A Breeder's.... Veterinary Perspective

Types of Vaccines

By Colin Palmer, DVM

My previous article: Viruses, Disease and Vaccine – A Brief Overview; explained that most infectious diseases are caused by bacteria or viruses; antibiotics are intended to combat bacteria, not viruses; and the best way to fight a viral disease is through prevention. Avoiding contact with viruses, including those potentially shedding viruses, is arguably the best way to prevent infection, but is not always practical or possible. Maintaining a completely isolated population of animals, or even a closed herd with absolutely no contact with outside animals of the same species is often difficult or even impossible on most beef cattle operations. Several viruses may survive outside of the animal and can be carried on boots, clothing and equipment. Some can be transported by alternative host species, in many cases without disease symptoms. The most economically important livestock disease on the planet is Foot-and-mouth disease (FMD). Foot-and-mouth disease virus (FMDV) can be shed in milk; survive in imported meat; carried on human skin, clothing, vehicle tires; transported by birds and other animals; and can survive in contaminated bedding, dry manure, and even frozen soil for several weeks. Maintaining closed borders, strict import requirements, and limiting or preventing contact with livestock by visitors are the best measures to keep FMD out. What about when a viral disease takes up permanent residence; in other words, become endemic? Limiting spread of the disease and consequent losses becomes almost impossible without a vaccine. Remember, antibiotics kill bacteria, not viruses!

All vaccines are made by modifying or replicating a piece of the original virus or bacteria to stimulate the production of specialized white blood cells called memory T- and B-lymphocytes. The main types of vaccine are:

1) killed (inactivated)
2) modified-live (live-attenuated)
3) messenger RNA (mRNA)
4) subunit (component), recombinant, polysaccharide, and conjugate
5) toxoid
6) viral vector.

An important detail is that all, or nearly all, vaccine products contain what are known as adjuvants. An adjuvant is a substance added to a vaccine product to stimulate the immune response thereby, enhancing both the level and the duration of protection. Since 1990, there has been a revolution in our understanding of the immune system. We now know that there are specialized receptors on very specialized cells that present what I think of as items that identify the perpetrator to the immune system. Sort of like how a tracking dog utilizes an individual's unique scent. In more scientific terms, these specialized cells are called dendritic cells and they possess pattern recognition receptors (PRRs) which recognize select proteins called antigens, or more specifically pathogen-associated molecular patterns (PAMPs) on the invading pathogens. The PPRs function like switches that activate the dendritic cells which, in turn, activates other components in the immune system. Newly discovered molecules that target these receptors are being incorporated into adjuvants to regulate various components of the immune system. Although PRRs have only recently been discovered, it is now evident that many very effective killed and attenuated vaccines already had their own built-in adjuvant. We just didn't know it! These discoveries have enabled vaccines producers to incorporate very specific components as adjuvants resulting in improved vaccine performance with fewer side effects.

Dr. Colin Palmer is an Associate Professor of Theriogenology (Animal Reproduction) at the Western College of Veterinary Medicine. Originally from Nova Scotia, Dr. Palmer worked in mixed practices in Ontario and British Columbia and has owned/operated a practice in Saskatchewan. Dr. Palmer along with his wife Kim and children Lauren, Emily and Carter run a herd of purebred Red Angus cattle under the KC Cattle Co. name.

Inactivated or heat inactivated, also known as killed vaccines and bacterins (another name for vaccine directed against a bacteria) represent the first generation in vaccine technology. These products contain whole forms of killed, disease causing bacteria or virus. Generally, inactivated vaccines do not confer as strong or as long-lasting immunity against the disease agent as other types of vaccines. A notable exception are the rabies virus vaccines. Inactivated vaccines are safe and do not cause disease. Many inactivated vaccines can now rival some of the more efficacious vaccine types largely due to advances in adjuvant technology.

Modified-live (live-attenuated) vaccines use a form of the disease-causing virus or bacteria (also called a bacterin, like the killed vaccine) that does not cause full-blown disease yet has a similar antigenic profile. The virus is alive, therefore, it can still invade and replicate within the host for several days or even weeks before it is neutralized. This is the reason that attenuated vaccines create such a strong and long-lasting immunity. Attenuated vaccines can take a long time to develop and sometimes may cause just enough disease to be harmful to the recipient. For example, modified-live infectious bovine rhinotracheitis (IBR) vaccines have traditionally not been recommended for use in pregnant animals because of the risk of abortion. Select products are now considered safe if used according to specific manufacturer recommendations. Mixing of sterile diluent with dried powder and the fragile nature of these vaccines require the product to be used within 1 or 2 hours of mixing are other disadvantages.

Messenger RNA (mRNA) vaccines contain the genetic code for a select viral proteins that elicit a suitable immune response. Instead of using the whole virus, mRNA vaccines use a tiny piece of the genetic code of the virus which will then teach the host cells how to make a protein or a piece of a protein. Live viruses would normally take over host cells then use their own genetic code (RNA or DNA) to replicate themselves and in so doing create a number of proteins. By exposing the immune system to only a few select proteins the host can create memory T- and B- cells without risk of disease. The mRNA is destroyed after the new protein is made and the new protein tends to be made for a few weeks enabling stimulation of the immune system. Messenger RNA vaccines have been in existence for a few decades. Benefits include rapid production, improved storage and transport compared to other vaccine types, and no risk of causing disease in the patient. A very high level of safety has been advantageous in the fight against COVID-19. A disadvantage is relatively short-lived immune protection compared to having live virus replicating in the body.

Subunit, recombinant, polysaccharide, and conjugate vaccines all contain a piece or pieces of the disease agent that have been shown to elicit an immune response that is targeted at that piece of the organism. Part of a cell wall of a bacterium, perhaps 1 or more proteins, a sugar etc. They represent a purified form of an inactivated, whole-organism vaccine. Another name used for this class of vaccines is component vaccine. These vaccines are safe but generally do not confer long protection, therefore, regular booster shots are needed.

Toxoid vaccines use the toxin produced by select toxin-producing bacteria to create the immune response instead of the bacteria itself. Many cattle producers are familiar with blackleg (Clostridial) vaccines – those products providing protection against tetanus contain tetanus toxoid produced by Clostridium tetani. The clinical signs associated with tetanus are due to the toxin produced by the bacteria rather than the bacteria itself. By vaccinating using a toxoid vaccine the immune system will be directed towards neutralizing the toxin.

Viral vector vaccines used a modified version of another virus to create the immune response. The vector virus does not cause disease; however, it will infect cells and create its own proteins as it replicates. One or more of these proteins will be the same as the proteins produced on the surface of the harmful virus, aptly named spike proteins. If the body encounters the harmful virus, it will recognize these spike proteins and will already have antibody protection to fight the disease.

Modified-live and viral vector vaccines tend to confer longer periods of protection in recipients because the administered virus lives and replicates within the body for an extended period allowing continued stimulation of the immune system.

Multivalent and polyvalent are two terms often encountered in the vaccine literature and product labels. Essentially these terms mean the same thing – the vaccine product contains antigens from different strains of the same disease-causing organism; therefore, a broader range of immune protection will be produced. Most of the cattle vaccines available now are multi-disease or combination vaccines which means that they confer protection against several disease agents. Many of these vaccines often contain inactivated and modified live components within the same product.

In the past, all vaccines were administered into the muscle mass; however, many were proven effective when administered subcutaneously and labelled instructions followed suit. Very recently intranasal vaccines have been introduced for cattle. My next article will discuss routes of vaccine administration.