a research and development aimed at understanding and working with seeing, measuring and manipulating matter at the atomic, molecular and supramolecular levels (NSTC, 2004). This correlates to length scales of roughly 1 to 100 nanometres. At this scale, the physical, chemical and biological properties of materials differ fundamentally and often unexpectedly integrated sensing, monitoring and controlling system could detect the presence of disease and notify the farmer and veterinarian to activate a targeted treatment delivery system. This is possible with nanotechnology and could permit a wide range of advances in the field of agriculture, animal and veterinary sciences such as conversion of agricultural and food wastes to energy and other useful by-products through enzymatic nanobioprocessing, development in reproductive science, breeding management, disease prevention and treatment in animals and public health through food safety.

Applications of Nanotechnology

Nanotechnology has the potential to solve many more puzzles related to animal health, production, reproduction, good hygienic practices during rearing and maintaining of food animals, the possible applications of the technology is almost incredible in relation to livestock. Although much research and major company developments are necessary before nanotechnology is common place in veterinary and animal sciences, there are numerous glimpses of applications as discussed below.

Drug delivery system

Smart drug delivery systems in animals would

1. Ph.D. Scholar, Division of Animal Nutrition 2. Research Assistant, Division of Animal Nutrition

most likely contain small, sealed packages of the drug to be delivered. Smart drug deliveries allow judicious use of smaller quantities of antibiotics than would otherwise be possible. A molecular coded 'address label' in the package could allow the package to be delivered to the correct site in the body. Nano and microscale mechanical systems would serve as the 'carriers' in such a system. Smart delivery systems could also contain on-board chemical detection and decision-making capability for self regulated drug delivery or nutrient treatments as per need. This will aid livestock owners to minimize use of antibiotic and to reduce the expenditure on medication.

Smart delivery systems can also have the capacity to monitor the effects of the delivery of pharmaceuticals, nutraceuticals, nutrients, food supplements, bioactive compounds, probiotics, chemicals and vaccines. Thus, in the future, further technological advances will make it possible to develop delivery systems more precisely with use of *nanomaterials* (are materials that provide the potential to manipulate structures or other particles at the nanoscale and to control and catalyze chemical reactions, e.g. *buckeyballs, nanotubes, quantum dots and dendrimers* etc.) for biological and bioactive organisms for targeted site, develop integrated sensing, monitoring and controlling capabilities, including the ability of self-regulation, develop large as well as small animal health monitoring and therapeutic intervention (Tomànek and Enbody, 2000).

Diagnosis and treatment of disease

Biochips can be used for early disease detection in animals. A *Biochip* (or *microarray*) is a device typically made of hundreds or thousands of short strands of artificial DNA deposited precisely on a silicon circuit. Biochips can also be used to trace the source of food and feeds to detect the presence of animal products from different species as a means to locate the source of pathogens a response to public health threats such as avian flu and mad cow disease. In addition to DNA biochips, there are other variations that detect minute quantities of proteins and chemicals in a sample, making them useful for detecting biowarfare agents or disease. Using biochips, biological samples such as blood, tissue and semen can be instantaneously analysed and manipulated. *Bioanalytical nanosensors* are devices or systems that measure or detect a chemical with the use of a biological material or tissue. These will enable us with detection of very small amounts of a chemical contaminant, virus or bacteria in agriculture and livestock system.

Nanoshells are a new type of optically tunable nanoparticle composed of a dielectric (for example, silica) core coated with an ultra-thin metallic (for example, gold) layer. Nanoshells can be injected into the animal's bloodstream with targeted agents applied to the nanoshells to seek out and attach to the surface receptors of cancer cells. Illumination of the body with infrared light raises the cell temperature to about 55°C, which 'burns' and kills the tumour (Hirsch *et al.*, 2003). Others have been experimenting with 'smart' super paramagnetic nanoparticles, which when injected in the bloodstream target tumour receptor cells. These nanoparticles are made from iron oxides that when subjected to a magnetic field enhances the ability of the nanoparticles to locate tumour cells. At the site of the tumour the nanoparticles emit an attached drug to kill the cancer cells. Other form of nanomaterial is *Quantum dots* which are nanometre-scale crystals that were originally developed for optoelectronic applications (Scott and Chen, 2002). Quantum dots may be injected into the bloodstream of animals and they may detect cells that are malfunctioning. Because quantum dots respond to light it may be possible to illuminate the body with light and stimulate the quantum dot to heat up sufficient to kill the cancerous cell. Nucleic acid engineering-based probes and methods offer powerful new ways to deliver therapeutic or preventative treatment for particular diseases (Luo, 2003). These various methods of nanotechnology can be a potential therapeutic aid in extenuating the health problems of the animals.

Food safety through identity preservation

Identity preservation (IP) system is a system that creates increased value by providing consumers with information about the practices and activities used to produce an agricultural product. Today, through IP it is possible to provide stakeholders and consumers with access to information, records and supplier protocols regarding the farm of origin, environmental practices used in production, food safety and security, and information regarding animal welfare issues. Quality assurance of the safety and security of agricultural and animal products could be significantly improved through IP at the nanoscale. The future of the meat industry may well depend on an ability to track all stages in the life of the product, including the birth of the animal, its medical history, and its movements between the ranch, the slaughterhouse and the meat-packing plant, right through to the consumer's table.

Breeding and Reproduction

Management of breeding is an expensive and time-consuming problem for dairy and swine farmers. One solution that is currently being studied is a nanotube implanted under the skin to provide real time measurement of changes in the level of estradiol in

the blood. The nanotubes (O'Connell *et al.,* 2002) are used as a means of tracking oestrus in animals because these tubes have the capacity to bind and detect the estradiol antibody at the time of oestrus by near infrared fluorescence. The signal from this sensor will be incorporated as a part of a central monitoring and control system to actuate breeding. *Microfluidics* is used today in animal science to significantly simplify traditional *in vitro* fertilisation procedures used in animal breeding. It is being used in livestock breeding to physically sort sperm and eggs. Microfluidic and nanofluidic are the systems which analyse by controlling the flow of liquids or gases through a series of tiny channels and valves, thereby sorting them, much as a computer circuit sorts data through wires and logic gates.

With the mapping of the human genome behind them, geneticists are now rapidly sequencing the genomes of cattle, sheep, poultry, pig and other livestock hoping to identify gene sequences that relate to commercially valuable traits such as disease resistance and leanness of meat. By including probes for these traits on biochips, breeders will be able to speedily identify champion breeders and screen out genetic diseases.

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