

Cat cancer vaccine

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OSU vet research prevents fatal feline leukemia



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Professor
Richard Olsen

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By Earle Holland

A vaccine that prevents the onset of feline leukemia, a commonly fatal disease in cats that is similar to human leukemia, has been developed by veterinary researchers at Ohio State University.

Similar types of leukemia threaten at least a half-dozen other kinds of animals including man, and the clue that led to the success with feline leukemia is present in all types of the disease.

A small protein molecule nestled in the surrounding envelope of the feline leukemia virus is the key. The molecule, long known to exist but little understood, is able to turn off the body's immune system which otherwise would destroy the virus.

The vaccine is really two vaccines in one, explains Richard Olsen, professor of veterinary pathobiology. As a disease, leukemia presents two threats to the body. The virus causes a massive viral infection within the body and, later, the development of tumors.

A decade of blind alleys

Work on the vaccine had continued for nearly a decade with the conventional approaches toward vaccine development leading from one blind alley to another.

The traditional method of producing a vaccine has always been to inject some of the weakened or killed virus into the animal or human. Then the body's own immune system will produce specific antibodies for the virus, providing permanent immunity.

But, Olsen says, when they tried this method with cats, it just didn't work. In fact, it made the cats even more susceptible to the disease.

"That was hard to explain," Olsen says. "It could have been that killing the virus rendered it toxic. There could be all kinds of explanations."

Walking carriers of feline leukemia

The researchers then tried another tactic. Instead of trying to attack the original virus, Olsen's team sought to thwart the tumors that develop later in the disease.

The tumor antigen, a foreign protein that shows up on the tumor, is fairly well characterized, he says, and has been for some time.

"We thought that if we grew tumor cells in tissue culture, killed them and the virus, and inoculated the cats with the combination, this would serve as a vaccine," Olsen explains.

The researchers went through a complicated procedure to kill the tumor cells and virus, and initial tests were encouraging. Those cats that were inoculated did not develop tumors from the disease.

But while the cats developed no tumors, they still developed the viral infections and became walking carriers of feline leukemia.

"They were shedding the virus like crazy. This would have been a more dangerous situation than if we just let the cats die of the disease," he says.

Killed virus shut down the immune system

Their next attempt was to make a vaccine against the virus and to add it to the anti-tumor vaccine. "Then, we thought, we'd have the best of both worlds. It would be a dual vaccine—one for the tumor and one for the virus," he says.

But the cats that were given the dual vaccine proved even more susceptible to the disease than were the control cats who received nothing. This negative result proved to be the turning point in conquering the disease.

"The killed virus wasn't simply toxic. It was immunosuppressive," he says. Therefore, the cats' built-in protective systems offered no protection.

"It turns out that this is how leukemia in cats and humans works. There is this loss of immune functions that accompanies disease."

Later tests showed that the killed virus was able to shut down the immune system. The researchers tested each of the seven proteins in the virus and discovered that one on the "envelope" of the virus was the trigger.

Vaccine gives 'phenomenal' protection

The researchers were able to grow the tumor cells in the laboratory and then harvest the needed material for the vaccine from the cultures.

"We used this material as the vaccine and it worked fantastically. We're getting a protection greater than 80 percent, which is phenomenal," Olsen says.

The vaccine works as a preventive agent. It will protect the cat from feline leukemia before exposure but does little for the animal after it has contracted the disease.

As for the human leukemia connection, research is continuing to compare the intricacies of the two diseases. Olsen's team is taking part in another study which examines whether humans produce antibodies for feline leukemia by checking the families that have leukemic cats in their households.

"The animal link to human leukemia is a valid point to investigate. It shouldn't be swept under the rug. But nothing has been shown to substantiate a linking as yet," Olsen says.

"There's not one shred of solid evidence that feline leukemia has anything to do with human leukemia." On the other hand, he adds, nothing has been found that disproves a relationship between the two diseases.

Earle Holland is the University's research editor and assistant director of communications services.



The Ohio State University

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NOTE TO EDITORS: A radio actuality of Olsen discussing the vaccine is available by calling the OSU Info Line at (614) 422-4053 through Jan. 29.

COLUMBUS, Ohio -- Veterinarians are now receiving the first batches of a new vaccine that will protect cats against their No. 1 killer -- feline leukemia.

The vaccine, developed by Richard Olsen, professor of veterinary pathobiology at Ohio State University, is produced by Norden Laboratories, a subsidiary of SmithKline Beckman.

Distribution began in early January. Most veterinarians do not have the vaccine yet.

The new vaccine provides protection against all cancers known to exist in cats, Olsen says. Scientists believe that cats develop cancers primarily from the feline leukemia virus.

Feline leukemia virus causes various problems in cats, including lymphosarcomas (cancers of the lymphatic system), aplastic anemia, reproductive failure and respiratory infections. It also causes the immune system to fail.

The immune system failure is similar to that which occurs in

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acquired immune deficiency syndrome (AIDS) in man. Because of the similarity of feline leukemia virus and AIDS, Olsen believes the unusual method that he used to create the cat vaccine may provide a clue to developing a vaccine for AIDS.

The vaccine is the first to use a new approach to protect animals against disease. Applying this approach to other diseases may lead to the development of vaccines against other ailments that have eluded vaccine efforts in the past.

Traditionally, killed or modified live virus were injected into the body to initiate immunity to that virus. Attempts at using those techniques to produce a feline leukemia vaccine have failed.

Modified live vaccines also produce a mild case of the diseases, Olsen says, so they carry a certain element of risk.

"The feline leukemia vaccine does not risk infecting animals," he says. It creates immunity through two protein molecules derived from cells infected with the virus, rather than from complete virus cells.

One protein molecule immunizes cats to the viral infection caused by feline leukemia virus.

The second protein molecule protects cats from the development of tumors caused by the virus. This protection is needed only when the vaccine has failed to completely prevent growth of the feline leukemia virus in a cat.

Both proteins used in the vaccine are of types that can reside on the membrane of viral infected cells. This is important because using proteins from the cell membrane is safer than using the virus itself as an immunizing agent.

Development of some vaccines against some other diseases in animals and man has been hampered by the same problems that plagued feline leukemia vaccine research. Vaccines using modified live virus of those diseases actually would do more harm than good because they would give the diseases to vaccine recipients.

"In theory, the approach we used in feline leukemia virus has the potential to aid in developing vaccines for many other viruses," Olsen says.

Olsen developed the vaccine in 1980. He and others conducted field tests of it for several years.

Those tests lead him to believe that the vaccine will be effective in close to 100 percent of the cats that receive it. Cats will receive maximum protection if they they receive a second dose of the vaccine two to three weeks after they get their first dose of it and receive a booster shot two to four months later.

The vaccine is licensed by the U.S. Department of Agriculture. Ohio State's Research Foundation holds a patent to it.

The incidence of feline leukemia virus varies from area to area. Up to 10 percent of the cats in some suburban areas where many cats run outdoors have it, Olsen estimates.

"If one cat in a home has the disease, it is not uncommon for all cats in the home to become infected," Olsen says.

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Contact: Richard Olsen, (614) 422-5661.
Written by Chris Eversole

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College Researcher Invents First Feline Leukemia Vaccine

by Connie Bart

When Norden Laboratories Inc. began distributing Leukocell, the first vaccine effective against feline leukemia virus (FeLV), early this year, it brought to triumphant conclusion a detective drama that began at The Ohio State University's College of Veterinary Medicine almost 15 years ago.

Dr. Richard Olsen, professor of veterinary pathobiology, and colleagues at the college had been working since 1970 on FeLV and the complex immunological puzzles that stood in the way of a vaccine effective against it. Literally through trial and error, they unraveled the virus's mysteries and developed the experimental vaccine that was the forerunner of Leukocell.

The commercial vaccine was approved by the U.S. Department of Agriculture in November 1984 and is now being distributed to veterinarians throughout the United States and Canada. It is expected to provide almost complete protection against FeLV disease, the leading cause of morbidity and mortality in cats.

FeLV, which is highly contagious, impairs the immune systems of infected animals, making them more susceptible to respiratory diseases, infectious peritonitis, reproductive failure, panleukopenia-like syndrome, fading kitten syndrome, and other diseases. The virus is also linked to several blood cell cancers and lymphosarcomas that develop after the initial infection.

While some cats exposed to FeLV become resistant to the virus, about 30 percent develop a persistent FeLV infection that usually causes death in 16 to 21 months. Another 30 percent become "latent carriers," capable of transmitting the virus to other cats without appearing sick themselves.

John Swartz



Dr. Richard Olsen and feline friend

Before Leukocell, cat owners could only hope to protect their animals against FeLV by isolating them from other cats—a strategy that was impractical for many owners.

The significance of Dr. Olsen's work goes beyond its obvious benefits to cats and cat fanciers, however. The understanding of basic disease mechanisms gained from work with FeLV may be applicable, for example, to other diseases that depress the immune system (e.g. human acquired immune deficiency syndrome or AIDS) or to those caused by similar retroviruses (e.g. equine infectious anemia). Moreover, the unusual methods used to produce the vaccine may be applicable to other viral diseases for which no vaccine is yet available.

Dr. Olsen's work on FeLV began initially along conventional lines, using vaccines made from both killed and modified live viruses. The results were both puzzling and disappointing. Vaccines made from killed viruses seemed to protect adult cats but often made kittens even more susceptible to FeLV disease.

Modified live viruses seemed to protect adult cats but often killed young kittens, who are naturally more susceptible to the disease. Even more distressing, the modified live virus vaccines posed the threat of creating a large population of animals with sub-clinical signs who might be active carriers of the disease.

Since FeLV is a two-part disease characterized first by anemia and suppression of the immune system and subsequently by the development of tumors, Dr. Olsen and his colleagues also tested a vaccine made from killed FeLV tumor cells. This vaccine did protect animals against development of tumors, but it did not prevent the initial FeLV infection or prevent infected cats from becoming carriers of the virus.

And when Dr. Olsen combined killed tumor cells and killed FeLV in one vaccine—an approach that logically might be expected to prevent both phases of the disease—cats became even more susceptible to FeLV and lost their immunity to tumors.

(continued on page 5)

The commercial vaccine was approved by the U.S. Department of Agriculture in November 1984 . . . It is expected to provide almost complete protection against FeLV disease, the leading cause of morbidity and mortality in cats.



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protection . . . E. coli vaccine with an exclusive genetically-engineered toxoid . . . the list goes on.

The challenge also goes on. At the moment, research projects are underway in recently enlarged facilities. Projects that may begin with something as simple as making improvements in an existing product . . . or as exciting as a vaccine for feline leukemia.

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Obviously something was interfering with the cat's ability to respond immunologically to FeLV virus or tumor antigen. The "something," Dr. Olsen and his colleagues discovered, was a small immunosuppressive protein molecule (FeLV p15E). Their goal became production of a vaccine free from the immunosuppressive protein that would protect cats of all ages against FeLV.

The result was the soluble tumor antigen vaccine upon which Leukocell is based. Immunity is conferred by two protein molecules, one that protects cats against infection by FeLV virus and a second that protects cats from the subsequent development of tumors. The proteins are shed naturally by a line of FeLV-induced tumor cells kept in serum-deficient medium at 37 degrees C. The troublesome FeLV p15E protein, which presumably is also shed by the dying tumor cells, seems to lose its immunosuppressive properties in the process.

Soon after Dr. Olsen developed the soluble tumor antigen vaccine, Norden Laboratories Inc. became interested in its commercial

development. Dr. Olsen has since worked closely with Norden on further tests of the vaccine and on adapting his methods to commercial production.

While Dr. Olsen's basic methods of vaccine production remain essentially unchanged, they have been adapted to make them economical in large scale production and to ensure adequate and consistent concentrations of vaccine antigens. Norden has also employed an adjuvant that enhances immunity without increasing the risk of adverse reactions.

The vaccine was tested for efficacy in cats of various ages under a wide range of conditions, both in the laboratory and in a large multi-cat household in central Ohio, with excellent results.

Even among animals whose immune systems had been artificially suppressed, the vaccine was 80 percent effective in preventing FeLV infection and 92 percent effective in preventing subsequent tumor formation. These studies suggest that the vaccine should be almost 100 percent effective under conditions of general use.

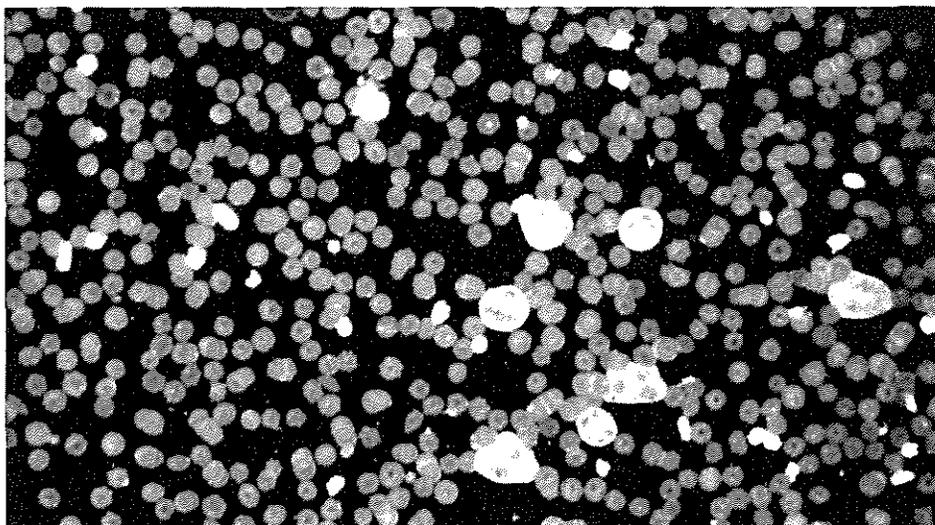
Dr. Olsen's work on the FeLV itself was patented in June, 1982, and his procedure for producing the vaccine was patented in February, 1984. Ohio State owns both patents and will receive royalties from Norden on vaccine sales, which are expected to be between \$10 million and \$75 million annually.

Like all vaccines, Leukocell can only prevent infection; it cannot help animals already infected with FeLV. Therefore, cat owners and veterinarians may want to determine before vaccination whether or not an animal is infected with FeLV. Several blood tests are now available to detect persistent FeLV infections; detection of "latent carriers," however, is a more complex process requiring sampling of bone marrow. Cats that test positive for FeLV should be isolated from other cats or euthanized to prevent spread of the disease.

The virus is transmitted from cat to cat primarily through saliva while cats are licking, biting or sneezing. Less frequently FeLV is spread via urine or feces through shared litter pans or from infected mother cats to their nursing kittens.

FeLV infection is particularly troublesome in multi-cat households and catteries, but it also has become a problem in many suburban areas where cats are allowed to run outdoors. In some suburban areas, it may affect as much as 10 percent of the cat population.

Because of the wide incidence and often devastating consequences of FeLV disease, Norden recommends vaccination for all healthy cats nine weeks of age or older. Maximum protection is achieved with two doses given two or three weeks apart and a booster given two to four months later. After that, yearly revaccination is advised.



This is an indirect immunofluorescence diagnostic test for feline leukemia demonstrating positive cells in a blood smear from leukemia-infected cat.

Student Awards and Scholarships

DAVID WILSON MEMORIAL SCHOLARSHIPS

John Swartz



Seated, left to right: Alan Downie, Anita Kay Poling, Marilyn Sexton
Standing, left to right: Salvatore Butera, Richard Hurley

The following five students received the David Wilson Memorial Scholarships consisting of a \$100.00 award. This scholarship is based on financial need and good academic standing.

Salvatore (Tom) Butera is a fourth-year student simultaneously pursuing the doctor of veterinary medicine degree and the master of science degree in veterinary pathobiology. Tom previously received a bachelor's degree in chemistry from Otterbein College, graduating with honors. After graduation he plans to continue his education in physiology or pathology and do research in his chosen field.

Freshman student **Alan A. Downie** previously received a bachelor's degree in chemistry from Carlton College, graduating magna cum laude. He plans to work toward owning his own small animal hospital upon completion of his formal veterinary medical education.

Richard James Hurley is a second-year student who previously received a bachelor's degree in biology from Iona College and master's degree in zoology from the University of New Hampshire. Upon graduation, he plans to teach and conduct research in veterinary parasitology.

Anita K. Poling is a first-year student who previously received a bachelor's degree in zoology from Ohio State, graduating summa cum laude. When she completes her DVM program, Anita plans to enter a mixed veterinary practice.

Junior student **Marilyn A. Sexton** has an associate degree in nursing which she has found helpful in the management of her animal patients. Her interests lean toward small animal medicine and surgery, and Marilyn has also expressed an interest in veterinary medical research.

John Jewett



NATIONAL ALPHA ZETA FOUNDATION SCHOLARSHIP

Freshman student **Penny S. Stalnaker** was awarded a National Alpha Zeta Foundation Scholarship of \$1,000 for the 1984-85 academic year. Prior to her admission to the College of Veterinary Medicine, she was an agriculture honors student at the University of Nebraska. The Burkett-Cunningham-Dennis Scholarship is the top honor made by the Foundation. The recipient serves as the voting member of its board of trustees for the academic year in which it is received and Penny will be the 18th member to serve in that capacity.

ANIMAL CHARITY OF OHIO

John Jewett



William F. Greentree, a third-year student in the College, has been

Twice-Told Tales

Catching up on past stories

1980

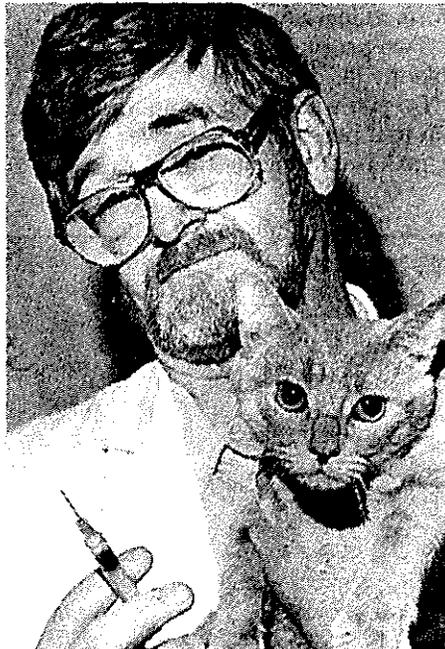
A feline leukemia vaccine developed by researchers here has proved to be a boon, not only to cats and their owners but also to the University.

In 1980, *Quest* (Vol. 2, No. 5) profiled the development of the revolutionary vaccine by Richard Olsen, professor of veterinary pathobiology. The vaccine was the first to successfully prevent the onset of feline leukemia, which afflicts an estimated 1.5 million of the nation's 50 million cats.

The University has the reaped rewards of that vaccine.

The U.S. Department of Agriculture approved the use of the vaccine in November 1984, and it was made available to veterinarians the next January. The drug is sold by Norden Laboratories, Inc., which pays royalties to Ohio State.

"This drug has been a tremendous commercial success and has proved to be very effective in the field," Olsen said. The technique responsible for producing the immunity may also be useful in developing other, perhaps human, vaccines.



Cat disease not AIDS, OSU researchers say

By Gail Bushman
Lantern staff writer

The recent research findings from California indicating the existence of an AIDS-like virus in cats, may be nothing more than mere smoke and are not accurate, according to Dr. Richard Olsen, professor of veterinarian medicine for Ohio State.

"Not to be cynical, but the information must be confirmed first," Olsen said.

"It wouldn't be appropriate for any scientist to say that the cat AIDS virus is real," Olsen added.

He said the research techniques and findings of the scientists in California do not follow the standard research methods developed by Robert Koch, a 19th century German microbiologist who discovered microbes. Microbes are bacterial agents which cause viruses, Olsen explained.

According to Koch and other scientists who accept his scientific theory, an organism believed to cause diseases must be specifically investigated. First it must be isolated, then studied and finally reproduced by inoculation into a living specimen to be considered valid. Olsen said this has not been done in the research with the AIDS-like virus in felines — cats.

Louis Lafrado, OSU research associate for retrovirology said, "I would be very hesitant to say that the (AIDS) virus (in cats) is real as it has not been validated. It is more likely a contamination from outside the living specimen and requires more intensive research and study."

The virus in cats was first discovered in 1982 in Petaluma, Calif. In research there a female kitten developed bouts of diarrhea and infections lasting for over a two-year period. Finally, the cat became anemic and died the next year after it was introduced into a pen with 42 other cats.

Since 1985, Olsen said there have been no significant reports of AIDS findings in cats.

The OSU College of Veterinary Medicine is not presently researching the possible AIDS virus thought by California researchers to exist in cats.

There are not adequate research funds available for Ohio State to pursue the project, Olsen said.

New center to study AIDS, other viruses

By Ryan Somerville
Lantern staff writer

A research center is being developed in the OSU Department of Veterinary Pathobiology to search for the disease-causing mechanisms of retroviruses, a family of viruses that includes the feline leukemia virus and the human AIDS virus.

Dr. Richard G. Olsen, a professor of pathobiology and the developer of the feline leukemia vaccine, will head the center.

Olsen said the retrovirus, a relatively new area of study, is of great interest because of AIDS in humans.

Even though a vaccine has been found for the feline leukemia virus, Olsen said they will continue to study it with hopes of making it relative to humans.

The cat leukemia vaccine provides a good model of what an AIDS vaccine should do, Olsen said.

Retroviruses inject their genetic material into the host cell and then replicate themselves.

Feline leukemia is a communicable disease that causes the cat's immunity system to break down.

When the feline leukemia virus attaches itself to a cell, proteins

are released that break down the immunity systems of neighboring cells, Olsen said.

"That is the very same logic we are extending to AIDS," he said.

Retroviruses first got serious attention in the 1960's and similar research is going on at Duke University, Harvard, and the University of California. But none are doing what Ohio State plans to do, Olsen said.

"We will be unique in our research approach," he said.

Olsen said they want to fully understand the behavior of retroviruses. If doctors are to find a cure for a retrovirus-related disease, he said, they must know what they are preventing and how they are preventing it.

Because the center will be located in the School of Veterinary Medicine, Olsen said they will have the advantage of working with animal models.

"You can't experimentally deal with humans," he said.

Dr. Vernon L. Carter, the associate dean of the College of Veterinary Medicine, will organize the center and interact with the staff so the center will run as smoothly as possible, he said.

Monkey vaccine

Ohio State researchers for the first time have immunized monkeys against infection by a distant relative of the AIDS virus that causes a rare form of leukemia, notes the *Los Angeles Times* in a front-page article.

The finding could help in development of an AIDS vaccine, the paper adds.

Richard G. Olsen, professor emeritus of veterinary pathology, estimated at least another three years of further studies will be required before the vaccine can be tested in human beings.

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Teacher, Rustin High School, Kansas, MO, 1960-1961.
Instructor, Met Jr. College, Kansas City, MO 1963-67.
From assistant professor to professor, microbiology,
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Author: Immunology and Immunopathology, 1979.
Feline Leukemia, 1981.
Also author of numerous papers.

Inventor of method of recovering cell antigen and preparation
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National Cancer Institute Grantee, 1973-

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International Society Immunopharmacology
International Association Research Leukemia
American Association for Cancer Research
American Society for Virology

Source of Information: Who's Who in America. 1988-1989.
45th Edition. Volume 2 (L-Z). p. 2337.

K. Grossi 7/89

Viruses and the Cancer Connection

By Earle Holland

Viruses are insidious creatures. Evading the body's immune system, they sneak inside normal cells and meld their genetic material with that of the host cell. As a result, when the cell multiplies, so does the virus. Often the cell produces so much virus that it bursts at the seams, killing the cell and spreading the virus further throughout the body.

This ability to transform the host cell's DNA and RNA has led some researchers to use certain viruses as carriers of new genetic instructions in hope of producing new gene therapies for diseases that can't be treated otherwise.

But this transformation of the cells also makes it impossible to kill the virus without killing the host cell, which can be fatal for the infected patient. Moreover, many viruses "hide" in the body in areas virtually impervious to drugs. This way, they can patiently wait until the immune system weakens and then attack. And, with cancer-related viruses, once infected, always infected.

For years, researchers hoped to discover that a single virus—or family of viruses—is the cause of all cancers. If that were the case, they reasoned, then an anti-cancer vaccine would be a possibility. As smallpox virtually is today, cancer might be eradicated.

We know better now. There are some links between a few viruses and certain cancers, but they're not the magic road to cures that we had hoped. So far, the progress by Ohio State University researchers has been considerable. The remaining challenges, however, may well be greater.

Sitting outside his woodworking shop on a small farm a half hour south-east of Columbus, Richard Olsen hardly looks the part of warrior. With classical music playing in the background, his graying hair shifting in the breeze of an unusually pleasant winter day, he seems the typical retired professor.

But for more than a decade, Olsen, a professor emeritus of veterinary pathobiology, led the battle to understand how one virus caused cancer; that fight led to the first practical anti-cancer vaccine. His feline leukemia vaccine was effective against the number one killer of cats. But it also offered a radically new way to make vaccines.

The story of how he and his colleagues thwarted the Feline Leukemia Virus (FeLV) is classic in several ways. First, there were no real "eureka" moments when great revelations suddenly appeared. The path to a practical vaccine was slow, spanning at least a decade. Second, it was non-traditional—that is, it defied almost all precedents in what led to past vaccines. And third, like so many other discoveries, it offered a new way of preventing viral infections.

Central to understanding viruses and their role in cancer is understanding the system that protects against them. Most people see the system as a simple machine that turns on when it senses a threat. An antigen—a bacteria or virus, for example—is recognized by the system, which produces antibodies to fight it.

In reality, this explanation is about as valid as saying a Model T Ford is no different from a Grand Prix race car. True, both are automobiles, but one is a thousand times more complex than the other. Immunity involves a multitude of different cells and proteins, enzymes and compounds that together control potential invaders. But any alteration in any part of that system can trigger an immune breakdown. And with feline leukemia, the triggers were two proteins called FOCMA and P15c.

In the mid-1970s, Olsen left Roswell Park Cancer Institute to begin work at OSU's Comprehensive Cancer Center on the feline leukemia virus. The project had been under way for some time, but nothing seemed to work. Researchers had tried the traditional approaches of using live virus, weakened virus, and dead virus to try to immunize cats against the disease but were unsuccessful.

"The vaccinated cats were dying faster than the controls. Our attempts at cure were killing the animals!" Olsen said it was a "classic mistake. We had a preconceived idea of what we expected, and ultimately it was wrong."

The key lay in the cats that resisted the virus, Olsen explained. They produced an antibody to a very unusual antigen that showed up on the surface of a cat's virally infected cells. The researchers called it FOCMA—feline oncornovirus cell membrane antigen. In the life cycle of the cell, the antigen is naturally shed into the bloodstream.

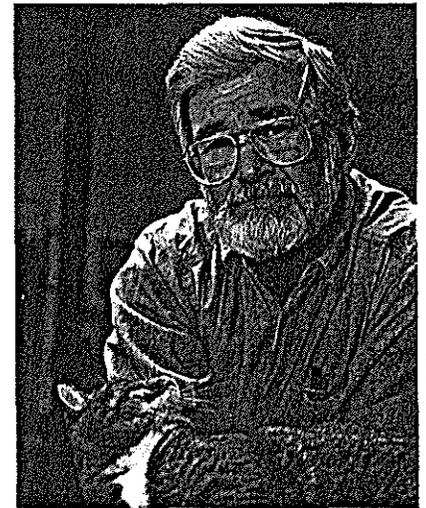
"Cats that responded strongly to FOCMA showed great resistance to disease. Those with little or no response to the antigen showed little, if any, disease resistance. That was a major finding."

But the FOCMA results were only half of the puzzle. P15c was the other half. The feline leukemia virus carried with it this other protein, one capable of slowing or halting the animal's normal immune response, giving the virus a better chance to survive and flourish.

"It turns out that P15c or its equivalent is in all retroviruses," Olsen said, "including the human immunodeficiency virus (HIV) that leads to AIDS."

Later work suggested that the researchers had located the P15c at just the right moment. These proteins are first made in an inactive precursor form—that is, they migrate to the surface of the infected cell and are then altered in a way that allows them to re-enter the cell and change its DNA.

Using the FOCMA and inactive P15c proteins as a basis for the vaccine produced immunity in the animals. The vaccine was mar-



PHOTOGRAPHS BY JO MACULTY

Richard Olsen