Transgenic Animals By Next Decade

By Metta Winter

Thirteen years ago the proceedings of the first symposium on the genetic engineering of animals showed promise for the development of agriculturally important animals containing foreign genes. These so-called transgenic animals could revolutionize our food supply, acting as factories for producing scarce drugs and as research tools for improving our understanding of basic animal physiology. The news from the second international meeting, held at Cornell in June, is that their commercial production could begin by year 2000 or earlier.

"Symposium presentations showed the truly remarkable progress in addressing the problems that have limited the development of genetic engineering in animals," said Dr. William Hansel, chairman of the local and national organizing committees for the symposium and the Liberty Hyde Bailey Professor of Animal Physiology. "Although there's much work to be done, I'm optimistic that in the next ten years we'll see at least three commercial applications of this technology. First, the widespread manufacture of genetically engineered hormones, enzymes, and antiviral and antiserum products for use in both animal and human medicine. Second, reproduction techniques in which embryos are transferred into large groups of animals with synchronized cycles. And third, the genetic engineering of those embryos to contain genes for economically valuable traits."

Such commercial enterprises depend on several crucial advances in biotechnology that are now well on the way. One of the most important, according to Hansel, is targeted gene insertion. "Until this year getting the gene in was a random process. You didn't know what chromosome it would turn up on, therefore whether or not it would be expressed, and if it was expressed, whether it would be in a way that's healthy for the animal. With targeted gene insertion you know not only the chromosome but also the gene's location on that chromosome. Genes can also be targeted for expression in specific tissues."

That highly accurate insertion technique can be combined with another breakthrough—stem cell culture. Hansel explained that instead of micro-injecting the foreign gene into a pronucleus, as was previously done, in stem cell culture it's inserted more simply into undifferentiated cells that have been removed from an embryo and placed in culture. The stem cells are then put back into the embryo, which becomes a chimera, or a mixture of desirable genetic traits. The result can be pure lines of transgenic animals.

Success with in vitro fertilization and cloning of embryos by nuclear transfer makes it possible to produce an animal totally from an oocyte and sperm in the laboratory. As gene-mapping links specific genes to economic traits and as methods of gene insertion become more accurate and efficient it becomes possible to produce large numbers of genetically identical embryos that have been frozen, sexed, and screened for economic traits. Hansel foresees the establishment of companies that sell specialized cattle, sheep, swine, and poultry embryos designed to meet specific market criteria; for example, in lean, fast-growing pigs or dairy cattle that produce low-fat, low-cholesterol milk. The large artificial breeding units, he said, are potential embryo transfer centers.

The pure lines of transgenic animals produced through the centers can also be used to make pharmaceuticals. One symposium presentation described the successful production of an important blood clotting factor by transgenic sheep. "Animals can sometimes manufacture such drugs much more cheaply than even recombinant DNA.

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It is understandable why Arthur Gordon Danks selected veterinary medicine as his lifetime pursuit: he was born to a farm family at Allamuchy, New Jersey and his father was a widely known breeder and judge of dairy cattle and sheep. Danks also greatly admired, Dr. Neil Gordon Darby, the farm veterinarian.

Danks' began his formal education at Blair Academy Blairstown, New Jersey, then he went on to earn a B.S. at Pennsylvania State College in 1929. He leased and operated a 100 acre dairy farm in northern New Jersey during the year 1926-27, but this minor interruption only confirmed his desire to obtain a veterinary degree.

He entered Cornell's College of Veterinary Medicine in 1929 and, because of his advanced training, was able to finish his coursework in three and one half years. Since his classroom obligations were completed in midterm, he was permitted to assist in the Small Animal Clinic during the second semester of this final year. He was awarded the DVM degree in June 1933.

Upon graduation he spent a year in general practice at Allamuchy, New Jersey. In 1934 he obtained an appointment as instructor in the Department of Surgery and Medicine at Kansas State College, Manhattan, Kansas. It was in Kansas that he met and married Bernice Sutherland. To this happy union in due time were added four children. They are Mrs. Gary Homer (Marguerite), Gordon Sutherland, Edward Robert and Paul Douglas.

Dr. A. Gordon Danks

December 10, 1906—July 1, 1989

A. Gordon Danks, professor emeritus of veterinary surgery at the College of Veterinary Medicine at Cornell, died at home July 1st after a long illness. He was 82 years old. A memorial service will be held September 30, 1989, at 2:00 p.m. in the College's James Law Auditorium. The following is based upon a memorial statement written by Dr. Ellis P. Leonard '34.

Dr. A. Gordon Danks

In addition to this clinical and teaching duties he became active in the affairs of the Cornell Veterinarian, a unique veterinary publication with world-wide circulation. With the January issue of 1938, he became the assistant editor to Dr. D. H. Udall. When Dr. Udall resigned in 1939, Danks took over the editorship. At that time he was the youngest editor of a major veterinary publication in this country. He held this position until 1942 when the pressure of clinical teaching forced him to give it up.

By now World War II was in progress, the curriculum had been accelerated and Danks was the only person of faculty rank in the department (Dr. J. N. Frost was on sabbatic leave). Despite this, in the autumn of 1942, he published a new revised edition of Williams' Surgical and Obstetrical Operations.

In 1948 he left Cornell to become the director of the Department of Surgery and Medicine at the University of Illinois, Urbana, Illinois. He was disappointed with his choice and after a brief period moved to the University of Pennsylvania as professor of animal husbandry and manager of the New Bolton Farm at the School of Veterinary Medicine.

His return to Cornell in 1950 occurred shortly after the death of Dr. J. N. Frost. For the next twelve years he served as professor and head of the Department of Veterinary Surgery and director of the Large Animal Clinic. At that time he was forced to abandon his surgical activities because of a physical disability.

He was appointed the first director of Student Administration in 1962 and remained in that position until he retired in 1970. He was granted emeritus status that same year. His was an encyclopedic knowledge concerning the veterinary graduates from Cornell and many questions about our alumni were referred to him over the years. For his distinguished alumni service he was presented the Daniel Elmer Salmon Award in 1986.

Gordon Danks' contributions to veterinary medicine covered a broad spectrum. His publications, primarily on clinical veterinary surgery, were sound and concise. He was a good teacher and instilled professional discipline in his students. He served the American Veterinary Medical Association as a member of several councils and committees and as a trustee on the Group Insurance Trust. The AVMA awarded him Gold Star membership. At the state level, he was president of the New York State Veterinary Medical Society in 1973 and elected a distinguished member in 1981. He was also voted "Veterinarian of the Year" by the State Society in 1964. The Southern Tier Veterinary Medical Association elected him president in 1967 and in 1976 the New York State Agricultural Society awarded him a distinguished service citation.

His fraternal affiliations included Alpha Zeta, Gamma Sigma Delta, Phi Zeta, Phi Kappa Phi, Sigma Xi and Alpha Psi.

The Danks family requests that memorial contributions be directed to the A. Gordon Danks Large Animal Surgery Award in care of the Office of Public Affairs, College of Veterinary Medicine, Cornell University, Ithaca, New York, 14853. The award, initiated in 1978 by the faculty of the surgery section of the Department of Clinical Sciences, is in recognition of Dr. Danks' outstanding contributions. The award is presented to a senior student demonstrating outstanding knowledge and talent in the diagnosis and treatment of surgical problems of large animals.

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Alumni Profile

Practitioner Earns Research Award

Dr. Barry A. Lissman DVM '77, has received the Practitioner Research Award from the American Veterinary Medical Association in recognition of his outstanding accomplishments in veterinary medicine research.

Lissman was the first person to discover and report clinical findings on Rocky Mountain spotted fever and Lyme disease in dogs. In 1979 he was engaged in full-time companion-animal practice on Long Island—in what is now known to be an endemic area for Rocky Mountain spotted fever. "I was working on the eastern end of Long Island, and I had a case I couldn't diagnose," he said, "Nothing fit the signs. I keep up on human medicine, and I knew what Rocky Mountain spotted fever was like in a person. So I called some researchers at the U.S. Department of Health at SUNY Stony Brook who had developed a diagnostic test. They ran some blood samples for me." The patient, a dog, was found to be positive for the disease and responded well to subsequent treatment. Lissman continued to research the disease and to write about his findings for professional journals and textbooks.

Lyme disease, now the most commonly diagnosed tick-borne human disease in the United States, was first recognized in Lyme, Connecticut in 1975. No one had seen the disease in a dog until 1983 when Lissman diagnosed a case in his practice. "It was a lame dog with arthritis," he said. "Sure enough, he was positive for Lyme disease. The researchers at SUNY Stony Brook were able to culture the organism that causes Lyme disease [Borrelia burgdorferi] from a blood sample." Again Lissman wrote about his findings.

Surprisingly, Lissman never thought of a career in research after he received his DVM degree. The work that earned him the Practitioner Research Award was, he said, "just work I was doing in clinical practice." He received his doctor of veterinary medicine degree from Cornell in 1977. He is now the owner of Sachem Animal Hospital in Holbrook, NY.

The graph shows the total number of applicants to the College of Veterinary Medicine since 1934, the year class size began to be limited and selective admissions were initiated.

The first prominent peak in applicant numbers comes in 1947 shortly after the end of World War II, when men returning from the war may have decided to make veterinary medicine their career. It would be difficult to pinpoint a single reason for the rise in applications reflected by the strong peak in 1975. However, the large number of applications does reflect a worldwide trend at that time of more women entering the profession.
In The James Law Tradition

The College of Veterinary Medicine at Cornell University has established six James Law Professorships to recognize distinguished faculty who have earned national and international reputations in veterinary medicine and the biomedical sciences. The recipients also demonstrate a commitment to excellence and academic leadership. Dr. James Law was the first dean of the College of Veterinary Medicine and, as such, was responsible for giving shape to the College's tradition of excellence in teaching, research and service. The first James Law Professorship was held by Dr. George C. Poppensiek until his retirement in 1988. Two James Law Professors have been selected in 1989: Dr. Bud Tennant and Dr. Robert H. Wasserman.

Dr. Robert Wasserman is a former chairman of the Department of Physiology. In 1980 he was elected to membership of the National Academy of Sciences. He was a member of the Food and Nutrition Board in the National Academy of Sciences and he chaired a National Research Council committee that examined the scientific basis of this nation's meat and poultry inspection program. The first course on cellular physiology for veterinary students was organized by Dr. Wasserman and he helped develop graduate courses on the properties and function of biological membranes and on mineral metabolism. Over the years, he and colleagues have investigated various aspects of mineral metabolism, with emphasis on the action of vitamin D on the intestinal transport of calcium and phosphorus. Demonstrated early was the mediated transport of calcium and phosphate in vivo, and a major contribution was the discovery and determination of properties of a protein involved in calcium absorption, the vitamin D-induced calcium-binding protein, now named calbindin-D. Work on plants responsible for the economically important debilitating disease of calcinosis in ruminants in South America resulted in the isolation and identification of the toxic principle shown to be the most active metabolite of vitamin D, 1,25 dihydroxyvitamin D₃. Investigations continue on calcium metabolism and the action of vitamin D in various biological systems. These studies have been supported for thirty years by a continuing grant from the National Institutes of Health. Dr. Wasserman received the Mead Johnson Award in Nutrition in 1969, the Andre Lichtwitz Prize from the Institut National de la Sante et de la Recherche in 1982, and the Wise and Helen Burroughs Lectureship in 1980 and again in 1987. Dr. Wasserman holds a Ph.D. in nutrition from Cornell University and has been a member of the College's faculty since 1957.

Dr. But Tennant is chief of the Section of Medicine in the Department of Clinical Sciences and professor of comparative gastroenterology at the college. For almost a decade, he has studied the link between the hepatitis B virus group and liver cancer. It is estimated that worldwide more than 250 million people are chronic carriers of the hepatitis B virus and more than 300,000 die each year from liver cancer attributed to the viral infection. Recently his project was awarded an $8.9 million grant from the National Institutes of Health to continue study of the woodchuck hepatitis virus, a virus closely related to the hepatitis B virus that affects humans. The work will examine the role of hepatitis B virus infection in the pathogenesis of hepatitis and liver cancer and attempt to find improved methods of treating and preventing these diseases. Dr. Tennant is a diplomate and past-president of the American College of Veterinary Internal Medicine. In 1986 he was elected to membership in the National Academies of Practice and in 1988 he received the Alumni Achievement Award from the University of California at Davis. He has been a consultant or advisor to the U.S. Departments of Agriculture and Health and Human Services, the Fox Chase Cancer Center, the Morris Animal Foundation, and the Rockefeller Foundation. He has been a member of the College's faculty since 1972.
Fatal Syndrome Studied in Salmon

The offspring of landlocked salmon in Cayuga Lake are dying, says Dr. Jan Spitsbergen, and no one knows why. An assistant professor in the Department of Avian and Aquatic Animal Medicine, Spitsbergen is studying the problem of early mortality in landlocked Atlantic salmon in Cayuga Lake. Last fall Cornell's Fish Pathology Laboratory and the Department of Environmental Conservation (DEC) initiated a joint investigation of the mortality syndrome. They found that 98 percent of the Cayuga Lake salmon weakened and began dying three weeks after hatching, while the offspring of fish taken from a similar lake in the Adirondacks showed less than 5 percent mortality by the onset of feeding.

Salmon were once indigenous to several of the Finger Lakes, but the native population died out in the late 1800s when mill dams appeared on many streams and inlets, blocking the salmon's access to Lake Ontario, a major feeding area. Then growing urban areas and farming silted in most of the original spawning beds. “Now,” said Spitsbergen, “natural reproduction can’t occur in most of the lakes because the spawning habitats have disappeared.”

The DEC, in order to keep the sport of salmon fishing alive, strips eggs from adult salmon, artificially fertilizes them, and raises the offspring in a hatchery. It later releases the fish into the waterways. To stock the Finger Lakes, a large supply of eggs is needed. According to Spitsbergen: “Because the fish can’t reproduce in the Finger Lakes, you have to keep renewing the population. You want to get abundant eggs so you can stock all the lakes with sufficient numbers.” The DEC has relied on eggs from salmon in Little Clear Pond in the Adirondacks. Although the eggs are healthy, the pond's small size and limited food supply restricts the size of the females and their egg production. In Cayuga Lake, however, with its good forage base, female salmon grow quite large and produce lots of eggs. Unfortunately, none of the salmon eggs from Cayuga Lake survive. “We’ve tried to raise salmon from Cayuga Lake in the hatcheries since the early seventies,” said Spitsbergen. “All of them died three weeks after hatch at a particular stage of development.”

Why they die at three weeks is not an easy question to answer. Certain stages of development are exquisitely sensitive to some toxicants such as PCBs and dioxins. For her postdoctoral research Spitsbergen looked at the susceptibility to dioxins of lake trout embryos from Lake Superior. She found that when compared to the adult salmonids, (a category which includes trout or salmon) the embryos were twice as sensitive to dioxins. This means that most of the residues seen in the Great Lakes—even in the polluted areas—would not kill adult salmonids but would certainly kill embryos. According to Spitsbergen, “It’s just a matter of those early life stages when cells are rapidly dividing and differentiating. At that point they’re incredibly sensitive to toxic materials.”

Researchers found that fertilized eggs from Cayuga Lake salmon died even when raised away from their home waters. But combining sperm from Cayuga Lake salmon with eggs from Adirondack salmon produced healthy fish. That made researchers suspect some type of abnormality in the eggs from the Cayuga Lake females. The DEC performed various analyses, looking mainly for nutritional factors in the eggs. Last winter Spitsbergen investigated the possibility of viruses or bacterial disease. “But,” she says, “those causes have been pretty much ruled out. We’re now fairly sure it’s a contaminant-induced disease.” Since the lake trout and rainbow trout eggs in Cayuga Lake have adequate survival, researchers believe the contaminant is at a low level and is something to which landlocked salmon are particularly sensitive.

The DEC and Cornell researchers are waiting for the results from an assay that should tell them whether the suspected contaminant is a PCB or a dioxinlike compound. Once they know what family of chemicals it is, their work will concentrate on identifying which of the many possible contaminants may be responsible for the syndrome. “That will be the worst problem,” said Spitsbergen. “Once we figure out what it is, we have to figure out how widely the problem is distributed, and if it is in all the Finger Lakes.” A DEC contract, through the Return the Gift to Wildlife Program, is funding the initial study.
Design Phase of New Facilities to Begin

The State University Construction Fund has authorized the architectural firm of Davis, Brody & Associates/Russo + Sonder, to begin the design of new facilities at the College of Veterinary Medicine. They are the same architects who developed the master plan for the College’s facilities in 1985 and undertook the programming phase in 1987.

A spokesperson for the SUNY Construction Fund calls this project “very complex, perhaps one of the most complicated in the history of the Fund.” It is certainly the largest ever undertaken at Cornell. The program budget of $82 million, approved by the New York State Legislature, includes $60.2 million for new construction, $5.8 million for rehabilitation, with the balance set aside for site preparation, utilities, planning and some equipment.

In the next phase of design the architectural concept and “schematics” will be developed. These plans will help determine interrelationships and general locations of teaching, research, and service areas and the “footprint,” or general shape, of the buildings. The design phase will be followed by the development of construction documents. The final step, actual construction of the facilities, is expected to take more than three years.

The careful planning by architects and the college’s Central Planning Committee will ensure the construction of a veterinary college that provides for the college’s needs well into the twenty-first century. The existing physical plant, designed in the early 1950s, is aging and there is not enough room to accommodate faculty members, teaching, research and service programs. Many important college activities, victims of the space squeeze, have been moved off the main campus to makeshift quarters. Efficient sharing of facilities between research and clinical areas programs has been deferred because of the lack of adequate space.

In the construction of new space and renovation of some existing space the architects will eliminate many of the physical barriers which have hampered the way the college conducts its business. Off-campus services will return home to the main campus, and, with the new consolidation, there can also be shared access to central facilities by research and teaching programs. Finally, the logistical problem inherent in the College’s present design will be resolved. A physical connection between the campus’ main buildings will be built, uniting the teaching, research and service areas of the college by means of an academic research building. It will connect Schurman Hall and the Research Tower with the Teaching Hospital.

The College’s Central Planning Committee along with many faculty members and staff, and with the planning and design professionals, are determined to see the college ultimately housed in the finest physical facilities available anywhere in the field of veterinary medicine.

International Exchange Agreement

Dean Robert Phemister of Cornell’s College of Veterinary Medicine and Dr. O. R. Kaaden, rector of the Tierarztlche Hochschule Hannover (Hannover Veterinary School) in Hannover, Germany recently signed an exchange agreement between the two colleges. The agreement provides for an exchange of faculty members for periods from three months to a year. A similar arrangement has also been signed with the postgraduate school of veterinary science of the Universidade Federal do Parana, in Curitiba, Brazil. Faculty members who participate in the exchange are encouraged to take an active role in the educational and scholarly activities of their host college. The exchange of faculty members and students will contribute to a greater understanding of the cultures of the two countries and to the international dimension of veterinary medicine.

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methods,” Hansel said, “because animals produce protein so efficiently and then secrete it in a form that’s less expensive to extract.”

Veterinarians will play a vital role in supervising the use of these genetic engineering technologies as well as in treating an entirely new kind of animal. Thus far genetic engineers have succeeded in producing transgenic pigs, chickens, fish, sheep, cattle, mice, rats and rabbits.

Other research presented at the symposium supports technologies in the offing after the turn of the century. They include the use of gene therapy in animal and human medicine and the application of genetic-engineering principles for more-efficient techniques of breeding selection.

The Second Symposium on the Genetic Engineering of Animals was sponsored by Cornell Biotechnology Program and supported by the U.S. Department of Agriculture, the National Science Foundation, and a number of companies. More than three hundred scientists from government, corporate, and university laboratories attended the June 25-28 meetings.

Metta Winter is a freelance writer who frequently covers agricultural, and science topics.
Life & Work in China: A Personal View

Several thousand miles and the student pro-democracy protests in China almost came between Dr. Hung-Chang Wang, DVM '49 and his fortieth class reunion at the College of Veterinary Medicine, June 9-12th. Now a retired professor of veterinary medicine at Beijing Agricultural University, Wang spoke to an alumni audience about veterinary medicine in China.

After graduating from Cornell in 1949 he returned to China to join the Department of Veterinary and Animal Science in Beijing Agricultural University. (Although according to Dr. Wang, there are now a few private practitioners in China, but at that time there were none.) His veterinary work over the next eight years took him to Beijing farms—and occasionally to the Beijing Zoo. He recounted a time in 1957 when he was called to the zoo to examine a giraffe with a sore neck. At that time giraffes at the Beijing Zoo died soon after importation. Wang suggested that the animal might be suffering from rickets, a calcium-deficiency disease characterized by softening of the bone. However, the zoo staff insisted that they were feeding the giraffe enough vitamins and minerals and in the correct proportions. The animal died soon after, and at postmortem Wang was able to examine the bones. "The ribs," he said, "were as soft as a potato. So I had to think about the ecology of this animal." He reasoned that the giraffes didn't receive enough ultraviolet rays in Beijing to make use of all the minerals they were being fed. "We suggested that the problem was related to poor vitamin D metabolism, and we recommended they put ultraviolet lights in the cages of the giraffe and in the cages of some other African animals, such as the hippopotamus." The animals thrived, successfully reproducing in the zoo.

The sudden death of several dairy cattle on a farm near Beijing required even greater detective work. After investigating the possibility of poison, bacteria, viruses, and parasites and finding no cause for the deaths, he collected different kinds of feed used at the farm, including some unusually hard sweet potatoes that had black spots. A plant pathologist identified the black spots as mold but Wang found no references to the mold—except in the Japanese literature. He finally learned that the toxic mold grew only on a Japanese sweet potato. "It had high productivity," he said, "and after the Japanese surrendered, China imported this kind of sweet potato." Unfortunately, the sweet potato brought the toxic mold.

During the cultural revolution Wang worked in the countryside, but by 1972 he had returned to Beijing and his clinical work with large animals. In 1987, after nearly forty years of professional practice, he retired. In his closing remarks to alumni he emphasized the importance of practical work to an understanding of veterinary medicine. Said Wang, "I am not going to underestimate the value of lectures or reading textbooks or other materials. But clinic work made me understand how to work with sick animals and how to understand people, because you have to get the owner's cooperation. Sure, clinical work is much more complicated than simply working in the classrooms, the library, or the labs. But like Dr. Francis Fox always said, 'It's good for you.'"

Fogarty International Fellowship Awarded

Gleed to study low blood oxygen

Dr. Robin Gleed, associate professor of clinical sciences, has received a Senior International Fellowship from the Fogarty International Center of the National Institutes of Health. Under the fellowship program United States scientists are invited by foreign host scientists to participate in research projects of common interest. The program provides opportunities for research experience and the exchange of information in the biomedical and behavioral sciences.

Over the next year Gleed, a veterinary anesthesiologist, will work with faculty members at the Department of Physiology of McGill University, Montreal, on a study of the effects of chronic hypoxia on respiratory mechanics. Low blood oxygen is commonly seen in diseases of young patients, but its direct consequences are often difficult to isolate from other ongoing disease processes. Structural and organic changes associated with the low oxygen may persist after return to normal oxygen levels and may even be detectable in adulthood. The project evaluates the effects of long-term low oxygen levels, imposed at different stages of development, on the respiratory system of rats. The study also isolates the effects of the low oxygen from coincidental disease processes. The project will assess the extent to which long-term low oxygen levels, at various stages of growth, induce changes in lung and chest wall function and whether those changes occur during the low oxygen level or after the return to normal oxygen levels.

Reunion Rider

To attend June Reunion, Dr. Leo Dube simply hopped on his bike—and rode 307 miles. He made the trip in stages, leaving his home in Henniker, New Hampshire on Thursday, spending five nights with friends in towns along his route and arriving in Ithaca on Tuesday. Dube took up biking as a hobby about six years ago. His next trip? He and his wife, Priscilla, hope to bike across the country.
Mammoth Bones Tell Story of Age

Mammuthus columbi roamed what is now Utah at the end of the last ice age. Last fall, Dr. David Gillette, state paleontologist in Utah, and state archaeologist David Madsen, also of Utah, supervised the excavation of a nearly complete mammoth skeleton at Huntington Reservoir Dam, nine thousand feet above sea level. Carbon dating shows that a spruce branch in the soil surrounding the mammoth is 9,460 years old, which suggests the animal died between 10,000 and 12,000 years ago.

Gillette asked Dr. Lennart Krook, professor of pathology at the College of Veterinary Medicine, to examine the bones at the Utah Division of State History, where they have been drying. According to Krook, “The tissues are remarkably well preserved, considering that the mammoth died ten thousand years ago.” The high degree of preservation might be due to the moisture in the soil surrounding the skeleton and the overlying layer of peat. Amazingly, some of the bones were still flexible. Krook collected bone samples from the mammoth’s spinal column, ribs, front leg, and tusk for closer examination.

Back at the college, the bone samples were subjected to radiographs, ground sections, microradiographs, histologic sections, and chemical analyses. Dr. Ronald Minor, professor of pathology, and Jean Schadler '91 examined bone and tusk material by electron microscopy. Most of the collagen fibrils were intact and showed the typical cross-banding patterns. In a section of a vertebra an osteocyte with nucleus and nucleolus was still present—after ten thousand years! Krook found that the common denominator for all the sections was osteopenia—a decreased amount of bone mass. Osteopenia may be caused by several conditions, but Krook believes this mammoth’s problems were caused by osteoporosis which results in bones that are scantly and thin. Said Krook, “There are many causes of osteoporosis,” said Krook, “ranging from protein deficiency, either primary or secondary, to chronic gastrointestinal disorders and toxic action by a variety of agents.”

In news reports Gillette noted there were arthritic growths on almost every bone, which suggests the mammoth was quite old when it died. Krook found degenerative lesions in the vertebrae (ankylosing spondylitis deformans) and bone spurs at the junction of bone and cartilage in the ribs. “Ankylosing spondylitis deformans,” he said, “is a ubiquitous finding in aging human beings that develops in osteopenic vertebral. It also appears in older bulls fed at high calcium levels.”

Because the skull was nearly intact, the scientists were also able to study the mammoth’s teeth. Mammoths have six cheek teeth—three premolars and three molars. The first premolar erupts first and is used up in the grinding of feed. It is replaced by the second premolar, and so on. The presence of a third molar would suggest the animal was sixty to seventy years. This mammoth, a forerunner of the modern elephant, had only third molars and so was estimated to be sixty-five years old.

According to paleontologists, the mammoth (probably a Columbia, rather than a woolly) was tall, with descending tusks that came together in the front. It had slender legs and a graceful shape. It had a high-domed head with steeply descending tusks that came together in the front. Its contemporaries were mastodons—often confused with mammoths because both had trunks and tusks—saber-toothed cats, giant ground sloths, and short-faced bears. Several head bones from a bear were found near the mammoth skeleton.