Dr. Robert Gallo and Secretary Margaret Heckler hold a press conference concerning the cause of AIDS, April 23, 1984.
Bettmann / Contributor

"Good afternoon, Ladies and Gentlemen. The probable cause of AIDS has been found…Today we add another miracle to the long honor roll of American medicine and science. Today's discovery represents the triumph of science over a dreaded disease. Those who have disparaged this scientific search—those who said we weren't doing enough—have not understood how sound, solid, significant medical research proceeds. From the first day that AIDS was identified in 1981, HHS scientists and their medical allies have never stopped searching for the answers to the AIDS mystery. Without a day of procrastination, the resources of the Public Health Service have been effectively mobilized.…Credit must go to our eminent Dr. Robert Gallo [ΑΩΑ, Sidney Kimmel Medical College, 1962], who directed the research that produced this discovery."

—Margaret Heckler, Secretary of Health and Human Services (HHS), April 23, 1984, Washington, DC

Quest for the AIDS virus

Harry W. Haverkos, M.D.

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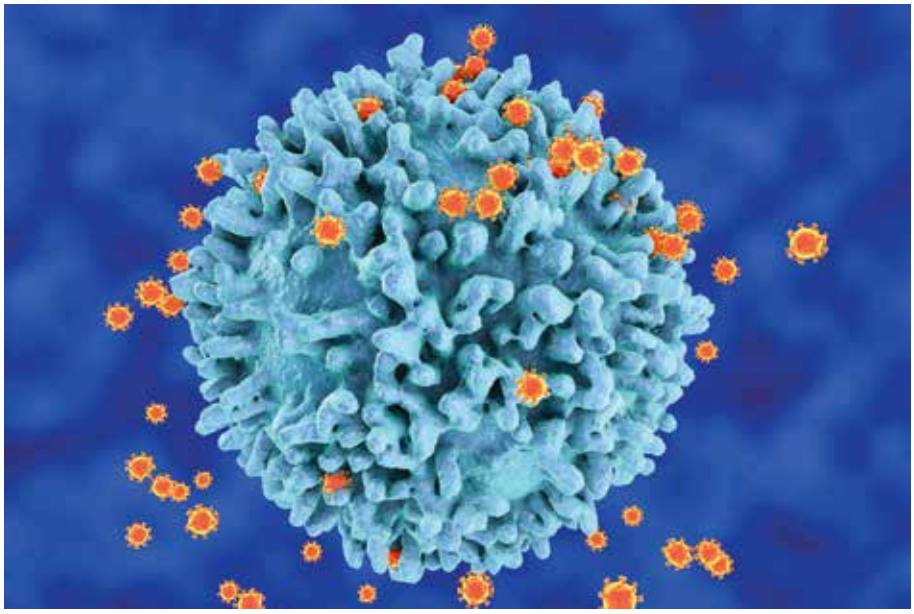
In July 1981, I entered the Epidemic Intelligence Service (EIS) of the Centers for Disease Control (CDC) and was immediately recruited by James Curran, MD, (ΑΩΑ, University of Michigan, 2002, Alumnus) to work on an outbreak of infections and Kaposi's sarcoma among homosexual men. After setting up surveillance for those diseases among previously healthy persons, a case-control study among men in Atlanta, Los Angeles, New York City, and San Francisco was conducted.[1]

The study identified the two leading risk factors for Kaposi's sarcoma and/or *Pneumocystis carinii* pneumonia (PCP) as the lifetime number of sexual partners, and meeting partners in bathhouses.[2,3] Those results suggested that a novel sexually transmitted agent was involved, and retroviruses soon became a target for the search.

Donald Francis, MD, was convinced that a retrovirus was the cause of AIDS. He based his assertion on his experiences working on feline leukemia virus, a retrovirus, at Harvard University, under Max Essex, MD. Francis



HIV viruses infecting T-lymphocytes, computer illustration. KATERYNA KON/SCIENCE PHOTO LIBRARY

graduated from Northwestern Medical School in 1968, then spent six months in India working on tetanus control. He completed two years of training in pediatrics at the University of Southern California Medical School before entering the EIS in 1971. He was assigned to the Oregon State Health Department, but spent much of his time working on smallpox eradication in Nigeria, Sudan, India, and Bangladesh. In 1975, he started an infectious diseases and microbiology fellowship and received a Doctor of Sciences degree from Harvard in 1979. He returned to the CDC in 1978, and was assigned to the Hepatitis Diseases Laboratories in Phoenix, Arizona.

Retroviruses

Retroviruses are RNA viruses with a unique enzyme, reverse transcriptase (RT). RT allows the genetic material of the virus to revert, or reverse, into DNA, enter the nucleus of the host cell, and alter cell growth and replication. In the 1980s, there were three known subtypes of retroviruses.

1. **Oncoviruses or tumor viruses**—Feline leukemia virus is one such virus that causes leukemia, a cancer of white blood cells, in cats. In the 1960s, several investigators, including Robert Gallo, at the National Institutes of Health (NIH), linked two oncoviruses—human T-lymphotropic viruses (HTLV-I and HTLV-II)—to cancers of white cells and bone among humans in Japan and the Caribbean. HTLV-I and HTLV-II cause malignant growths of T-cells, the same cells depleted in AIDS patients.

2. **Lentiviruses or slow viruses**—No known human diseases had been linked to a lentivirus at this time; but a few had been identified to affect animals, such as, visna virus which caused encephalitis (inflammation of the brain), and chronic pneumonitis (inflammation of the lung) in sheep. White cells of monocyte/macrophage lineage are the main targets of visna virus.

3. **Spumaviruses or foamy viruses**—These viruses form large vacuoles in infected host cells, but are not associated with disease in humans or animals. Spumaviruses are generally considered laboratory contaminants when found.

At Francis' suggestion, Curran invited Essex to come to the CDC in February 1983 to give a lecture on his work with the feline leukemia virus, and explain why he and Francis thought that a retrovirus was the likely cause of the new diseases. Francis arranged to have blood samples from the case-control study sent to Boston to test for antibodies to HTLV-I. Nineteen of 75 (25%) of AIDS patients had antibodies to HTLV-I, compared to two of 336 (0.5%) of control samples tested, suggesting a possible role for HTLV-I, or a related virus.[4]

As the session was winding down, Paul Feorino, a

From left, Bruce Evatt, MD, (AΩA, University of Alabama College of Medicine, 1963), Steve McDougal, MD, and Ohno van Assendelft, MD, of the Epidemic Intelligence Service, conduct AIDS research, 1973.

virologist at the CDC, mentioned that he had isolated a retrovirus in one of the case-control samples, but assumed that it was a lab contaminant. He suspected, but did not prove, that it was a spumavirus. He then explained that he put the isolate in the freezer. Could this be the agent everyone was seeking?

After the meeting, Feorino tried to re-isolate the agent, but without success. Curran asked Francis to help the CDC labs develop a comprehensive plan to search for retroviruses, and other related viruses. In September 1983, Francis moved to Atlanta to be the CDC's Assistant Director of Viral Diseases.

The CDC was also working with Gallo at the National Cancer Institute (NCI). Gallo was born in Waterbury, Connecticut, March 23, 1937. He earned a Bachelor's degree in biology from Providence College, and an MD from Jefferson Medical College in Philadelphia. He was among a select group of scientists who first grew T-lymphocytes in 1976, and later identified a new T-cell growth factor, interleukin-2. Those breakthrough discoveries led to his identification of the first retrovirus associated with human cancer HTLV. In 1982, he received a Lasker Award, considered the highest honor for sciences conferred in the U.S. The award was presented "for his pioneering studies that led to the discovery of the first human RNA tumor virus and its association with certain leukemias and lymphomas."

In September 1981, following a presentation by Curran on the new outbreak among homosexual men, Curran asked Gallo to join his work on outbreak. Curran suggested that Gallo's work on leukemia viruses might be relevant; T-cells seemed to be affected by what was causing the problem. Gallo correctly pointed out that his virus, HTLV-I, caused T-cells to proliferate and form a cancer; whatever was causing the new problem was destroying T-cells.

Gallo's interest in the epidemic was further stimulated when his research fellow, Edward Gelmann, MD, identified proviral DNA of HTLV-I in the T-cells of two patients with AIDS. One was a 32-year-old African-American gay male Vietnam veteran living in New York City. He had intermittent fevers, weight loss, lymphadenopathy and PCP. The second was a 48-year-old African-American gay male from Philadelphia with Kaposi's sarcoma and extensive perianal herpes simplex virus infection.

When Gelmann tested the same two patients later in their disease course, he could no longer detect proviral DNA. He also could not find proviral DNA of HTLV-I in the next 30 AIDS patients he studied.[5,6] Why could he find evidence of HTLV-I infection in two AIDS patients, but not others?

A gathering of experts

In the spring of 1983, the CDC received two invitations to attend meetings in Europe. Gaetano Giraldo, an Italian oncologist who associated cytomegalovirus with Kaposi's sarcoma while working in Africa in the 1960s, organized an international conference to discuss AIDS in Europe. The second invitation was from the World Health Organization to meet to plan a meeting on AIDS.

Giraldo's meeting was held in Naples, Italy, in June 1983 at the Castel dell'Ovo, a 12th century concrete fortress overlooking the Porto Santa Lucia. The meeting was billed as the first workshop of a European study group on AIDS and Kaposi's sarcoma. Giraldo and his wife, Elke Beth, also a scientist with an interest in cancer, hosted the meeting, which was prompted by reports of a new group at risk for AIDS—Europeans returning from Africa.

Giraldo and others speculated that AIDS might be an old illness, endemic in equatorial Africa, and related in some way to cytomegalovirus. The meeting included participants from the U.S. and eight European countries, and listed the following goals:

1. Outline the overall spectrum of the disease from clinical, epidemiologic, and etiologic perspectives;

2. Report the most recent data from the U.S. and Europe;

3. Sensitize clinicians and the general public of Europe about the pandemic; and

4. Establish a multidisciplinary European Study Group on the disease to expedite rapid and direct communication and cooperation.

The CDC data through April 26, 1983 was presented—1,361 cases of AIDS reported, of which 40 percent had died. More than 70 percent were homosexual men, but several other groups of patients had been identified including intravenous drug abusers; Haitians living in the U.S. and Haiti; hemophiliacs receiving factor VIII concentrates; female and male heterosexual partners of AIDS patients; blood transfusion recipients; and infants and children of high risk parents.

A new retrovirus

Jean Claude Chermann, a virologist at Institute Pasteur, Paris, reported the isolation of a new retrovirus, Lymphadenopathy-associated virus (LAV), from a lymph node of a homosexual male with multiple lymphadenopathy. The virus was propagated in cultures of T-lymphocytes from a healthy adult blood donor, and umbilical cord blood of newborns. At 15 days in culture, reverse transcriptase activity was detected in the supernatant. A retrovirus was observed on electron microscopy of thin sections of virus-producing lymphocytes, however, its morphology was different than that of HTLV-I and HTLV-II. The core proteins of the new retrovirus were immunologically distinct from the two previously reported human retroviruses.[7]

The French were asked to send an LAV sample to the CDC. In turn, the CDC sent blood samples of AIDS patients and controls for analysis to the French team of researchers. Unfortunately, the CDC virologists could not identify reverse transcriptase in the sample, and requested a second sample from Paris, which also did not grow.

Blood recipients and their donors

On January 2, 1984, the CDC sent a team to Los Angeles to interview blood donors to four pediatric AIDS cases attributed to blood transfusions. One of the pediatric cases was the son of a prominent Los Angeles lawyer who demanded an investigation of his son's blood donors, but the Los Angeles Health Department claimed not to have the manpower to conduct the investigation.

Michael Gottlieb, MD, published in 1981 in the CDC *Morbidity and Mortality Weekly Report* on an apparent novel immunologic condition in homosexual men that was later identified as AIDS.

As part of the team, I was given a car, a map of the city, and a list of 42 donors linked to the four children. Over the next two weeks, I interviewed 14 of the donors, and linked each child to at least one homosexual male blood donor. A few of the donors were already symptomatic with AIDS-related complex.

While the team was in Los Angeles, Gottlieb had identified two unique PCP patients—one was a blood donor linked to a blood transfusion recipient. He wondered if we could grow the virus from them, and show that the two viruses were identical, and if that would fulfill part of Koch's postulates. The CDC sent Feorino to Los Angeles to start the viral cultures with fresh blood samples.

The blood transfusion recipient was a 38-year-old woman who was diagnosed with PCP a few weeks earlier. When Gottlieb took her history, she told him that she had developed uterine bleeding 12 months earlier, and had a hysterectomy. She had received two units of blood from two separate donors at the time of surgery. She was in a monogamous heterosexual relationship, and denied illicit drug abuse. Two weeks after surgery, she developed a transient mononucleosis-like syndrome with fevers and fatigue, but did not seek medical care. In December 1983, she was admitted to a hospital for an acute onset of pneumonia that did not respond to antibiotics, had undergone open lung biopsy, and was found to have PCP.

Gottlieb measured her helper-suppressor ratio and it was 0.46 (normal range is 0.9 to 3.7). He contacted the Los Angeles blood bank to see if he could determine the identity of the two blood donors. He found that one of them was a former patient of his, a 24-year-old gay male diagnosed with PCP 10 months earlier. His helper-suppressor ratio was 0.02. The other donor was a healthy male with no apparent risk factors for AIDS.[8]

Identifying the AIDS virus

On April 23, 1984, Margaret Heckler, HHS Secretary, announced that Gallo had found the virus that caused AIDS. She promised Americans that the NIH would have a blood test for the virus within six months, and a vaccine in two years.

The May 4, 1984 issue of *Science* contained four seminal articles from Gallo's group describing their virus, HTLV-III. The papers documented the two new findings of the NCI, and how they were the first to report the identification of a new retrovirus in AIDS patients, as opposed to a patient with lymphadenopathy, as the French had reported.

They also identified a cell system for the reproducible detection of the retrovirus from clinical samples. The cells were specific clones of a permissive human neoplastic T-cell line.[9–12] This cell system provided large amounts of virus for detailed molecular and immunologic analyses, and opened the way for the development of a blood test for detection of antibodies to the virus.

Around the same time, Francis reported that Feorino and colleagues had identified a retrovirus in Gottlieb's blood donor and recipient pair. The viruses were identical, and the same as LAV reported by the French in 1983. The CDC reported the findings in the July 6, 1984, issue of *Science*.[9] This pair of patients fulfilled Koch's third and fourth postulates of disease causation, specifically demonstrating transmission of an infectious agent to a previously uninfected host with subsequent development of the same disease, then isolating the identical virus.

In the August 24, 1984 issue of *Science*, Jay Levy and colleagues reported isolation of the same retrovirus in 22 AIDS patients, and in healthy gay men in San Francisco. The viruses could be propagated in an established adult T-cell line, HUT-78. Levy named the virus AIDS-related virus (ARV).[13]

Strategies to attack the virus

Researchers now agreed that a new retrovirus was the cause of AIDS, and strategies to attack the virus were the next step. First, was the development of a commercial antibody test suitable for screening the blood supply. Shortly after Heckler's announcement, HHS put out a call for candidate manufacturers to obtain licenses to develop a blood test under the pending patent for Gallo's HTLV-III test. Twenty-five companies applied for licenses, and the HHS awarded non-exclusive, royalty-bearing licenses to seven companies on the basis of experience in working with retroviruses; ability to grow cells in culture for mass production; ability to package, market, and distribute kits in a national system, i.e. millions of assays per year at a reasonable price; and potential for product improvement and refinement.

The FDA worked with the selected companies to facilitate development of candidate donor screening tests. Five companies' tests were licensed by the FDA:

- Abbott Laboratories, Chicago, Illinois;
- E.I. du Pont de Nemours & Co., Inc., Wilmington, Delaware;
- Electro-Nucleonics, Inc., Fairfield, New Jersey;
- Litton Bionetics, Sunnyvale, California;
- Travenol/Genentech Diagnostics, Cambridge, Massachusetts

Each of the licensed companies pursued a different configuration for an ELISA (enzyme-linked immunosorbent assay) test, but all used a disrupted HTLV-III (virus lysate) as the antigenic substrate—they broke the virus into constituent proteins, and tested for antibodies to those inactive pieces of virus.

By late summer of 1984, the manufacturers were ready for clinical trials. The FDA provided a panel of 18 sera to evaluate their performance compared to the Gallo prototype test.[14]

Each company was required to demonstrate that test kits were sensitive enough to detect at least the 1:100 dilutions of sera from patients with AIDS, or in ARC (AIDS-Related Complex) and remain nonreactive in populations presumably unexposed to HTLV-III. To demonstrate performance characteristics, the FDA estimated the sensitivity of each kit by reporting results of studies in which patients with a clinical diagnosis of AIDS were tested, assuming that 100 percent of those patients had antibody to HTLV-III. The specificity of the tests was estimated by testing samples from random blood and plasma donors, assuming a zero prevalence of HTLV-III antibody.

By December 1984, enough progress was made on the test kits that the Public Health Service developed three provisional recommendations for screening of blood and plasma for HTLV-III antibodies. First, all donated blood and plasma should be tested for HTLV-III antibodies. Second, all positive units must not be transfused or manufactured into other products capable of transmitting agents. And, third, the donor should be notified if positive (repeatedly reactive) on

French scientist Luc Montagnier poses in the courtyard of the Elysee Palace after a meeting with French President Nicolas Sarkozy, October 8, 2008, Paris. Pascal Le Segretain / Staff

the screening ELISA test, or confirmed as positive by another test such as a Western blot.

The ELISA test uses antibodies and color change to identify antibodies to HIV. To conduct the test, the sample serum is diluted at least 100-fold, and applied to a plate containing HIV antigens. If HIV antibodies are present in the serum, they will bind to the HIV antigens. The plate is washed to remove all components not attached to the antigens. A second antibody is then applied to the plate that binds to the person's HIV antibodies, if present; the plate is washed again. The second antibody is chemically linked (conjugated) to an enzyme that converts a substrate to generate a signal that can be measured, i.e., color, fluorescence. The plate contains the enzyme in proportion to the amount of second antibody attached to the sample HIV antibodies that bind to the antigens on the plate. The enzyme generates a signal in which its strength is correlated with the amount of HIV-specific antibody that was present in the test sample.

The ELISA test is reported as a number derived as the ratio of the signal strength to a cut-off value representing the upper limit of negative controls.

On March 2, 1985, the Abbott test was approved by the FDA, and immediately used by the American blood banking industry (sensitivity 93.4%, specificity 99.8%).

On March 7, the Pharmacia Diagnostics test was licensed (sensitivity 99.6%, specificity 99.2%).

A third test, developed by Litton Industries, was approved April 5 (sensitivity 98.9%, specificity 99.6%).[14]

Government officials applied to the U.S. Department of Commerce for a patent. On May 28, 1985, HHS was awarded a patent for Gallo's test.

Two additional licenses based on antigens of HTLV-III were awarded in October and November 1985 to du Pont and Travenol, respectively .

On February 18, 1986, Genetic Systems Corp., Redmond, Washington, was approved by the FDA for marketing a test kit based on antigens of LAV, instead of HTLV-III.

A contentious situation

In December 1985, the Institute Pasteur filed four lawsuits against HHS. Lawsuits filed with the U.S. Court of Claims alleged breach of contract, patent interference; damages in the amount of $200 million; and violations of the Freedom of Information Act for review of all NIH laboratory records and memos.[15]

In May 1986, a group of international viral taxonomists declared that all four viruses (Institute Pasteur, NCI, CDC, and San Francisco) reported were identical, and named it human immunodeficiency virus (HIV).[16]

In June 1986, Giraldo held a second European conference on HIV/AIDS, this time in Sorrento, Italy. It would be the first time that Gallo and Luc Montagnier would appear at a conference together. It was now more than a year since the availability of the Gallo antibody test for screening blood products.

Montagnier named his virus "Lymphadenopathy-associated virus" in a 1983 report, and "Lymphadenopathy AIDS virus" in a 1986 report; both designated as LAV. This may have been to counteract Gallo's claim that he was the first to find virus in AIDS patients.

Montagnier listed the evidence as to why he considered LAV the cause of AIDS:

- LAV is easily isolated from cultured T-lymphocytes of AIDS patients, those with ARC (AIDS-related complex), and asymptomatic carriers from all risk groups.

French scientist Francoise Barre-Sinoussi receives the 2008 Nobel Prize for Medicine for her discovery of the virus that causes AIDS. Pascal Le Segretain / Staff

- LAV replicates exclusively in a subset of T4+ lymphocytes, the same subgroup of cells reduced in AIDS patients.
- The receptor for LAV is associated with the CD4 molecule of T4+ cells.
- LAV can infect non-activated T-lymphocytes but only after mitogen stimulation of the cells.
- LAV can also infect and replicate in bone marrow precursor cells.
- Antibodies to LAV were found in some asymptomatic persons in the various high-risk groups indicating infection with the virus.
- LAV is present in blood products, semen, saliva, cervical fluids, as well as in tissue biopsies of spleen, lymph nodes and brain.[17]

Montagnier was allotted 20 minutes for his presentation, but he spoke for almost an hour, leaving no time for questions.

Gallo also gave his 20-minute talk in about an hour. He reviewed his work on AIDS, and his virus HTLV-III/LAV (note new dual name of virus). He made four points:

- He and his colleagues had been looking for retroviruses as the cause of AIDS for several years.
- The French had found LAV and associated it with a pre-AIDS condition, lymphadenopathy, but he was the first to find HTLV-III/LAV in patients with full-blown AIDS, and in various high-risk groups.
- The turning point in AIDS research was accomplished by his laboratory, namely establishing T-cell clones permissive for continuous production of the virus. Large-scale preparation of the virus permitted production of specific reagents, and the development of the antibody tests to identify symptomatic and asymptomatic infected persons.
- The genome of the virus suggests the relatedness of HTLV-III/LAV to HTLV-I, HTLV-II, and to animal lentiviruses.[18]

Gallo proposed a settlement for the 1985 French lawsuits. First, he and the French scientific team would be declared "co-discoverers" of HIV as the cause of AIDS. Second, the royalties from the blood tests would be split three ways—one-third to the Institute Pasteur, one-third to HHS, and one-third put into a trust to support AIDS research in Africa.

On March 31, 1987, U.S. President Ronald Reagan and Prime Minister Jacques Chirac agreed that HHS and the Institute Pasteur would share the patent for the HIV blood test, and future royalties would be split in three parts.

However, there were several findings in the NIH laboratory records provided in response to the freedom of information lawsuit that would disrupt the settlement. On review of electron micrographs of HTLV-III published in May 1984,[11] it was discovered that one of the micrographs was of an LAV sent to the NCI by the French.[19] This "inadvertent" mix-up established that Gallo had used a French virus in his report on AIDS causation.[20] In addition, the Gallo blood test was based on detecting antibodies against

a pool of five viruses, one of which was identified as LAV.[9]

On July 11, 1994, HHS agreed to cede to the French all future patent royalties, and acknowledged that NIH scientists used a virus provided by the Institute Pasteur in developing the AIDS blood test.

In 2008, the Nobel Prize in Physiology or Medicine was divided—one half jointly to Francoise Barre-Sinoussi and Luc Montagnier "for their discovery of HIV;" and the other half to Harald zur Hausen, a German scientist, "for his discovery of human papillomavirus causing cervical cancer." Robert Gallo was not mentioned in the announcement.

Note: The views expressed in this paper do not reflect the official policy or position of the Uniformed Services University, the Department of Defense, or the U.S. Government.

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Earl graduated from medical school in 1917, and answered the call from Washington to join the Army Medical Corps Reserve. He reported for active duty August 2, 1917.

Throughout his deployment, Earl frequently wrote home to his mother in Newark, NJ, often twice a week.

The U.S. Army Medical Corps Reserve of WWI

The early physician volunteers were sent to Fort Benjamin Harrison in Indiana, Fort Riley in Kansas, or Fort Oglethorpe in Georgia, for a few weeks of training that included map reading, field sanitation, litter drill, wound care, basic French, and horseback riding. In the British army it was customary for officers to be assigned horses for transportation.

After their training, the volunteers, now officers, went to England, generally in small groups, with a few days stop at Halifax, an assembly spot for crossing the Atlantic in convoys. The trip from Halifax to Liverpool, depending on German submarine activity, could be interrupted by a stop in Ireland. From Liverpool, the doctors entrained for London.

Of the physicians in the Medical Corps Reserve, the more senior ones, especially those on medical school faculties, were organized into six general hospital units. The others, about 1,200, were assigned to combat units as battalion medical officers or field ambulance personnel.

Of the 1,427 Medical Corps volunteers who signed up when the U.S. entered the war, 37 were killed in the line of duty, 250 were wounded, and a number were captured and held as prisoners of war. Earl was among those wounded, and along with 163 others, received the Purple Heart.

Soon after arrival in London, 1st Lieutenant Wood, along with one other American doctor, was assigned to duty at the Cherry Hinton Military Hospital, a 700-bed hospital in Cambridge, staffed by 10 doctors.

Wood's letters from this period highlight the difference between the daily customs of British and American officers. The British wore the Sam Brown belt and spurs, and carried canes, which Wood wrote, "Make the men look much more like officers than the American officers do."

Wood was able to take advantage of some of the differences offered by the British army, such as:

> One thing that officers in the British army have that is absent in the States is servents *[sic]*. Each officer has a servent to polish his boots, puttees, belt, etc., keep his clothes in condition, and to run his errands. This saves me time and drudgery, as of course, I have one over here.[2]

The servant was an enlisted man, called a "batman," and was a fixture at the front in France as well as in England.

Wood and another American physician shared quarters in a boarding house in Cambridge.

> The old lady who runs the house where I live is a very dear old woman. She has adopted me and is doing her best to mother me. Last night I washed a dozen handkerchiefs and left them to dry. When I came home this evening I found that she had ironed them all for me. I got my first wash back today from the laundry and she cautioned me about putting on fresh underwear right from the laundry as it might be damp. She told me to let her have it to warm and dry before a fire lest I get the rheumatism. And she wants to see that all the buttons are sewed on. Isn't that nice of her?[2]

In addition to his hospital duties, Wood, like many other soldiers, had the opportunity to tour Cambridge and the surrounding area, attended lectures, and was often invited for dinner by British officers and their wives.

The 38th Field Ambulance Company

In December 1917, Wood, his roommate, and several other Americans were sent to LeHavre, France. Upon their arrival they were required to attend gas school. "We were given a gas mask, taught the use of it and then sent into the real German poison gas as a test. If you come out all right you know your mask is OK. If the gas kills you, you know the mask is defective. Rather a good way of finding out, don't you think?"[2]

From LeHavre, via Rauen, Wood was sent to the 38th Field Ambulance Company.

In 1917–1918, the BEF was composed of squads, platoons, companies, and battalions. The basic numbered and named units were the battalions with 600–800 fighting men at full strength, commanded by a Colonel. Each battalion had two or three line companies, plus a headquarters company to which a medical officer (MO) was attached. Each MO had his batman, a sanitary inspector, and a few aid attendants. To assist the MO, several riflemen in each company received instruction in first aid.

Battalions formed brigades, brigades formed divisions, divisions formed corps, and corps formed armies. Each division had nine battalion MOs, and each brigade was signed a Field Ambulance Company commanded by a Lt. Colonel, and consisting of four to six MOs, and supporting personnel. The Field Ambulance Companies evacuated the wounded from the battalion aid posts, where the battalion

Not too many years later, my medical school, in one of its many curricular changes, eliminated the laboratory component of physiology. No more dog surgery. Yet, somehow students still managed to master cardiovascular physiology.

In *Voracious Science and Vulnerable Animals*, John Gluck describes an almost identical teaching protocol that went before the University of New Mexico's Institutional Animal Care and Use Committee (IACUC) in the mid-1980s. The committee approved the protocol, but several members, including Gluck, decided to observe the cardiovascular exercise in practice. They found that the dogs were inadequately anesthetized, improper cauterizing devices were used, students were confused about proper surgical methods, and an arrogant professor seemed indifferent to all of these problems.

Was this experiment conducted in an ethical manner? Was the sacrifice of these animals morally justified? Gluck describes his growing realization, over several decades, of the salience of such questions, and his internal struggles to resolve them. He began his career as a PhD student in psychology at the University of Wisconsin in the 1960s. He studied primate behavior under the mentorship of Harry Harlow, in an era of strict behaviorism, when only observable behavior was considered worthy of study. Internal states, like feelings or intentions, were strictly out of bounds.

Dr. Harlow was famous for his studies of maternal deprivation and social isolation in rhesus monkeys, and Gluck continued and expanded this work. He worked with three groups of monkeys: six reared for their first nine months in total isolation; six reared alone in wire cages, but with visual access to other monkeys; and six reared with their mothers and physical access to peers. He carried this model of comparative deprivation to study the influence of nature versus nurture on behavior to the University of New Mexico, where he founded a primate research facility.

From the beginning, Gluck demonstrated concern for his subjects' welfare, and valued their individual personalities. He sometimes experienced moral distress when his work caused them harm, but managed to rationalize his experiments as ethical because of their potential contribution to human welfare. As time went on, he became uncomfortable with the insensitive and cavalier way some other researchers treated their animals.

Gluck's journey included several seminal milestones, each of which stimulated an ethical leap forward. The first was his clinical psychology fellowship at the University of Washington in 1977–1978. He discovered that clinicians rarely, if ever, cite animal research in their teaching and practice. He also experienced the personal satisfaction of direct patient care. On returning to New Mexico, he explained, "I was not the same person I had been before I left."[p177] His teaching priorities now included "promoting self reflection and compassion," and advocating a more ethical approach toward experimental animals.

A second milestone occurred in 1985 when the United States Congress passed the Animal Welfare Act that established IACUCs, which provided the authority to regulate animal care and experimentation. According to Gluck, membership on New Mexico's IACUC was one of several elements that "combined to shake up my professional life and reinvigorate my ethical reexamination process, which had in recent years been stunted by my own psychological resistance."[p186]

IACUCs generated some forward movement improving living conditions for experimental animals, and requiring researchers to justify the level of pain to which their subjects were exposed. However, their success was diluted by negative feedback from some scientists who chose to interpret the regulations as disruptive interference.

The final milestone occurred in 1994 when Gluck embarked on a fellowship in bioethics at Georgetown University, where he studied with philosopher Tom L. Beauchamp, and physiologist F. Barbara Orlans. Orlans published *In the Name of Science*, a book on the ethics of animal research, which also became the focus of Gluck's work at Georgetown.

Gluck returned to Albuquerque, and successfully developed a multifaceted Research Ethics Service Project that featured a variety of ethics teaching and consultation functions.

Encouraged by recent cultural change, Gluck closes on an optimistic note:

> I remain unreservedly optimistic about the possibility that science, and society as a whole, will come to take seriously the notions that animals are not just property, that they have rights of some kind, and that appropriating animal lives for human use should always elicit ethical analysis that leans toward abstinence as the starting point.[p283]

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