vido

1997/98 annual**report**

interacting around the world

vido

FINANCIAL SUPPORTERS

The following individuals, groups, and agencies contributed funds to VIDO over the course of the past fiscal year through donations, grants, or contracts. Their support is acknowledged and greatly appreciated.

Agriculture Canada
Agri-Food Innovation Fund
Ag-West Biotech Inc.
Alberta Agriculture Research Institute
Alberta Cattle Commission
Alberta Chicken Producers
Alberta Pork Producers Development Corporation
Bayer Corporation
Beef Cattle Industry Development Fund
Beef Industry Development Fund
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Boehringer Ingelheim/Nobl Laboratories
Canada-Alberta Beef Industry Development Fund
Canadian Bacterial Diseases Network
Canadian Turkey Marketing Agency
China National Township Enterprise
Cyanamid Agricultural Products
Dairy Farmers of Ontario
Government of Canada - Department of Western Economic Diversification
Government of Canada - Department of National Defense
Dr. Norman Habermehl
Human Frontier Science Program
Kamloops Stockmen's Association
Manitoba Pork est.
Medical Research Council
Natural Sciences & Engineering Research Council of Canada
Ontario Cattlemen's Association
Ontario Pork Producers' Marketing Board
Province of Alberta - Alberta Agriculture, Food, and Rural Development
Province of British Columbia - Ministry of Agriculture, Fisheries, & Food
Province of Manitoba - Manitoba Agriculture
Saskatchewan Agriculture Development Fund
Saskatchewan Beef Development Board
Saskatchewan Cattle Marketing Deductions Fund
Saskatchewan Economic & Co-operative Development
Saskatchewan Health Research Board
Saskatchewan Horned Cattle Trust Fund
SPI Marketing Group
Swine Improvement Services Co-operative
Termidor Corporation Inc.
Transgene
Vetrepharm Canada Inc.
World Health Organization

mandate

To Serve the Canadian Livestock and Poultry Industry by:

Conducting animal health related research

Communicating livestock management techniques and information

Facilitating the transfer of technology for international commercial development

goals of vido

To serve and assist the economic competitiveness of the livestock industry through research on the common infectious diseases of animals and poultry.

To provide information leading to safe and effective animal health preventive medicine programs which enhance animal care through improved management and performance of livestock.

To identify opportunities to utilize VIDO's livestock research to improve human and companion animal health.

To maximize funding by enhanced visibility and development of innovative communication programs with all organizations that provide support to VIDO.

To transfer technology to the biological industry to enhance its commercial application for the benefit of the Canadian livestock producers and to provide financial stability to VIDO.

To manage its financial, educational, and human resource efforts to ensure long-term benefits to the organization's stakeholders.

vido

Fred van Ingen
Chair

Dennis Billo
Vice Chair

CHAIR'S report

Signs of globalization are all around us. Mergers and partnerships are tools the world is using to capitalize on opportunities. A few examples include Ford and Volvo Car Division, Chrysler and Daimler Benz, Exxon and British Petroleum, Rhone Merieux and Merck to form Merial and the list goes on. Mergers and alliances are common place. The days of protectionism and looking inward are over. It makes no economic sense to do otherwise.

The time has also come that VIDO cannot focus solely on support from the Canadian livestock industry. The technology developed at VIDO has benefits and applications for other countries, so why not explore that market. With this in mind, VIDO has established working relationships with national and global pharmaceutical companies. This is crucial to the producers because these working relationships are reducing the amount of time it takes to transfer the technology from the research laboratory to the marketplace. Through these working relationships, VIDO is able to meet two of its goals:

- *"To serve and assist the economic competitiveness of the Canadian livestock industry through the development of products"*, and
- *"To transfer technology to the biological industry to enhance its commercial application for the benefit of the Canadian livestock producers, thus, providing financial stability and pay back"*

Canada is a resource-based nation. We produce more than we can consume. We have clean air, water and large land base to produce commodities for foreign export markets. As primary livestock and poultry producers, the technologies developed at VIDO will have a positive impact on producers' competitiveness and profitability as it relates to the world demands. The increase in demand for Canadian products stimulates our economy, which in turn benefits everyone. One of the identified goals of the VIDO Board of Directors is to serve and assist the economic competitiveness of the livestock industry through research on infectious diseases affecting food-producing animals, which ultimately results in a pay back for producers. The producer dollars directed towards research has been gratefully accepted. However, it is not just the producer that stands to benefit from that investment. Consumers, who out number producers also benefit because of food safety in which disease free animals have a significant integrated part.

As a member of the VIDO Board of Directors for the past 6 years, I have witnessed a continued evolution of a world-class research organization. The interaction between VIDO and the world has provided a very significant benefit to the livestock and poultry industries, to society and to Canada's research and development infrastructure and international competitiveness. However, to maintain this momentum we need consumer funding through various levels of governments in Canada. We, the Board of Directors, make no apologies for soliciting these funds. Research at VIDO makes sense and creates benefits for producers and consumers.

Every year or decade has evolved its own lexicon of buzz words or jargon. However, as we enter the next millennium, we are convinced that globalization will not turn out to be a buzz word but will be a reality. Indeed, it is a reality today and we are convinced that globalization will increase in the future. We believe that organizations that do not position themselves to capture the opportunities that exist outside their borders will fail to thrive and will not be able to meet their overall mandate or provide maximum benefit to the local economy. Based on this belief, VIDO is continuing to position itself to be a major player in the global economy and in capturing both its share of research funding from international relationships and marketing its products globally. We feel that this approach will not only benefit VIDO but will also benefit all of its local stakeholders.

To help support this strategy, VIDO has refocused its approach and its research effort. Previously, VIDO would conduct all of the research in-house and develop products which producers identified as important for them. This approach was successful and has resulted in a number of world-first products that have helped producers by reducing animal suffering and improving productivity. During this process, we recognized that it took an inordinate amount of time to transfer the technology from the research laboratory to industry and subsequently to the marketplace. In order to shorten the time period between completion of the research and marketing, we are establishing relationships with the eventual marketing partner earlier, even before we initiate the research. This has become possible because of our strong track record in developing novel vaccines and our leadership role in using biotechnology for vaccine development. We identify our mutual needs and products to develop jointly, establish milestones and excellent relationships earlier in the product development pathway than previously.

Lorne Babiuk
Director

By developing these collaborations early, we can capitalize on the marketing expertise of the collaborating company and, more importantly, work closely with the company as true partners during the research phase so that technology transfer occurs much quicker and more smoothly and, therefore, the products reach the marketplace sooner. This benefits VIDO, the company, and the clients that will use the products. This integrated approach also dramatically reduces the cost of the entire development pathway. Since funding is always an issue with an organization such as VIDO which does not have any guaranteed funding from any source, these relationships also assist us by having the companies fund some of the early-stage research. This relationship also helps us in identifying and protecting the intellectual property through patents which have been the most critical component of our research. Today, VIDO has obtained patent protection for most of its technology. Forty-one patents have been issued and over 20 patents are pending. These patents are providing VIDO with an excellent stable of technologies and a strong position for negotiating licenses to these technologies with commercial companies.

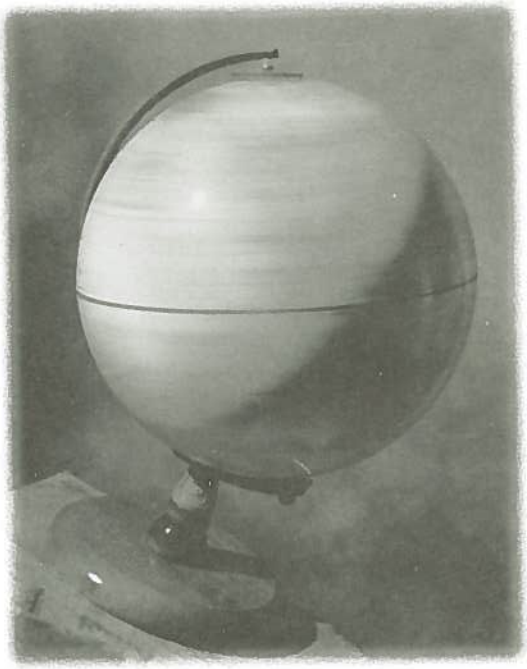
To support VIDO's strategy of aggressively obtaining research partners, we have signed 11 agreements with various companies active in various regions of the world. These agreements range from direct contracts to test products, develop specific products for which the "proof of principal" has been established, all the way to high risk basic research which have a potential for generating products in the future. This mix of agreements ensures a balance between immediate cash flow and long-term survival of VIDO as well as ensuring a strong "pipeline" of products for the future.

In addition to establishing research agreements with commercial companies, we have also signed a number of agreements with research institutes in various parts of the world. We have established these international collaborations for a number of reasons. First, research and development have become so complex that no one organization can possess all the expertise or sophisticated equipment required to

conduct the research. By establishing networks with scientists and institutions, we can readily access such expertise at much less expense both in time and financial resources. Secondly, by establishing agreements with institutions that have complementary technology and patents, we can jointly develop products with less concern for patent infringements and, more importantly, provide a much more complete package of technology and products to commercial companies.

In order to establish these research agreements, it is critical to establish relationships between individuals and institutions. We feel that people are the most important element in relationship building. As a result, we are spending a considerable amount of time in ensuring that these relationships flourish both at the personal and the institutional level. One way we are building on these relationships is scientific exchanges between these institutions. This has allowed us to expand the number of personnel that are actually working on VIDO-specific projects. This is critical at present since VIDO's physical facilities are being used to their capacity.

The strategy VIDO is employing is proving to be extremely successful in generating revenues, developing new patented technologies, and developing products for the marketplace. For example, VIDO's budget this year, even in tough financial times, has exceeded the $5 million dollar level for the first time in its history. As a result, our staff numbers have increased to 80 individuals, the highest number ever present at VIDO. Although this provides us with a broader range of expertise to help expedite our research programs, it has also resulted in overcrowding and in exceeding the capacity of our air handling system. Since we are at peak capacity, it will be difficult for us to respond to the collaborations that are becoming critical to us. As a result, we will be investigating various options over the next year as to possible expansion of VIDO's research laboratories and office wing.



VIDO's success could not be possible without the dedication of its Management Team, Board of Directors, and staff. As always, the staff has been extremely supportive of VIDO's mission and often put VIDO's mission ahead of personal gain. Regardless of the day of the week or time of day, someone is always excitedly putting the "finishing touches" on the experiment or waiting with excitement for the results to be spewed out of the machine. This type of dedication has allowed us to meet and often exceed our specific milestones. This has been critical as we continue to establish and maintain a high level of credibility with our stakeholders and financial supporters. Since our goal is to establish long-term relationships with our clients, exceeding the customer's expectation is critical for continued and repeat business. With the philosophy of providing value for a dollar, we hope to become the research institute of first choice for organizations that need challenging research programs carried out. We are confident that this philosophy will ensure VIDO's success and, more importantly, the success of our stakeholders.

Since VIDO is a non-profit organization and we do not pay our Board of Directors, I would like to specifically thank this group of dedicated individuals who provide VIDO Management with the guidance and support which they have given us during this past year. Their expertise and dedication have been instrumental in supporting Management and endorsing the evolution of VIDO. Their insight and guidance as we evolve from a national to an international research institute has been invaluable.

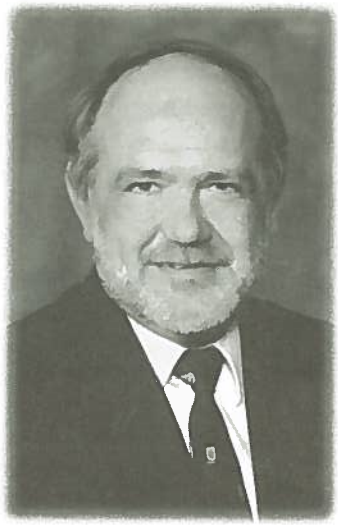
Infectious diseases affecting animals cross all geographical boundaries and as such, research efforts targetted at understanding specific animal health and food safety problems are global in nature. An excellent recent example of this is Post Weaning Multisystemic Wasting Syndrome (PMWS), an emerging disease of swine which has been identified in Canada, the United States of America and countries in the European Union (EU). Researchers in each of these regions are studying this disease including surveillance, its pathogenesis and vaccine development.

The question of whether the use of antimicrobials in animal feed has contributed to the increase in antibiotic-resistant human pathogens is also an issue of global concern. The EU has recently banned the use of four antibiotics in feed and it is likely that some form of action will be forthcoming in North America. This highlights the need for multi-national efforts to study this area and more importantly, to develop alternative tools for animal health and productivity.

VIDO has several ongoing research programs dealing with fundamental studies of how microorganisms cause disease in animals, vaccine development, as well as the development of new strategies for vaccine construction and use. Ongoing research programs in our Bacteriology, Virology and Immunology groups are described in this report, highlighting those in the Immunology group. In addition, the Chemistry and Clinical Research groups provide collaborative expertise for each research area.

IMMUNOLOGY RESEARCH PROJECTS

VIDO is exploring multiple vaccine delivery technologies and their potential applicability to different routes of vaccination. These investigations are motivated by two major concerns. First, the livestock industry and consumers have identified meat quality as a major concern. Many of the present vaccines, which are injected intramuscularly, are associated with injection site lesions that reduce meat quality and result in a significant economic loss to meat processors. Thus, alternative routes of vaccine delivery are desirable. For example, we are exploring the use of liposome formulations for the transcutaneous delivery of both DNA and protein vaccines. A second major concern during vaccine development is to ensure that the vaccine provides optimal immune protection. Over 90% of disease organisms enter the body through the mucosal surfaces. Thus, the most effective disease prevention is provided by local immunity at those body surfaces. However, induction of mucosal immunity requires vaccine delivery that is targeted to mucosa-associated lymphoid tissue which requires special vaccine delivery technology. For example, the adenovirus vaccine vector (see below) induces both systemic and mucosal immunity but there are a number of challenges to ensure delivery is practical and fits with current management practices.



Andrew Potter
Associate Director

Multiple vaccine delivery and formulation strategies are being investigated since VIDO recognizes that each disease and management situation may require unique vaccine delivery systems. For example, oral adenovirus vaccines may be practical for newborn animals but not older animals for technical or management reasons. Furthermore, it may be possible to effectively combine different delivery technologies. Thus, liposome technology may be used to enhance DNA vaccine delivery or cytokines may be included in adenovirus vectors to enhance mucosal immunity. Our exploration of these vaccine delivery technologies has just begun and many possible applications remain to be discovered.

Liposomes are lipid vesicles that can entrap vaccine antigens and deliver them to the body's immune system where the vaccine stimulates resistance to disease. We are assessing a novel approach based on the ability of liposomes to be absorbed directly through the skin. The development of non-invasive methods for the delivery of vaccines through such barriers will greatly facilitate the administration of veterinary vaccines. Our objective is to formulate vaccines that can be applied by a patch on the skin without

requiring a needle. Dr. Marianna Foldvari from the University of Saskatchewan and PharmaDerm Lab, in partnership with Helix BioPharma Corp., have been our collaborators in the area of liposome technology. Topical application of vaccine antigens formulated with a novel lipid-based delivery system is capable of inducing strong immune responses in mice. The ability of these novel formulations to induce immune responses are highly dependent on the compatibility between the vaccine antigen and the lipid composition of the delivery system. Therefore, it is important to optimize the formulations for each vaccine antigen. In addition, the immune responses induced can be further enhanced by the addition of immunomodulatory molecules such as adjuvants and cytokines. We are currently exploring the topical application of vaccine antigens in large animals.

The bovine adenovirus vaccine vector has substantial potential as a vaccine delivery system that can induce both systemic and mucosal immunity. This vector induces an immune response following intranasal, oral and subcutaneous delivery to newborn lambs. Regardless of the route of delivery, an immune response develops in the lung which suggests that this will be an ideal vaccine delivery system for respiratory infections. Oral vaccination would be practical with newborn animals and present research is focused on this area. To overcome the delivery barrier presented by the rumen and to target the vaccine to mucosa-associated lymphoid tissue we are working with Turbosonic Inc. (Waterloo, Ontario). This company is designing an ultrasonic nozzle that can be used to produce alginate microspheres that contain the adenovirus vaccine vector. These microspheres will then be used to orally immunize newborn calves with the adenovirus vaccine vector. We are also working on a new project to look at the ability of interleukin-6 to improve the response to vectored vaccines.

The Developmental Immunology project is searching for novel approaches to enhance mucosal immune responses. This research is being done in collaboration with several research groups in Europe. In conjunction with Prof. Jean-Claude Weill's group (Institut Necker, Paris, France) we are identifying genes that may regulate the production of antibody at mucosal surfaces. A joint collaboration with Dr. Anne Van den Broeke (University Libre, Brussels, Belgium) and Dr. Claude Bagnis (Gene Therapy Institute, Marseille, France) is exploring retrovirus vectors as a possible way to confer lifelong immunization. Finally, we are also looking for more efficient ways to target vaccine antigens to the mucosal immune system. Rotavirus VP6 protein has shown promise as one way to more efficiently deliver DNA vaccines that are incorporated into gelatine nanospheres. These projects are generating novel ideas and technologies that will require further work to fully explore the applications and limitations of these technologies.

Exciting alternatives to intramuscular vaccines have now been clearly identified. The challenge remains to determine how these vaccine technologies can best be developed into effective tools that meet the needs of both the livestock industry and consumers. The development of a commercial vaccine is a very expensive process and the final product must be safe, effective, and practical to produce and administer. This final goal will only be achieved with an effective exchange of ideas and substantial pooling of resources. VIDO can achieve this goal by looking to the world for research collaborators and commercial partners.

VIROLOGY RESEARCH PROJECTS

VIDO's Virology group is working on three main projects, two of which deal with the development of platform technologies for viral vaccine development (vectored adenovirus vaccines and nucleic acid immunization) and one dealing with the development of a vaccine for PMWS in swine. All three of these projects are international in scope and have a variety of applications outside of the traditional animal health field.

Since many disease organisms enter the host at mucosal surfaces, immunity is required at these sites to block the initial infection. The most effective way of inducing such immunity is to use live organisms which can no longer cause disease. Furthermore, the genes coding for protective antigens from other organisms can be inserted into the crippled "vector" to obtain protection against more than one disease in a single immunization. We have been characterizing both bovine and porcine adenoviruses for such a purpose and we have constructed recombinant bovine adenoviruses expressing vaccine antigens from bovine herpesvirus type 1 (BHV-1), bovine coronavirus and bovine parainfluenza virus-3. Intranasal immunization of calves with the recombinant adenovirus expressing BHV-1 gD has been shown to induce protective immunity following experimental challenge. We are currently testing the efficacy of similar viruses expressing the antigens from bovine coronavirus. These studies are

being carried out in collaboration with Bayer Inc. (Germany) with the ultimate goal of producing a family of recombinant bovine vaccines which will protect common infections of cattle. As part of this project we have also developed another series of bovine adenovirus vectors which are incapable of growing in the host and can be grown only in specially-constructed cell lines in the laboratory. These recombinant viruses have potential application in the field of human gene therapy and this is being pursued by our collaborators at Transgene (Strasbourg, France).

In collaboration with researchers at the National Veterinary Research Institute (Seoul, Korea), we have constructed a recombinant porcine adenovirus expressing a glycoprotein, gp50, from pseudorabies virus. They are currently testing the efficacy of this recombinant vaccine in pigs. Both the porcine and bovine adenovirus projects also involve a collaboration with CSIRO (Australia) for the development of vaccines for other geographic regions.

One of the problems associated with the development of recombinant viral subunit vaccines is the cost-effective production of the vaccine component. One way to circumvent this problem is to utilize nucleic acid vaccines rather than conventional protein components. By injecting the nucleic acids directly into animals, protective antigens from infectious agents are produced in the animal's cells which reduces production costs since tissue culture is not required. Once the antigens are produced, animals can develop protective immune responses to these proteins. VIDO was the first organization to demonstrate the utility of this technology in a target animal species and we have established several collaborations aimed at increasing the efficiency of this technology. We have collaborated with Dr. Stephen Johnson (Texas SouthWestern Medical Centre, USA) using his prototype "gene gun" for immunization of ruminants and are currently collaborating with Bioject Inc. (Portland, USA) on the use of a needle free injection device for use in cattle.

Aside from potential uses in vaccination, nucleic acids themselves may be immunostimulants in vertebrates and therefore have potential to be used as adjuvants to increase the response to conventional vaccines or as immunotherapeutic reagents. VIDO is collaborating with Qiagen (Germany) to test the effect of short DNA sequences on the immune responses of ruminants.

The final Virology project involves the development of a vaccine for PMWS in swine. This disease was described in Canada and the United States in the early 1990s and has now been identified in a number of countries in Europe as well. Our approach to studying this problem has been to first carry out surveillance studies in numerous countries in order to establish its prevalence and simultaneously to work on the molecular biology of porcine circovirus-II (PCV-II) which is commonly isolated from diseased pigs. We have developed a diagnostic method which can differentiate virulent PCV-II from related viruses. This technology is being used in Germany, China, France and the United States to determine the prevalence of this disease and its association with PCV-II.

We have also characterized at a molecular level several PCV-II isolates from various geographical locations and have obtained evidence that the growth of this virus is closely related to PMWS outbreaks in the field. The disease has been experimentally reproduced using partially purified virus fractions from infected animals and have shown that infection will induce host immune system malfunction. We are continuing the development and production of diagnostic reagents and hope to begin vaccine testing in the next 6-12 months.

In addition to these three projects, we are also continuing to work on the transfer of technology for other vaccines, including a recombinant subunit vaccine for bovine rotavirus and coronavirus (calf scours). This work is being carried out in collaboration with Vetrepharm Inc. (Ontario, Canada).

BACTERIOLOGY RESEARCH PROJECTS

The Bacteriology group at VIDO is working on four specific projects involving the development of vaccines for cattle, swine and poultry. Specifically, projects are underway to determine reservoirs for *Escherichia coli* (E. coli) O157:H7 in the feedlot environment and to develop control measures for this important human pathogen, the development of *E. coli* and Salmonella vaccines for use in poultry, and the development of vaccines for Streptococcal infection in dairy cattle and swine.

While not a pathogen of food-producing animals, *E. coli* O157:H7 has gained notoriety as the cause of "hamburger disease", a potentially fatal illness affecting humans. While it does not cause disease in cattle, as the name suggests, it is often recovered from ground beef. In collaboration

with researchers in Alberta and Washington State, VIDO is participating in a study to determine the prevalence of *E. coli* O157:H7 in feedlots in Alberta, both in cattle as well as the environment. This study, which has just been initiated will involve sampling over a one year period and will yield valuable information for potential management changes which may reduce the prevalence of this organism. In addition, in collaboration with Dr. Brett Finlay at the University of British Columbia, we are testing whether vaccination of cattle will prevent colonization by this organism. Dr. Finlay has characterized several novel proteins which are involved in colonization of the gut and thus vaccination with these components should eliminate the ability of *E. coli* O157:H7 to survive in cattle. We are now at the stage where we have demonstrated proof of concept for this control strategy and over the next year we will be further refining vaccine formulations which will ultimately be tested in the field.

Food safety concerns are also a priority in the poultry industry where organisms such as *Salmonella enteriditis* and *Camplylobacter jejuni* are prevalent and can be passed on to consumers. Over the past several years, we have been working on the development of an *E. coli* vaccine to prevent colisepticemia and cellulitis in poultry and this has involved collaborative research with researchers in Pennsylvania and Minnesota on the characterization of organisms found in the field as well as the development of a live attenuated vaccine. During the past year, we have modified our objectives to include *Salmonella enteriditis* and hope to have demonstrated proof of concept for a bivalent *E. coli*-Salmonella vaccine by the end of December, 1999. This work is being carried out in collaboration with Dr. Bill Kay at the University of Victoria who has Salmonella technology which complements VIDO's *E. coli* vaccine work. We have demonstrated that both Salmonella and *E. coli* can be crippled by the introduction of specific mutations and are now constructing defined vaccine strains for further development. Since these are vaccines produced through recombinant DNA technology, we have also established a collaboration with Dr. Cyril Lutze-Wallace of the Canadian Food Inspection Agency to develop potency assays and safety tests for these genetically modified vaccines. Ultimately, we hope to use the *E. coli* vaccine strain to deliver antigens from other pathogens important to the poultry industry. We are in the process of constructing prototype Campylobacter and Mycoplasma vaccine strains using the *E. coli* technology and we hope to start testing these for efficacy during the latter part of 1999.

Streptococcal bacteria cause a number of different diseases of animals and humans, including bovine mastitis as well as septicemia in swine. *Streptococcus uberis (S. uberis)* and *S. dysgalactiae* are often associated with so-called environmental mastitis and therefore are often resistant to conventional control measures. We have identified two antigens from each of these species which are attractive vaccine candidates. We conducted three vaccine trials in which we have shown that vaccines composed of recombinant streptococcal antigens are capable of preventing experimental mastitis. These vaccine studies have been carried out with researchers at Pennsylvania State University and Agriculture Canada (Lethbridge). We have also initiated a new collaboration with researchers at the University of British Columbia for further vaccine testing and during the coming year we will be applying the technology developed for *S. uberis* and *S. dysgalactiae* to another pathogen of dairy cattle, *S. agalactiae*. This research will be carried out in collaboration with a number of groups within the Canadian Bacterial Diseases Network, a group of over fifty top Canadian scientists studying bacterial diseases.

VIDO scientists have also identified protective antigens from *S. suis* which are capable of protecting pigs against experimental exposure to this organism. However, since there are over 30 different types of *S. suis* found in the field, this vaccine project is a complex undertaking which will involve the identification and testing of potential vaccine components from at least three or four different serotypes. While our long term goal remains the development of a recombinant vaccine for the prevention of this disease, we are collaborating with the Alberta Research Council on the development of a conventional *S. suis* vaccine which, in the past has provided excellent protection against natural disease. However, it was not economical to produce and we are hoping that ARC's expertise in scale-up and fermentation can overcome this problem.

In summary, while VIDO's research efforts remain driven by the needs of Canadian producers and consumers, we have expanded our external partnerships in order to facilitate the development of technologies and specific products for our stakeholders. In addition, over the course of the past 10-15 years, several "platform" technologies have been developed which can be exploited by the international community to combat infectious diseases which may not be a problem locally. We view these partnerships as being essential to our ability to conduct both fundamental and applied research which is relevant to all those involved in animal health.

To the Board of Directors of the
Veterinary Infectious Disease Organization (VIDO),
University of Saskatchewan

We have audited the combined balance sheet of the University of Saskatchewan - Veterinary Infectious Disease Organization as at September 30, 1998 and the statements of income, expenditure and fund balance (Research Trust, Dr. Alfred Savage VIDO Research Fund, Capital Trust and Technology Development Trust) and combined statement of cash flows for the year then ended. These financial statements are the responsibility of the Organization's management. Our responsibility is to express an opinion on these financial statements based on our audit.

Except as explained in the following paragraph, we conducted our audit in accordance with generally accepted auditing standards. Those standards require that we plan and perform an audit to obtain reasonable assurance whether the financial statements are free of material misstatement. An audit includes examining, on a test basis, evidence supporting the amounts and disclosures in the financial statements. An audit also includes assessing the accounting principles used and significant estimates made by management as well as evaluating the overall financial statement presentation.

The Organization derives part of its income in the form of donations and certain grants the completeness of which is not susceptible to satisfactory audit verification. Accordingly, our verification of revenues from these sources was limited to the amounts recorded in the records of the Organization and we were not able to determine whether any adjustments might be necessary to donations and grant revenue, excess of income over expenditure, assets and fund balance.

In our opinion, except for the effect of adjustments, if any, which we might have determined to be necessary had we been able to satisfy ourselves concerning the completeness of donations and certain grants referred to in the preceding paragraph, these financial statements present fairly, in all material respects, the financial position of the Organization as at September 30, 1998 and the results of its operations and the changes in its financial position for the year then ended in accordance with generally accepted accounting principles.

The financial statements for the preceding year were audited by other auditors.

Ernst & Young LLP

Saskatoon, Canada
February 26, 1999

Chartered Accountants

ERNST & YOUNG

UNIVERSITY OF SASKATCHEWAN
VETERINARY INFECTIOUS DISEASE ORGANIZATION (VIDO)

RESEARCH TRUST - STATEMENT OF INCOME, EXPENDITURE AND FUND BALANCE

YEAR ENDED SEPTEMBER 30, 1998

(1997 figures restated - see Note 12)

	1998	1997
INCOME		
Donations and unconditional grants (Schedule 1)	$ 387,430	$ 287,834
Conditional grants (Schedule 2)	2,379,798	1,919,730
Contract research		
Department of Western Economic Diversification	591,378	565,649
Commercial	744,815	422,318
Associated Company	21,922	361,921
Government of the Province of Saskatchewan		
-Saskatchewan Department of Agriculture & Food	300,000	300,000
-Department of Saskatchewan Economic and Co-operative Development	785,943	-
Ag-West Biotech Inc.	99,510	-
Department of National Defence	48,028	115,724
Contract services	8,596	7,617
Royalties (Note 11 (b))	200,000	189,125
Interest	25,166	27,237
Animal sales	30,983	34,373
University of Saskatchewan	158,730	138,211
Miscellaneous Income	-	460
	5,782,299	4,370,199
EXPENDITURE		
Salaries and benefits	3,036,287	2,523,255
Materials and supplies	834,290	568,906
Animal services	151,050	174,370
Equipment repair and service agreements	52,510	136,144
Sub-contract research (Note 8)	86,902	-
Travel and recruiting	141,413	137,126
Patents and legal fees	146,300	152,701
Amortization	226,698	214,866
Other expenditures (Note 9)	183,986	130,457
	4,859,436	4,037,825
EXCESS OF INCOME OVER EXPENDITURE	922,863	332,374
FUND BALANCE, BEGINNING OF YEAR (Note 12 (b))	4,109,847	3,917,331
	5,032,710	4,249,705
TRANSFER TO CAPITAL TRUST	143,438	139,858
FUND BALANCE, END OF YEAR	$ 4,889,272	$ 4,109,847

UNIVERSITY OF SASKATCHEWAN
VETERINARY INFECTIOUS DISEASE ORGANIZATION (VIDO)

DR. ALFRED SAVAGE VIDO RESEARCH FUND
STATEMENT OF INCOME, EXPENDITURE AND FUND BALANCE
YEAR ENDED SEPTEMBER 30, 1998

	1998	1997
INCOME		
Investment earnings	$ 4,539	$ 6,401
Other: Market Value Increase	-	8,712
	4,539	15,113
EXPENDITURES		
Administration fees	148	429
EXCESS OF INCOME OVER EXPENDITURE	4,391	14,684
FUND BALANCE, BEGINNING OF YEAR	69,328	85,840
	73,719	100,524
TRANSFER TO CAPITAL TRUST	-	31,196
FUND BALANCE, END OF YEAR	$ 73,719	$ 69,328

	1998		1997	
	Restricted for Endowment Purposes	Expendable Funds	Restricted for Endowment Purposes	Expendable Funds
FUND BALANCE, BEGINNING OF YEAR	$ 58,031	11,297	$ 56,697	29,143
EXCESS OF INCOME OVER EXPENDITURE	996	3,395	1,334	13,350
	59,027	14,692	58,031	42,493
Transfer to Capital Trust	-	-	-	31,196
FUND BALANCE, END OF YEAR	$ 59,027	14,692	$ 58,031	11,297

UNIVERSITY OF SASKATCHEWAN
VETERINARY INFECTIOUS DISEASE ORGANIZATION (VIDO)

CAPITAL TRUST
STATEMENT OF INCOME, EXPENDITURE AND FUND BALANCE
YEAR ENDED SEPTEMBER 30, 1998
(1997 figures restated - see Note 12)

	1998	1997
INCOME		
Investment earnings	$ 6,499	$ 2,961
Grant from University of Saskatchewan	21,000	-
EXCESS OF INCOME OVER EXPENDITURE	27,499	2,961
FUND BALANCE, BEGINNING OF YEAR	316,015	142,000
	343,514	144,961
Purchase of Capital Assets	(56,562)	(60,142)
Transfer from Research Trust	200,000	200,000
Transfer from Dr. Alfred Savage VIDO Research Fund	-	31,196
FUND BALANCE, END OF YEAR	$ 486,952	$ 316,015

TECHNOLOGY DEVELOPMENT TRUST
STATEMENT OF INCOME, EXPENDITURE AND FUND BALANCE
YEAR ENDED SEPTEMBER 30, 1998

	1998	1997
FUND BALANCE, BEGINNING OF YEAR	$ 677,920	$ 1,645,819
Provision for Revaluation of Note Receivable (Note 11 (c))	(530,867)	(967,899)
FUND BALANCE, END OF YEAR	$ 147,053	$ 677,920

UNIVERSITY OF SASKATCHEWAN
VETERINARY INFECTIOUS DISEASE ORGANIZATION (VIDO)

COMBINED BALANCE SHEET
AS AT SEPTEMBER 30, 1998
(1997 figures restated - see Note 12)

ASSETS	1998	1997
CURRENT ASSETS		
Funds held - University of Saskatchewan	$ 1,196,948	$ 755,625
Due from University of Saskatchewan - operating fund	574,873	833,830
Accounts receivable (Note 3)	634,666	609,829
Inventories (Note 4)	102,097	150,804
	2,508,584	2,350,088
INVESTMENTS	574,345	133,031
NOTE RECEIVABLE (Note 5)	147,053	677,920
CAPITAL ASSETS (Note 6)	2,961,705	3,049,754
	$ 6,191,687	$ 6,210,793
LIABILITIES		
CURRENT LIABILITIES		
Accounts payable	$ 6,100	$ 10,500
Unearned revenue (Note 7)	588,591	1,027,183
	594,691	$ 1,037,683
EQUITY		
RESEARCH TRUST	$ 4,889,272	4,109,847
DR. ALFRED SAVAGE VIDO RESEARCH FUND	73,719	69,328
CAPITAL TRUST	486,952	316,015
TECHNOLOGY DEVELOPMENT TRUST	147,053	677,920
	5,596,996	5,173,110
	$ 6,191,687	$ 6,210,793

APPROVED BY THE BOARD:

Director

Trustee

UNIVERSITY OF SASKATCHEWAN
VETERINARY INFECTIOUS DISEASE ORGANIZATION (VIDO)

COMBINED STATEMENT OF CASH FLOWS
YEAR ENDED SEPTEMBER 30, 1998
(1997 figures restated - see Note 12)

	1998	1997
CASH FROM OPERATING ACTIVITIES		
Research Trust-Excess Income over Expenditure	$ 922,863	$ 332,374
Technology Development Trust - Provision for valuation of Note Receivable	(530,867)	(967,899)
Dr. Alfred Savage VIDO Research Fund-Excess Income over Expenditure	3,395	13,350
	395,391	(622,175)
Net change in non-cash working capital	(160,165)	(235,892)
Amortization of capital assets	226,698	214,866
Net cash provided by (used in) operating activities	461,924	(643,201)
CASH FLOWS FROM INVESTING ACTIVITIES		
Investment in University of Saskatchewan long-term investment pool	(441,314)	(78,188)
Decrease in note receivable	530,867	967,899
Purchase of Capital Assets	(138,649)	(221,122)
Net cash (utilized by) generated by investing activities	(49,096)	668,589
CASH FLOWS FROM FINANCING ACTIVITIES		
Dr. Alfred Savage VIDO Research Fund-Excess Income over Expenditure	996	1,334
Capital Trust - Grant from University of Saskatchewan	21,000	-
Capital Trust-Investment income related to capital purchase	6,499	2,961
Net cash generated by financing activities	28,495	4,295
NET INCREASE IN CASH	441,323	29,683
CASH, BEGINNING OF YEAR	755,625	725,942
CASH, END OF YEAR	$ 1,196,948	$ 755,625
CASH CONSISTS OF:		
Funds held - University of Saskatchewan	$ 1,196,948	$ 755,625

UNIVERSITY OF SASKATCHEWAN
VETERINARY INFECTIOUS DISEASE ORGANIZATION (VIDO)
NOTES TO THE FINANCIAL STATEMENTS
SEPTEMBER 30, 1998

1. ESTABLISHING AGREEMENT

The Organization was established by an Agreement dated August 11, 1975 between the Devonian Foundation of Calgary, Alberta, the Province of Alberta, the Province of Saskatchewan and the University of Saskatchewan to conduct research on infectious diseases of food producing animals.

Effective April 1, 1980 the above Agreement was replaced by a Constitution which provides for a Board of Directors to assume the responsibilities formerly performed by the Board of Advisors and the Governing Committee.

2. SIGNIFICANT ACCOUNTING POLICIES

These financial statements have been prepared in accordance with generally accepted accounting principles which include the following policies:

Fund Accounting

The Organization follows the deferral method of accounting for contributions and grants to each of its funds. VIDO classifies its funds by purpose and objective as follows:

The Research Trust fund consists of revenue and expenses related to the Organization's program delivery and administrative activities.

The Capital Trust fund consists of grants, investment earnings and authorized transfers from the Research Trust fund and Dr. Alfred Savage VIDO Research fund to be used for the purpose of acquiring capital assets approved by the Board of Directors.

The Dr. Alfred Savage VIDO Research fund was approved as an endowment for VIDO until 2010. During the endowment period, 80% of the fund's annual investment earnings are available to purchase equipment, instruments, materials and supplies to be used in research projects.

The Technology Development Trust fund consists of net income generated from Technology Access Agreements and the proceeds will be used for future development of technology under patent or license.

Inventories

Inventories of materials and supplies are valued at the lower of cost and net realizable value. Animal inventory is valued at cost.

Investments

Funds designated as endowment funds, restricted for the purposes of acquiring capital assets or future expenditures are invested with other funds from the University of Saskatchewan in a long-term investment pool. Long-term investments are carried at market value.

Revenue Recognition

Restricted contributions are recognized as revenue of the Research Trust fund in the year in which the related expenses are incurred. Unrestricted contributions are recognized as revenue of the Research Trust fund when received.

Investment income earned on the Dr. Alfred Savage VIDO Research fund is recognized as income of that fund; 20% of the fund's earnings are retained for reinvestment. Investment income earned on the Research Trust fund and Capital Trust fund is recognized as revenue when earned.

Capital Assets

Purchased capital assets are recorded at cost. Amortization is provided on a straight-line basis over the asset's estimated life as follows:

Computers	3 years
Software	3 years
Vehicles	6 years
Furnishings and equipment	8 years
Site improvements	20 years
Buildings	40 years

Royalties

Royalties are recognized as they are received or earned.

3. ACCOUNTS RECEIVABLE

	1998	1997
Conditional grants (Schedule 2)	$ 87,931	$ 5,156
Contract research	442,725	490,614
Contract services	3,412	1,904
Royalties	100,000	100,000
Accrued interest	598	12,155
	$ 634,666	$ 609,829

4. INVENTORIES

	1998	1997
Animals	$ 49,320	$ 80,430
Materials and supplies	52,777	70,374
	102,097	150,804

5. NOTE RECEIVABLE

As of December 15, 1993, the University of Saskatchewan, as represented by VIDO, signed a Debenture/Debt Transfer Agreement with 598707 Saskatchewan Ltd., the trustee of the BIOSTAR Trust. This agreement transfers the debt obligation including related interest as evidenced by the Debenture made between BIOSTAR Inc. and the University of Saskatchewan, effective December 11, 1991, to 598707 Saskatchewan Ltd. Consideration for the transfer was a Promissory Note of $4,699,876 bearing no interest and due on demand. The only asset of the BIOSTAR Trust is shares in BIOSTAR Inc. The book value of those shares based on the audited financial statement of BIOSTAR Inc., is $147,053 at March 31, 1998 (1997-$677,920).

6. CAPITAL ASSETS

	1998			1997
	Cost	Accumulated Amortization	Net Book Value	Net Book Value
Computers	$ 637,718	$ 598,426	$ 39,292	$ 47,774
Software	19,362	19,362	-	-
Vehicles	96,033	93,376	2,657	3,266
Furnishings & Equipment	1,917,553	1,671,050	246,503	224,513
Site Improvements	158,512	140,594	17,918	13,631
Buildings	5,089,649	2,434,314	2,655,335	2,760,570
	$ 7,918,827	$ 4,957,122	$ 2,961,705	$ 3,049,754

7. UNEARNED REVENUE

	1998	1997
Conditional grants (Schedule 2)	$ 588,101	$ 1,027,183
Contract research	490	-
	$ 588,591	$ 1,027,183

8. SUB-CONTRACT RESEARCH

During the year VIDO entered into sub-contract research collaborations with various third parties relating to funding from conditional grants and contracts including the following:

	Total Contract	Sub-Contract Research
Natural Sciences & Engineering Research Council of Canada	$ 89,600	$ 28,200
Beef Industry Development Fund	217,440	26,702
Vetrepharm Canada Inc.	125,000	32,000

9. OTHER EXPENDITURES

Other expenditures consist of VIDO operating accounts which include repairs and maintenance, equipment rental, annual report and technical bulletins, professional fees and Board expenses.

10. INCOME TAXES

The Organization is not subject to either federal or provincial income taxes.

11. RELATED PARTY TRANSACTIONS

a) VIDO is a research affiliate of the University of Saskatchewan. The University of Saskatchewan maintains, as part of its normal operations, various financial and administrative functions relating to VIDO. The financial statements do not include expenditures for administrative and ancillary services, or in-kind support provided by the University of Saskatchewan.

b) The University of Saskatchewan is the beneficiary of a Trust which owns 27.54% of BIOSTAR Inc. as at March 31, 1998 (1997-35.6%). BIOSTAR Inc. is a research and development company associated with the development of some of VIDO's products and technologies. During the year VIDO had the following transactions with BIOSTAR Inc.:

	1998	1997
Income from BIOSTAR Inc. to VIDO		
Contract research	$ 21,922	$ 320,448
Contract services and leases	8,596	7,617
Royalties	200,000	189,125
Expenditures made by VIDO on BIOSTAR's behalf	-	41,474

At September 30, 1998 the Organization has a receivable from BIOSTAR Inc. of $108,659 (1997 - $137,783).

c) In 1993, VIDO entered into technology access agreements relating to specific products with BIOSTAR Inc. Income of $4,699,876 generated from these agreements is in the Technology Development Trust fund. Consideration for this transaction was a Note Receivable (Note 5). During the current year, the allowance was increased by $530,867 to $4,552,823 to recognize a potential decline in value of this receivable.

12. RESTATED FINANCIAL STATMENTS

In compliance with the new accounting recommendations of The Canadian Institute of Chartered Accountants, VIDO has changed its accounting policies regarding capital assets and the presentation of restricted funds. Certain of the prior year's comparative figures have been reclassified to conform to the current year's presentation.

a) Capital Assets

Previously, capital assets purchased through the Capital Trust fund were recorded as expenditures to that fund with a corresponding entry to equity in Capital Assets. Capital assets purchased with Research Trust funds were expensed as purchased and not included on the balance sheet as assets. Under the new recommendations, capital assets are capitalized and are amortized in the Research Trust fund.

b) Restricted Fund Presentation

During the year, certain activity was transferred between the year-end fund balances of the Research Trust fund to accurately reflect changes which resulted from compliance with the deferral method of accounting for restricted contributions.

The effect of these changes have been reflected retroactively to the financial statements as follows:

		1998	1997
Research Trust fund balance, beginning of year as previously reported		$ 1,481,159	$ 1,299,166
Restatements:			
a) Capital Assets:	Capitalize expenditures	2,136,926	1,915,804
	Record amortization	(4,730,423)	(4,515,557)
	Capital assets purchased through Capital Trust	5,643,251	5,643,251
b) Change in fund balance reflecting change in accounting policy		(421,066)	(425,333)
		$ 4,109,847	$ 3,917,331

13. CONTINGENCIES

VIDO has entered into certain contractual arrangements which may require repayment of the contracted amount if the research sponsored by the contract results in commercialization. There are no amounts repayable under these contracts at September 30, 1998.

14. UNCERTAINTY DUE TO THE YEAR 2000

The Year 2000 Issue arises because many computerized systems use two digits rather than four to identify a year. Date-sensitive systems may recognize the year 2000 as 1900 or some other date, resulting in errors when information using year 2000 dates is processed. In addition, similar problems may arise in some systems which use certain dates in 1999 to represent something other than date. VIDO relies on the computer systems utilized by the University.

The University is currently working to resolve the potential effect of computer system failure in the event the University's computer programs fail to properly recognize the year 2000 before, on, or after January 1, 2000. If not addressed, the impact on operations and financial reporting may range from minor errors to significant systems failure which could affect an entity's ability to conduct normal business operations.

Despite the University's efforts to address this issue, it is not possible to be certain that all aspects of the Year 2000 Issue affecting the University, including those related to the efforts of customers, suppliers, or other third parties, will be fully resolved.

UNIVERSITY OF SASKATCHEWAN
VETERINARY INFECTIOUS DISEASE ORGANIZATION (VIDO)

SCHEDULE OF DONATIONS AND UNCONDITIONAL GRANTS

YEAR ENDED SEPTEMBER 30, 1998

(1997 figures restated - See Note 12)

	1998	1997
LIVESTOCK INDUSTRY		
Beef		
Ontario Cattlemen's Association	$	$ 6,000
Saskatchewan Horned Cattle Trust Fund	35,000	-
Kamloops Stockmen's Association	-	700
Saskatchewan Cattle Marketing Deductions Fund	85,000	-
	120,000	6,700
Dairy		
Alberta Milk Producers	-	25,000
Dairy Farmers of Ontario	25,000	50,000
	25,000	75,000
Swine		
Ontario Pork Producers' Marketing Board	55,000	35,000
Alberta Pork Producers Development Corporation	50,000	46,260
BC Hog Marketing Commission	-	2,500
Manitoba Pork est.	20,000	20,000
SPI Marketing Group	40,000	24,770
Swine Improvement Services Cooperative Ltd.	190	174
	165,190	128,704
Poultry		
Alberta Chicken Producers	15,840	16,330
Canadian Turkey Marketing Agency	25,000	25,000
	40,840	41,330
PROVINCIAL GOVERNMENTS		
Alberta	20,000	20,000
British Columbia	700	700
Manitoba	15,200	15,200
	35,900	35,900
OTHER FOUNDATIONS, COMPANIES AND INDIVIDUALS		
Individuals	500	-
Saskatoon Livestock Marketing Association	-	200
	500	200
	$ 387,430	$ 287,834

Schedule 2

UNIVERSITY OF SASKATCHEWAN

VETERINARY INFECTIOUS DISEASE ORGANIZATION (VIDO)

SCHEDULE OF CONDITIONAL GRANTS AND CONTRACTS

YEAR ENDED SEPTEMBER 30, 1998

(1997 figures restated - see Note 12)

	September 30, 1997		1998	September 30, 1998			
	Accounts Receivable	Unearned Revenue	Funds Received	Accounts Receivable	Unearned Revenue	1998 Income	1997 Income
Natural Sciences & Engineering							
Research Council of Canada (NSERC) -Operating, Strategic and Equipment	$ -	$ 271,739	$ 413,870	$ -	$ 128,913	$ 556,696	$ 456,743
-Industry Matching	-	13,362	-	-	-	13,362	52,642
BIOSTAR Inc. - NSERC Industrial Research	-	13,717	-	-	-	13,717	66,285
Canadian Bacterial Diseases Network (CBDN)	-	15,087	179,690	-	35,951	158,826	194,380
Agriculture Canada/NSERC Research Partnership Grants	-	80,786	65,750	-	79,609	66,927	48,640
Medical Research Council	-	236,506	154,558	-	44,365	346,699	162,930
World Health Organization	5,156	-	28,334	-	232	22,946	74,088
Ontario Cattlemen's Association	-	-	40,000	-	23,001	16,999	-
Alberta Agriculture Research Institute (AARI) -Matching Grants Program	-	58,716	285,786	44,255	78,572	310,185	318,158
Human Frontier Science Program	-	-	80,710	-	16,164	64,546	-
Alberta Cattle Commission	-	21,331	36,000	-	-	57,331	86,395
Saskatchewan Agriculture Development Fund	-	112,921	172,946	-	12,365	273,502	129,882
Saskatchewan Beef Development Board	-	46,920	19,000	42,806	-	108,726	112,181
Canada-Alberta Beef Industry Development Fund	-	-	67,965	-	38,864	29,101	-
Beef Industry Development Fund	-	81,843	218,412	-	71,375	228,880	138,509
Beef Cattle Industry Development Fund	-	5,561	4,920	870	-	11,351	229
Agri-food Innovation Fund	-	-	90,000	-	58,690	31,310	-
Health Services Utilization and Research Commission	-	7,056	-	-	-	7,056	28,992
Saskatchewan Health Research Board Fellowship	-	61,638	-	-	-	61,638	49,676
	$ 5,156	$ 1,027,183	$ 1,857,941	$ 87,931	$ 588,101	$ 2,379,798	$ 1,919,730

Patents Issued on Which VIDO Staff are Inventors

United States Patent No 5,708,155
Title: Enhanced immunogenicity using leukotoxin chimeras.
Date – January 13, 1998
Inventors – Potter, A.A., Redmond, M.J., and Hughes, H.P.A.

Australian Patent No 683,221
Title: Novel bacterial vaccines using vaccine strains of pathogenic bacteria.
Date – February 26, 1998
Inventors – Allan, B. and Potter, A.A.

United States Patent No 5,723,129
Title: GnRH-leukotoxin chimeras.
Date – March 3, 1998
Inventors – Potter, A.A. and Manns, J.G.

United States Patent No 5,747,309
Title: Novel bacterial vaccines using vaccine strains of pathogenic bacteria.
Date – May 5, 1998
Inventors – Allan, B.J. and Potter, A.A.

United States Patent No 5,801,018
Title: Vaccines for *Actinobacillus pleuropneumoniae*
Date Issued- September 1, 1998
Inventors – Potter, A.A., Gerlach, G.F., Willson, P.J., Rossi-Campos, A.

Research Publications in Scientific Journals

Abdelmagid, O.Y., Mansour, M., Minocha, H.C., and van Drunen Littel-van den Hurk, S. 1998. Evaluation of baculovirus-expressed bovine glycoproteins for detection and analysis of BHV-1 specific antibody responses. Vet. Microbiol. 61: 249-259.

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Braun, R.P., Babiuk, L.A., and van Drunen Littel-van den Hurk, S. 1997. Enhanced immune responses to an intradermally delivered DNA vaccine expressing a secreted form of BHV-1 gD. Vaccine Research 6: 151-164.

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Huang, H.S., Potter, A. A., Campos, M., Leighton, F. A., Willson, P., and Yates, W.D.G. 1998. Pathogenesis of porcine *Actinobacillus pleuropneumonia*: Part I. Effects of Surface Components of *Actinobacillus pleuropneumoniae in vitro* and *in vivo*. Can. J. Vet. Res. 62: 93-101.

Jiang, M., MacLachlan, P.R., Babiuk, L.A., Bolton, A., and Potter, A.A. 1998. The abp locus of *Streptococcus uberis* encoding a protein homologous to polar amino acid and opine binding proteins of gram-negative bacteria. Can. J. Micro. 44: 784-788.

Kumor, L.W., Olkowski, A.A., Gomis, S.M., and Allan, B.J. 1998. Cellulitis in broiler chickens: Epidemiological trends, meat hygiene, and possible human health implications. Avian Diseases. 42: 285-291.

Lee, J.B., Babiuk, L.A., and Yoo, D. 1998. A neutralizing monoclonal antibody to bovine rotavirus VP8 neutralizes rotavirus infection by mechanisms bypassing inhibition of virus attachment to MA-104 cells. Can. J. Vet. Res. 62: 63-67.

Lee, J.B., Baxi, M.K., Idamakanti, N., Reddy, P.S., Zakhartchouk, A.N., Pyne, C., Babiuk, L.A., and Tikoo, S.K. 1998. Genetic organization and DNA sequence of early region 4 of bovine adenovirus type 3. Virus Genes 17: 99-100.

Lee, J.B., Yoo, D., Redmond, M.J., Attah-Poku, S., van den Hurk, J., and Babiuk, L.A. 1998. Characterization of the Interaction Between VP8 of Bovine Rotavirus C486 and Cellular components on MA-104 Cells and Erythrocytes. Can. J. Vet. Res., 62: 56-62.

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Zakhartchouk, A.N., Reddy, P.S., Baxi, M.K., Baca-Estrada, M.E., Mehtali, M., Babiuk, L.A., and Tikoo, S.K. 1998. Construction and characterization of E3 deleted bovine adenovirus type 3 expressing full length and truncated form of bovine herpesvirus type 1 glycoprotein gD. Virology 250: 220-229.

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Braun, R.P., Babiuk, L.A., and van Drunen Littel-van den Hurk, S. 1998. Effect of antigen on the bias of the response induced by DNA immunization. Keystone Symposium on Cellular and Molecular Biology of Dendritic Cells. Santa Fe, NW.

Bunka, S., Potter, A.A., Gerlach, G.F. 1998. Cloning and sequencing of the transferrin-binding protein genes of *Actinobacillus pleuropneumoniae*, biotype 1 – serotype 5 and biotype 2 – serotype 2. American Society for Microbiology Annual Meeting, Atlanta, GA. May.

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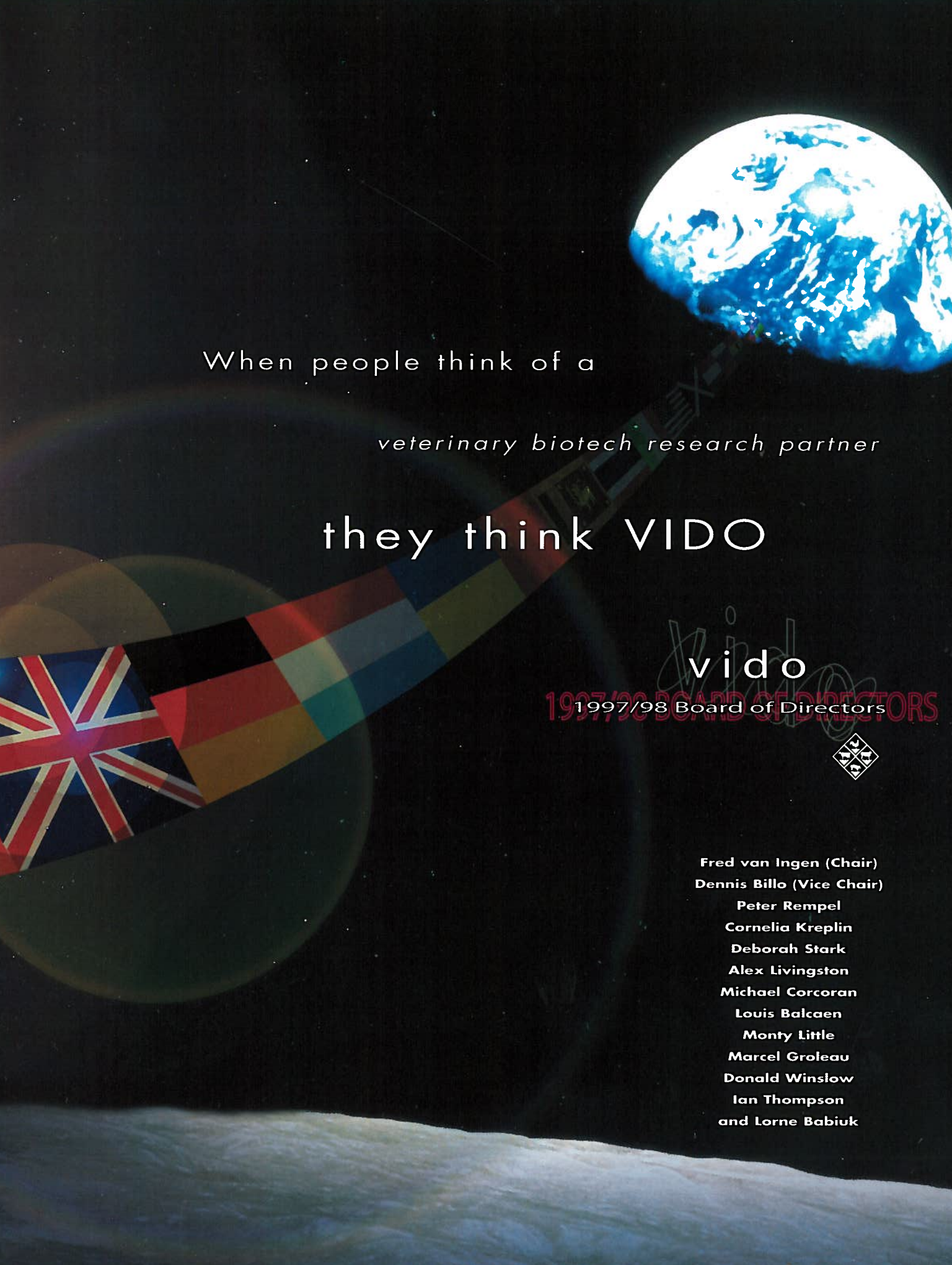
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