Vaccinology

Vaccinology is the science or method of vaccine development. Over 200 years ago, English physician Edward Jenner observed that milkmaids who contracted a mild viral disease called cowpox were rarely victims of a similar but deadly disease called smallpox. This observation led Jenner to infect a healthy young boy with cowpox, and six weeks later challenge the boy with fluid from a smallpox pustule. The boy remained free of smallpox, and the era of vaccinology began. The foundation that Jenner laid began a course of vaccine development that would lead to the eradication of smallpox and polio, and vaccines for a spectrum of human pathogens that include influenza, bacterial pneumonia, whooping cough, rubella, rabies, meningitis, and hepatitis B.

The term “vaccine” is derived from the Latin word “vaccinus” which means “pertaining to cows” – a reflection on Jenner’s pioneering studies using cowpox vaccinia virus to prevent human smallpox (variola). Vaccines take advantage of using relatively harmless foreign agents to evoke protective immunity that resists infection and/or disease pathogenesis. There are many different types of vaccines including attenuated microbes, inactivated microbes, inactivated toxins, and purified proteins or polysaccharides derived from human pathogens. Some examples include attenuated measles, mumps, and rubella (MMR) vaccine routinely administered to infants, inactivated influenza vaccine, inactivated tetanus toxoid vaccine, and purified hepatitis B virus protein antigen vaccine. Vaccines provide acquired immunity to pathogens and are generally used to prevent disease rather than cure it. There are a variety of vaccine strategies that may be commonly used in the future including DNA vaccines, skin patch vaccines, and edible vaccines.

Despite the ability to vaccinate people and animals for protection against several important pathogens, the majority of people and food or companion animals worldwide are still plagued by known and emerging infectious diseases. Emerging or re-emerging infectious diseases continually threaten human health and impact global security by affecting food for an increasing world population, access to international trade and economic growth, and raise concerns for potential use as pathogens in bioterrorism. The majority of emerging infectious diseases are of zoonotic origin, i.e. transmissible between humans and animals causing infection in both species. For example, in the past 10 years the world has had to respond to SARS-associated coronavirus identified in some domestic and wildlife species, Nipah virus from bats via pigs, influenza viruses from birds, and the West Nile virus from birds via mosquitoes. In addition, naturally occurring zoonotic diseases such as anthrax and antimicrobial-resistant organisms have emerged in part as a result of the agricultural practices that include use of antimicrobials for disease prevention and growth promotion of several domesticated species. Finally, the U.S. and
other countries remain vulnerable to agroterrorism by agents such as foot and mouth disease.

There are a number of factors that affect emerging infectious disease including (1) introduction of infection into new host populations, e.g. bovine spongiform encephalitis; (2) establishment and further dissemination within new host population, e.g. ecological factors favoring vectors or reservoir hosts; (3) agricultural or economical development, e.g. dams (shistsosomiasis) or deforestation (malaria); (4) human demographics and behavior, e.g. population growth, international travel, drug use; and (5) microbial adaptation, e.g. antibiotic resistance (tuberculosis). Unfortunately, the capacity to address emergence or re-emergence of infectious diseases is limited in part by (1) lack of efficacious vaccines or therapeutic treatment modalities; (2) limited support for and deterioration of surveillance of vector-borne and zoonotic diseases; (3) erosion in the number of scientists, public health investigators, and particularly veterinarians who are educated in relevant fields that include medical entomology, vector ecology, epidemiology, tropical medicine, and microbiology of zoonotic pathogens; (4) limited tools to address emergence of drug resistant pathogens and arthropod vectors; and (5) limited biosafety facilities, e.g. BSL3 and BSL4, that can contain the pathogens and animal models need for study.

To effectively prevent and control known and emerging infectious diseases, the scientific and health communities need to develop a discovery-to-control continuum. It is imperative that those in human, animal, agricultural and environmental sciences work together to address threats associated with infectious diseases. Basic research and a greater understanding of disease epidemiology can lead to improved diagnostics and vaccine strategies to control infectious diseases; however, veterinary medicine must bridge the gap between recognizing zoonotic diseases and preventing transmission among animal and human populations. To achieve these goals, the veterinary medical mission must be closely aligned with training students and professionals in relevant fields, and in advanced technologies to combat zoonotic and animal infectious diseases.

The development of effective vaccines represents one of the most promising approaches for providing cost-effective interventions against zoonotic and animal infectious diseases. Animal models have contributed to the considerable progress in our understanding of the mechanisms of immunity and disease pathogenesis associated with infectious agents by providing identification of vaccine candidate antigens, and in demonstrating proof-of-principle vaccine strategies. It is clear that vaccines can be an effective strategy to control infectious diseases, and clearer that veterinary medicine is at the interface between animal and human health.

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Dr. Zhen Fu’s lab is involved in development of rabies virus vaccines using reverse genetics technology. They are attenuating rabies viruses by producing mutations in viral genes. Their goal is to construct and select completely avirulent rabies virus which is still capable of stimulating a protective immune response in animals. Such mutant viruses will be safer and more efficacious than currently used vaccines and thus can be developed as live attenuated vaccines for both wild and domesticated animals. (zhenfu@vet.uga.edu)

Electron micrograph of a neuron infected with rabies viruses (Viruses are seen here inside and outside of the cell as shown by arrows)