

ROBERT P. COOKE

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JANUARY 9, 1928.—Committed to the Committee of the Whole House and ordered to be printed

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Mr. McSWAIN, from the Committee on Military Affairs, submitted the following

REPORT

[To accompany H. R. 8772]

The Committee on Military Affairs, to which was referred the bill (H. R. 8772) granting an annuity to Dr. Robert P. Cooke, having considered the same, report thereon with the recommendation that it do pass.

A similar measure was reported in the Sixty-ninth Congress and passed the House, and the report made at that time is made a part of this report, as follows:

[House Report No. 2169, Sixty-ninth Congress, second session]

Your committee, to whom was referred H. R. 17057, a bill granting an annuity of \$100 per month to Dr. Robert P. Cooke in special recognition of the eminent services rendered by him, the sufferings endured, and the permanent disabilities contracted by him while assisting in the experiments relating to yellow fever, having had the same under consideration, do respectfully recommend that the same do pass without amendment.

Practically all the other persons, both commissioned officers, contract surgeons, and enlisted men, who volunteered to assist in conducting such experiments upon their own bodies have been recognized and pensions granted either to them or to their dependent loved ones, with the possible sole exception of the proposed beneficiary of this bill. The following account of the work of the United States Army Yellow Fever Commission and the connection of Dr. Robert P. Cooke with same is printed for its connection with the bill and for its historic interest:

EXPERIMENTS IN RELATION TO THE CAUSE AND TRANSMISSION OF YELLOW FEVER MADE BY THE UNITED STATES ARMY YELLOW FEVER COMMISSION, QUEMADOR, CUBA, 1900

In October, 1900, Dr. Robert P. Cooke was stationed at Columbia Barracks, Cuba, garrisoned by the Seventh United States Cavalry, as a contract or acting assistant surgeon, United States Army. During that summer, owing to the alarming mortality among officers and enlisted men of the Army and civilian foreigners from yellow fever, an intensive effort had been set on foot to discover the cause and transmission of the disease. An additional incentive lay in the fact that many thousand dollars were being spent annually in fumigating ships and cargoes clearing from Habana and other West Indian and tropical ports. The Surgeon General of the Army had in June appointed a yellow fever commission, headed by Maj. Walter Reed, Medical Corps, United States Army.

to proceed to Habana and make a study of the causes and modes of transmission of infectious diseases, especially yellow fever. Associated with him were Acting Asst. Surgs. James Carroll and Jesse W. Lazear and Dr. Aristides Agramonte, a Cuban. Previous to this, efforts of Army authorities to limit the spread of the disease had been confined to general sanitary measures.

Several years before, Dr. Carlos Finley, an English physician practicing in Habana, had reached the conclusion that yellow fever was conveyed by a certain variety of mosquito, but had not had the means at his disposal to make any conclusive experiments or secure definite proof. Going on this vague supposition and from several other facts on record, Reed was convinced that sanitation alone would not check the disease, but that its transmission was probably effected by means of an insect.

Application was made to Gen. Leonard Wood, Governor of Cuba, for permission to conduct experiments on nonimmunes and a liberal sum requested for the purpose of rewarding volunteer immigrants. General Wood, being a medical man and realizing the vital importance of the work, wisely gave the desired authority.

Before the arrangements were completed, Doctor Carroll allowed himself to be bitten by an infected mosquito and suffered a severe attack. This was the first experimental case. Shortly afterwards, Doctor Lazear, while working in the wards of Las Animas Hospital in Habana, noted a mosquito feeding on his hand. He allowed it to take its fill and acquired the disease in a virulent form, dying in a few days. These cases were not considered conclusive evidence of mosquito transmission, as no adequate control measures had been adopted to rule out the possibility of other modes of infection.

In October, a camp was especially constructed about 4 miles from Habana and christened "Camp Lazear," in honor of the dead comrade. The personnel included 3 nurses, 9 nonimmunes, all in the military service, and 2 nonimmune physicians, Dr. Roger Ames and Doctor Cooke.

The camp inmates were put under rigid quarantine and ample time given to eliminate the possibility of the disease being brought in from Habana. Spanish emigrants direct from the quarantine station came in from time to time. No nonimmune person was allowed to leave the camp. Records were kept of the health of every inmate to be experimented on, eliminating the possibility of any other disease than yellow fever complicating a case. Two buildings were erected, one for experiments with infected bedding and clothing and one for infected mosquitoes. It was necessary first to obtain volunteers from the military personnel to lead the way, as it were, so Doctor Cooke, together with Privates Lévi P. Folk and Warren Gadston Jernigan, Hospital Corps, United States Army, agreed to enter the first house containing bedding and clothing from the yellow-fever wards of Las Animas Hospital, Habana. This house was constructed with a minimum of ventilation and kept at a maximum temperature to duplicate as far as possible the conditions under which the disease was most apt to occur. It was very carefully screened against mosquitoes.

The volunteers, during a period of three weeks, were required to enter this building shortly after dark each evening and remain until morning, to unpack large boxes of soiled bedding and clothing sent from the yellow-fever wards of Las Animas Hospital, to hang them around the room and place them on the beds. Later on, some slept in the pajamas soiled with black vomit of persons who had died of the disease in Habana. None of us suffered any impairment of health during this time.

Later on another relay of three nonimmunes spent the same length of time in the building without ill effects, thus proving conclusively that the disease could not be conveyed by these means.

Concurrent with this experiment, other men were being bitten by infected mosquitoes in the other building, which was especially constructed for that purpose and clean and well ventilated and located at a distance from any other known source of infection. Near the end of the stay in the infected clothing building, the first case absolutely proven to be the result of mosquito infection occurred. This was also an Army volunteer asking no reward, as was the case with all the Army personnel taking part in these experiments. Later on many nonimmune immigrants, after executing a signed agreement to receive \$200 in gold for their services, were bitten by infected mosquitoes and nearly all contracted the disease. Fortunately, no further fatalities occurred.

These experiments demonstrated the uselessness of destroying valuable property for fear of infection, and through the knowledge obtained, resulted in the almost complete eradication of yellow fever from Cuba and the Canal

Zone, through the work of Gen. W. C. Gorgas, afterward Surgeon General, United States Army.

It might be truly stated that the building of the Panama Canal was largely dependent on the preventive measures instituted as a result of their experiments.

It is true that Dr. Robert P. Cooke was a contract surgeon and not a commissioned officer of the United States Army, but the value of his services are not thereby diminished and he rather stands in the relation of a double volunteer, having volunteered for general professional work and having volunteered to submit to personal experimentations. A very interesting account of the good work of this United States Army Yellow Fever Commission and of their investigators in connection with the same disease is found in Chapter VIII of a recent volume entitled "The Conquest of Disease," written by David Masters and published by Dodd, Mead & Co., of New York, in 1925. Because of the intensely human and scientific interest connected with said experiments and triumphs over the historic disease the entire chapter is herewith printed:

One day I was gazing intently at a large net cage full of mosquitoes, studying the insects in a philosophic frame of mind, when a world-famous scientist came up behind me unawares. A finger slid into my ken, pointing at a mosquito.

"That's the devil!" said a well-known voice in my ear.

It seems incredible that anything so tiny, so frail, should be one of the scourges of civilization. A flick of the finger will kill it, yet this frail-winged insect has performed astonishing feats. It has vanquished men, swept aside civilizations and blotted them out; it has effectually stemmed the tide of human progress.

The great Ferdinand de Lesseps, flushed with the success of the cutting of the Suez Canal, looked at the map of the world, saw the narrow neck of land that joined the two Americas, and told the nations that here he would cut another canal, that he would mingle the waters of the Pacific Ocean with those of the Atlantic Ocean, that he, who had opened the gateway of the East, would open the gateway of the West.

He went to the Isthmus of Panama, saw the hills to be cut through, made light of the work. Had any man pointed out to him a mosquito and said "This will prevent you from building the Panama Canal!" de Lesseps would have laughed the idea to scorn.

He asked for money, and the French people poured millions of francs into his coffers. They did not question him. He had built the Suez Canal, and that to them was proof that he would build the Panama Canal. He called in his engineers, collected the most up-to-date canal-cutting machinery the world had ever seen, brought it to the scene of operations with an army of helpers, and heralded the great tragedy of the canal by playing one of the most amusing comedies in all history.

On January 1, 1880, De Lesseps and his commission, with the Bishop of Panama, were aboard a steamer in the Bay of Panama ready to cut the first sod at the Pacific entrance of the canal. But while they were feasting as a preliminary to starting the gigantic undertaking, they forgot that time and tide wait for no man. In this case it was the tide that refused to wait. They were ready to begin operations when they found it had run out to such an extent that the nearest point they could reach was still 2 miles away from the desired spot.

In nowise discouraged, De Lesseps explained matters and said that it really did not matter. They would hold the ceremony on board, which they promptly did, a wine box full of earth representing the proposed entrance to the canal. Solemnly, one after another, they dug a pick into the box of soil, while the Bishop of Panama blessed the undertaking. If coming events cast a shadow, that wine box was significant, for much of the money that should have poured into the canal was deflected into wine boxes.

The many dark pages in the history of those days—jobbery and corruption, the utterly incomprehensible behavior of De Lesseps—these are brightened by the gallantry of the young Frenchmen, who, knowing that they were going to certain death, still went out to Panama and worked heroically until the dread yellow fever ended their endeavors. Money was poured out, thousands of lives were sacrificed. All was in vain. The little *stegomyia* mosquito, with the parasites

of yellow fever lurking in its grey-striped body, brought the work to an end, and drove the white men from the Canal Zone.

Death was in the air, but no one seemed to recognize that it was literally winged. A man would be working, when a mosquito alighted on his arm and made a minute puncture. Instantly the man, feeling the stab, would brush the insect away. But he was too late. In that brief moment death entered his body, and in a few days he was no more. The isthmus was a graveyard. No wonder it was feared.

One party of gallant Frenchmen followed another, sacrificing their lives so long as funds lasted; then the survivors retreated, leaving the canal zone to the deadly mosquito. Railway engines, trucks, transporter bridges and all the other gear remained where it was last used. Machinery worth a dozen fortunes was scattered about the landscape, and lay there for year after year while the relentless jungle decorated it with vines and other growths as if to celebrate the defeat of the canal builders. Years later, in the heart of the jungle, men would stumble across these silent relics of one of the greatest engineering defeats in the history of man. Over \$250,000,000 was wasted on the ill-fated enterprise, and between 15,000 and 20,000 lives were sacrificed.

A year after the Gilbertian cutting of the first sod on board a steamer in the Bay of Panama, Dr. Carlos Finlay, of Habana, stated that the dread disease of yellow fever, the disease which was then thinning the ranks of the pioneers at Panama, was carried from person to person by the mosquito. It was an age of scepticism, and his suggestion was treated in the same way as was Laveran's announcement a year previously that malaria was due to a parasite.

Doctor Finlay, putting his theories to the test, actually allowed mosquitoes to feed on patients who were suffering from yellow fever, and then permitted the same mosquito to feed on one or two healthy men. But nothing happened. The symptoms of yellow fever failed to appear, and the bitten persons remained in perfect health. If Doctor Finlay had come forward with every proof in his favor, he would have had difficulty in getting the medical world to accept his views. As it was, the position was practically hopeless. Manson had proved that the man who talked mosquitoes was regarded as a fool and a lunatic by the great majority of practitioners, whose minds were apparently shut to the new ideas. So Finlay's paper shared the fate of Beauperrhuy's and lapsed into oblivion.

Twelve years after the Panama Canal was abandoned by the French, the Americans were fighting the Spaniards in Cuba, and yellow fever was raging in the American ranks. Habana, the capita lof the island, was a hot-bed of infection. Hundreds of men went down with it. The hospitals were full of them. Doctors did all they knew, but they were helpless. Yellow Jack laid its finger on the men and tortured the lives out of them.

Then Doctor Sternberg, the Surgeon General of the United States Army, took action. Appointing four Army doctors, James Carroll, Jesse W. Lazear, Walter Reed, and Aristides Agramonte, who were then in Habana, he instructed them to try to discover the cause of the disease. They lost no time. In June, 1900, they straightway began to experiment to see if the disease was caused by fomites, and soon satisfied themselves that yellow fever was not contracted directly from patients or articles soiled by them.

They now determined to work upon the mosquito theory, to see if it held good in the case of yellow fever as well as in elephantiasis and malaria. Knowing that human beings were necessary for the tests they desired to make, this little band of heroes decided that they would first of all experiment upon themselves. They had witnessed the horrors of yellow fever so long that they knew that they were risking their lives. Nor did they flinch. They were prepared to make the supreme sacrifice for science.

Agramonte was immune from the disease, and at the last moment Reed was recalled to America, but Carroll and Lazear made ready to go through with their program. Lazear bred some mosquitoes, and infected them by allowing them to bite patients who were suffering from yellow fever. On July 27, 1900, Doctor Carroll submitted to the ordeal of being bitten. The insects alighted on him and fed, and in a short time he became terribly ill. His colleagues fought desperately for his life, although for three days his condition was very grave, he managed in the end to pull through.

Any doubts that remained were settled in the most heroic manner by Doctor Lazear. He was in the hospital taking samples of blood from stricken patients for experimental purposes, when a mosquito hummed round his head and alighted on his hand. He did not disturb it. Calmly he watched it feed, and made a note of all its movements. His one desire was to solve the mystery of Yellow Jack.



In five days he was down with a raging attack of yellow fever. Often he was delirious, but he was perfectly conscious when the deadliest symptoms of all supervened. He knew then that he was doomed. Carroll was just recovering from his own grave attack, and for a moment the two men gazed at each other. "I shall never forget the alarm in his eyes," said Carroll.

Two days later Lazear was dead.

No truer words were ever written than those engraved on the tablet to his memory:

"With more courage than the devotion of a soldier, he risked and lost his life to show how a fearful pestilence is communicated, and how its ravages may be prevented."

The Government of the United States showed its recognition of his heroic services by granting his wife and two children a paltry allowance of £1 a week. Anything more niggardly is impossible to conceive. Eight years later the force of public opinion made the authorities deal more justly towards his widow, and the pension was increased to a little more than £6 a week.

Lazear gave his life to prove that mosquitoes caused the disease of yellow fever, but there were still many aspects of the problem to be solved. It was nearly twenty years previously that Finlay had allowed infected *stegomyia* mosquitoes to bite healthy people. How and why did those people escape? Several other people had also recently been bitten by infected mosquitoes. What was it that enabled them to evade any evil consequences, while Lazear was murdered by the mosquito and Carroll nearly lost his life?

Reed and Carroll both had a suspicion that a certain period must elapse after the mosquito had bitten one yellow-fever patient before it could transmit the disease to another human being, an "incubation period" during which the parasites of the disease developed. But they were not certain. The tests pointed to it, just as they indicated that the mosquito alone was the cause of yellow fever. But everybody thought the disease was spread in other ways, and only further tests could clear up the matter.

Doctor Reed set out to make these tests, and to show that mosquitoes alone were responsible for transmitting the disease. He called for volunteers, and offered a reward of \$200 for every man who came forward to be bitten. Doctor Lazear's dreadful death was the talk of Habana, but it did not deter volunteers from coming forward. The first two were John Kissinger and John Moran.

Doctor Reed pointed out the great risk, and mentioned the reward.

"We do not offer ourselves for the sake of money," they said quickly. "We will only consent providing we are not paid for it. We offer ourselves solely for the cause of humanity and in the interest of science."

The doctor was profoundly moved. "Gentlemen, I salute you," he said. He was their superior officer, they were simple privates, but the doctor saw before him only two very gallant gentlemen as he came smartly to the salute. \* \* \*

Kissinger was the first to go through the tests. Three times he underwent the ordeal of resting quietly on a bed while the infected mosquitoes bit him. On the third occasion five mosquitoes bit him and he had a severe attack of fever, from which he subsequently recovered.

On the day that Kissinger was bitten by the five mosquitoes, the scene was set for Moran's ordeal.

"At noon on the same day," wrote Major Reed, "five minutes after the mosquitoes had been placed therein, a plucky Ohio boy, Moran by name, clad only in his nightshirt and fresh from a bath, entered the room containing the mosquitoes, where he lay down for a period of 30 minutes. Within two minutes from Moran's entrance he was being bitten about the face and hands by the insects, which had promptly settled down upon him. Seven, in all, bit him at this visit. At 4.30 p. m., the same day, he again entered and remained 20 minutes, during which time five others bit him. The following day, at 4.30 p. m., he again entered and remained 15 minutes, during which time three insects bit him; making the number 15 that had fed at these three visits. On Christmas morning at 11 o'clock this brave lad was stricken with yellow fever, and had a sharp attack which he bore without a murmur."

Moran, too, recovered, and the world will indorse Major Reed's tribute to the two heroes: "In my judgment this exhibition of moral courage has never been surpassed in the annals of the Army of the United States."

As a result of his ordeal, Kissinger later on became permanently paralyzed, and the country he had served so well awarded him 15s. a week. Following an agitation, this was later increased to £6 per week by Congress, but the American exchequer in the same parsimonious spirit that characterized it throughout cut it down to £5 a week before passing the grant.

Other tests carried out on other men proved conclusively that the mosquito actually transmitted the disease, and a final experiment to prove that yellow fever was not contagious, like smallpox, was carried out by Dr. R. Cooke and two other volunteers.

A special hut was prepared for them, carefully screened to keep out mosquitoes, and here the foul bedding and clothing of patients who had died of yellow fever was collected. With the utmost heroism the three men calmly entered the hut donned the awful night clothes of the victims, drew the soiled sheets over them, and went to sleep. Nobody knew but that they were going to their deaths. Each man was all too familiar with the risk, yet each went into the hut night after night and breathed in the foul air until daylight. It was a remarkable exhibition of cool courage. For three weeks they underwent their ordeal for the sake of humanity, and when, after a further period, not one of the heroes contracted yellow fever, it was definitely proved that the mosquito alone carried and spread the disease and the way for building the Panama Canal was plainly indicated.

"Rejoice with me, sweetheart," Reed wrote to his wife on December 11, 1900. "I could shout for joy that heaven has permitted me to establish this wonderful way of propagating yellow fever. I suppose that old Doctor Finlay will be delighted beyond bounds, as he will see his theory at last fully vindicated. Wonderful is nature. And I thank God that He has allowed me to look a little way into His secret. Six months ago when we landed on this island, absolutely nothing was known concerning the propagation and spread of yellow fever; it was all an unfathomable mystery; but to-day the curtain has been drawn. Hurrah!"

Twenty days later, on the last day of the old year, he wrote: "Only 10 minutes of the old century remain. Here have I been sitting reading that most wonderful book, *La Roche on Yellow Fever*, written in 1853. Forty-seven years later it has been permitted to me and my assistants to lift the impenetrable veil that has surrounded the causation of this most wonderful, dreadful pest of humanity and to put it on a rational and scientific basis. I thank God that this has been accomplished during the latter days of the old century. May its cure be wrought out in the early days of the new! The prayer that has been mine for 20 years, that I might be permitted in some way or in some time to alleviate human suffering, has been granted! A thousand Happy New Years."

Doctor Reed worked night and day to unravel the mystery of yellow fever, trying to arouse the medical world to the danger of the mosquito. The doctors of Habana believed, but those elsewhere turned a deaf ear. For nearly 20 years Finlay had been condemning mosquitoes, and the doctors who got into touch with him thought he had an obsession on this particular point.

Instead of Reed meeting the recognition he deserved, he came up against the deadly medical inertia, and his health was much affected by the crass stupidity and folly that he saw around him. Worn out and disappointed, he had an attack of appendicitis in November, 1902. He seemed to sense that the end was nigh, but his thoughts were not of himself or his sufferings; his mind was troubled about his loved ones. Just before he went under the anesthetic to be operated on, he turned to an old medical friend: "I am not afraid of the knife," he said. "But if anything should happen to me, I am leaving my wife and daughter so little."

He died on November 22, 1902, and the American Government awarded his widow the same pension as that awarded to Lazear's dependents. Five years later Doctor Carroll passed away; thus the little band of heroes did not long survive their discovery.

It is strange that one of the biggest sceptics of the mosquito theory of transmission of yellow fever was Maj. Gen. Sir W. C. Gorgas, who afterwards achieved miracles in wiping out yellow fever and malaria in the Panama Zone and was knighted on his death bed for his brilliant work by King George.

Gorgas was the chief health officer of Habana during the American occupation, and the yellow fever experiments were carried on under his eyes. He saw Carroll lying ill of the fever, heard almost at once of the sad death of Lazear, still he could not believe that the mosquito alone was responsible. In a report to General Wood in July, 1902, Gorgas wrote of Major Reed's paper, which was read before the American Medical Congress in Habana in February, 1901: "This idea was so new and so entirely contrary to all former theories on the subject, and, apparently, to all former experience, that the paper was received with scant belief. I myself had seen the work, and was convinced that the mosquito could convey yellow fever, but I was hardly prepared to believe that it was the only way, or even the ordinary way, of conveying the disease."

Speaking of the measures he put into force in Habana, and which were so successful in stamping out every case of the disease in three months, he wrote: "I had very little hope of accomplishing much; it seemed to me that even if the mosquito did convey yellow fever, he could not be got rid of, and, apparently, from all past experience, the mosquito was not the only way, or even the principal way, of conveying the disease; but, as he evidently could convey the disease, it was our duty to take precautions in that direction."

The precautions consisted of fumigating all houses where cases occurred in order to kill off the mosquitoes therein, and keeping all fever patients in specially screened buildings where mosquitoes could not bite them. As the mosquitoes were thus prevented from sucking up the parasite of the disease, the disease died out.

As in malaria, so in yellow fever, only the female mosquito transmits the disease; after feeding on a yellow-fever patient who has had the disease not more than three or four days, it can bite anyone with impunity up to eight or nine days. On about the twelfth day, the parasites complete their cycle of life in the body of the mosquito and infect the first person that the mosquito bites thereafter. When a yellow-fever patient gets better, he does not become a carrier, like the person who suffers from malaria, and it is assumed that the parasites of the disease are swept completely from the body, for he can not afterwards infect mosquitoes. The *stegomyia*, which is the only mosquito to carry yellow fever, lives in houses, and breeds in accumulations of water in artificial receptacles. Originally it inhabited tree holes; thus by eliminating all artificial water containers and keeping all tanks covered so tightly that there is no hole for a mosquito to enter, the *stegomyia* can be kept under control and wiped out comparatively easily.

Although we were now familiar with the way yellow fever was spread, for years its cause remained undiscovered. It eluded the keenest eyes. Then in 1918 came a gleam of hope. Dr. Hideyo Noguchi, the brilliant Japanese bacteriologist, whose labors add to the renown of the Rockefeller Institute of New York, journeyed to Guayaquil in Ecuador on a hunting expedition, not for big game, but the smallest of small game, the tiny organism that was responsible for yellow fever. He went to the haunts of "Yellow Jack," made his tests, and at last found himself looking at a tiny spiral organism wriggling on the slide of his microscope.

When Noguchi announced his discovery of the new *Leptospira icteroides* as the cause of yellow fever, he encountered the usual scientific skepticism. He set to work to sweep it away; to prove that the tiny spiral organism was indeed the soul of "Yellow Jack." This was a task demanding considerable patience and outstanding ability, but directly his microscope revealed the organism in drops of blood taken from yellow-fever patients, the evidence was distinctly favorable. Thereupon he injected the blood of yellow-fever patients into guinea pigs, which in due course contracted the fever in all its virulence. Again his magic microscope revealed the tiny organism in the blood and bodies of the fever-stricken animals. Setting to work to grow this organism in his laboratory, he at last succeeded. Directly his cultures were injected into guinea pigs, the animals sickened of the disease. So he forged his chain of evidence, link by link.

Allowing the deadly *stegomyia* mosquitoes to bite one of his infected guinea pigs, he caged the mosquitoes for a dozen days until the parasites had undergone their normal period of development, then let them feed on a healthy guinea pig. The healthy animal sickened of yellow fever and died. The chain to all appearance was complete.

Already Noguchi has followed up his work by seeking the cure for the disease. By injecting his cultures into horses, he has obtained a serum which during his experiments has given very promising results. If a single dose of this serum be injected within four days after the onset of yellow fever in a guinea pig which has been bitten by an infected mosquito, the serum brings about prompt recovery. Once the fever develops, however, the serum is powerless to mitigate the attack.

Yet men who have spent their lives studying yellow fever still doubt. Under the microscope Noguchi's spirochæte looks similar to the spirochæte that causes infectious jaundice. Trained eyes can not tell one from the other, and the trained brains behind the eyes sometimes wonder if Noguchi could succeed in infecting a human being with yellow fever by using his cultures.

The suggestion that human tests should be made has not been taken seriously by Noguchi, who does not see the necessity for such a step now that a complete picture of yellow fever has already been induced by the presence of his organism

in various animals. The blood serum of persons who have recovered from yellow fever has the power to destroy *Leptospira icteroides*, while the serum of normal persons or those suffering from other diseases does not affect the organism. Further proof is obtained if the organism that causes infectious jaundice be tested with the serum of yellow fever convalescents, for in this case the serum that has the power to destroy *Leptospira icteroides* does not affect the infectious jaundice organism, thus indicating beyond doubt that both organisms are distinctly different. Experimental medicine is making such advances that the day has almost gone when it is necessary to ask men to risk their lives in order to prove the relations between a certain disease and the microorganism that causes it.

In 1891, an attempt to give immunity by allowing the mosquito to "vaccinate" a person with the germs of yellow fever led to three deaths among the eight persons who offered themselves for trial, and it was realized that immunity was not to be obtained in this manner. Yellow fever, alas, did not allow itself to be defeated without taking heavy toll of its conquerors.

The scepticism of the medical mind toward a new idea is emphasized by a remark of Gorgas concerning Doctor Finlay: "My good friend Doctor Finlay, during the 20 years preceding our occupation of the island had written and advocated the theory continuously. I had often heard him expound his views on the subject, but, like the Cuban woman, I smiled in a superior way at the 'crazy Cuban doctor.'"

Only the work that Gorgas himself did in stamping out yellow fever in Habana in three months convinced him of the truth of the mosquito theory. So successful was he that when the Americans took over the building of the Panama Canal, he was appointed to look after the health of the workers on the Isthmus. The first thing he did was to send for Sir Ronald Ross and consult the famous British doctor about the steps to be taken to reduce the mosquitoes. Ross himself had recently accomplished miracles in freeing Ismailia of malaria and mosquitoes on behalf of the Suez Canal Co., and his methods had previously been applied on the famous plain of Marathon in Greece where the illness due to malaria was 90 per cent of the whole illness of the population; with the result that this sickness was reduced to 2 per cent.

When the Americans went to the Isthmus of Panama, it was as big a death trap as when de Lesseps retreated defeated. Colon and Panama were cities of pestilence, with no drains, and no water supply. Garbage lay about the streets, stagnant pools were everywhere at the doors. Gorgas set to work. He created a system of drainage for every house in the cities, a drainage system such as exists in London or New York; he paved the streets, made up the roads to eliminate puddles and ruts, gave the cities waterworks and a supply of pure water, screened doors and windows to keep out mosquitoes. He set men cutting down the undergrowth that encroached too near the buildings, and drained all pools within a certain distance of habitations. Those pools that could not be drained were attended to by negroes who went about with tanks of oil on their backs and oiled pools and ditches to destroy the larvae of mosquitoes.

None deserves more credit for the part he played at Panama than Joseph Le Prince. Working hand in hand, Gorgas and he had banished yellow fever from Habana, and as chief sanitary inspector of the Isthmus Le Prince was the chief driving force of the fever fighters. Often he was working for 24 hours at a stretch. And frequently after a day's gruelling work he would get into a rowing boat and paddle up and down the water courses to try to discover the secrets of the mosquitoes, to find out whence came the clouds of pitiless insects that made such savage attacks on the settlements of an evening.

Not without pain did he and his helpers solve the problem. Rigging up large tentlike net traps in the woods, they offered their own bodies as bait, and when the fiendish bloodsuckers crowded to the feast, the men brushed them off to drive the insects up into the trap. So vicious were the mosquitoes, and so maddening their constant attacks, that sometimes the most stoical of the negro helpers were only prevented from fleeing from their self-imposed duty to the free side of the river because the boats in which they had crossed to the woods had been withdrawn. The endurance of all the volunteers was tried to the uttermost.

Pigeon fanciers may easily mark their pigeons by placing rings on their legs; even fishes can be marked and turned loose in the ocean so that when caught at some future date somewhere in the seven seas they may be identified and their wanderings traced. But handling mosquitoes is not so easy as handling birds and fishes. And marking a mosquito by tying a ribbon around its neck or a thread of cotton to its leg is not possible. Yet in some way the insects had to be marked. At first attempts were made to mark them with red ink, but without



success; finally the trapped insects were sprayed ever so lightly with a dye before being released. Those men who spent all their time catching the mosquitoes in the houses placed the catch from each house in a separate box, which was carefully labeled. The insects from each box were then treated with a fluid which immediately changed color if the merest speck of dye happened to be on a mosquito, and in this way they were tracked. The chief sanitary inspector found that the insects flew from half a mile to a mile to feed, the flight to the settlement setting in at dusk, and the homeward flight taking place just before dawn. The mosquitoes, indeed, flew to and from their feeding grounds just like a flock of birds.

The care and thought devoted to the work were endless. For instance, even the hoof marks of cattle, inasmuch as they caught and held rainwater, were systematically sought out and oiled. It was an expensive business. But it was the only way to get the canal built. By the time the canal was finished, it had cost the Americans £4,000,000 just to fight the mosquito. Gorgas swept away yellow fever utterly, but as 7 people out of 10 carried the parasites of malaria in their blood, and as it was quite impossible to destroy all the anopheline mosquitoes, malaria was not entirely stamped out. None the less, in a couple of years the Americans reduced the death rate from this disease by two-thirds, and in five years the death rate was reduced from 7 per 1,000 to under 1 per 1,000. The whole sanitary work of the Isthmus cost 14/6 per head of the population per year, and of this sum 8/4 was spent in direct attacks on the mosquito.

The female mosquitoes, after gorging themselves with blood, lay their eggs on the surface of the nearest stagnant water, where the larvæ soon hatch out. The larvæ of some kinds lie flat on the surface of the water; others hang head downward and breathe through a very delicate organ situated in the ends of their tails. They just hang with this tube thrust through the surface of the water into the atmosphere, and the slightest disturbance of the water will send them shooting off to the bottom, where they hide in the mud and filth and feed on the decaying matter. After a time they must come up for fresh air, just as a whale comes up to spout and fill its lungs, but the tiny larva of the mosquito does not spout like the giant mammal of the sea. Thus, if a film of oil be spread on the water, it seals the air tubes of the larvæ, which die through lack of air.

Where the usual methods of control can not be applied to fighting the mosquito, science is now turning to the natural enemies of the winged pest. It has long been known that certain tiny fishes love the eggs and larvæ of mosquitos and will feed on them all day long, but the mosquitoes, to escape their natural enemies, are cunning enough to breed in backwaters along the banks of rivers and lakes, where weeds and grass form an effective barrier against their finny foes.

To suggest that in the circumstances cows might help to exterminate the mosquitoes may be regarded as a sign of insanity, yet there was method in this scientific madness. Cows were in fact turned loose by the edges of the lakes and streams, and the animals naturally went for the tenderest and most luscious grass, which was growing at the water's edge, cropping it below the level of the water and allowing the fish free access to gobble up the larvæ of the pest.

The objection to using cows is that they are apt to breakdown banks of well-kept ditches and streams and give rise to the very conditions beloved by mosquitoes; also the water will collect in their footprints if the ground is soft, and here again the mosquito will breed. Le Prince in Panama found cattle so troublesome that he was forced to put up notice boards warning the natives to keep their animals away from the banks of ditches and streams. The comedy was that some of the natives, unable to read, gayly tied their beasts to the very posts holding the notice boards.

Among the Italians living in the Pontine marshes it is the custom to make use of herds of Indian buffalo to tear up the weeds in the drainage canals and thus destroy the lurking places of the mosquito larvæ. Sambon once described to me the animated scenes that he witnessed, how the buffaloes were driven into the water courses, with men in punts chasing them, men on horses galloping along the banks to prevent the beasts leaving the water, boys throwing stones and shouting, the animals ploughing along and masses of kicked-up weeds floating in their wake. It is a novel and clever way of clearing water courses.

When in 1920 an epidemic of the dread yellow fever broke out in Peru, all the forces of science were concentrated on stamping out the *stegomyia* mosquito and preventing the disease from spreading. A sanitary cordon was formed round the infected zone to stop sufferers carrying the disease all along the Pacific coast. Then the authorities made a wholesale distribution of small fish, which were

turned loose in every water tank, pond, and lake in the infected areas. Many people might object to the minnows being thus turned loose in their drinking water, but it was better to have three minnows in the water tank than yellow fever in the house. In six months, by July, yellow fever was completely stamped out. Not a single case existed on the Pacific coast. And to do this a force of 750,000 fish operated in the danger zones, and spent their days eating the eggs of the mosquito.

A year later the authorities on the Pacific coast carried on a further campaign against the mosquito, and distributed fish from Guayaquil in Ecuador to Callao in Peru, a distance of 500 miles along the coast. The authorities, realizing that prevention was better than cure, knew that if man sometimes nodded and was caught, the little fish would always be on the watch, and waging a war of extermination against the *stegomyia* mosquito. These fish campaigns against disease have so far proved wonderfully successful, and epidemics in Peru and Mexico, as well as in other parts of Central and Southern America, were stamped out in the years 1920-21.

A strange thing in connection with malaria is that the island of Barbados is quite free of the disease, yet you have but to go to the neighboring islands of the West Indies to find the air alive with mosquitoes and the disease rife. It seemed so unaccountable, for Barbados was no different from the rest of the islands. There were swamps and ponds in abundance for breeding places, but it was easier to find gold mines than mosquitoes.

A Mr. Gibbons, who lived in the island, could not understand why the island should be immune from the common plague of malaria. Studying the matter and looking down into the ponds, he saw swarms of little fishes, known locally as "millions," and as he watched the hungry little creatures feeding he concluded that the fishes in the waters of Barbados were actually protecting the inhabitants from the winged pests of the air.

The theory of Mr. Gibbons was proved to be a fact by Sir Rupert Boyce. So the island of Barbados is one of the greatest object lessons in the world of what fishes can do to protect mankind against malaria. Swarms of these little fishes have now been placed in the waters of the neighboring islands to help to free the people of malaria. It indicates that fishes may yet prove man's most powerful ally in his war against mosquitoes.

Using fish for this purpose is merely another instance of how man is directing nature to attain his own ends. When the Americans planted orchards of Australian fruit trees, a parasite spread through the orchards and made the trees look as though they had been caught in a snowstorm. The fruit growers, becoming alarmed, found that the pest was practically unknown in the antipodes, for the simple reason that a certain ladybird preyed on the pest and kept the trees free. Similar ladybirds were caught in Australia, taken to America, and let loose in the infected orchards. The abundance of food made the ladybirds thrive and multiply to such an extent that they practically wiped out the parasite. There was nothing more for them to eat, and they started to die out. To avoid this, special colonies of the pest were reared to feed the ladybirds; and the little beetles—for ladybirds are nothing but beetles—are now kept in certain laboratories ready to be sent to any orchards where signs of the woolly aphids appear.

It is rather strange how ladybirds seem to have a particular fancy for the green flies on particular trees. For instance I have found that ladybirds from infested apple trees, when removed to infested rose trees refuse to feed on the aphides and generally fly back to the apple trees. I have tried to induce ladybirds that were feeding on the green flies of black-currant bushes to feed on rose bushes, and also on apple trees, but with little success. I suppose that the sap of the apple trees and the black-currant bushes and the rose bushes gives the aphides a distinctive flavor which the ladybird prefers, and so long as it can get the particular aphides feeding on the trees where it has been bred, the ladybird will have none other. The green flies feeding on black-currant bushes seem to take on a dark tinge from the sap, just as the ripening black-currants do, and it seems fairly certain that the black-currant sap will give the green flies a black-currant flavor, just as garlic gives the human body a flavor and odor of onions.

Men are thus using ladybirds to wipe out a parasitic disease of the orchards, and certain fish for fighting the mosquito scourge. Perhaps the day will dawn when we shall have a specially developed breed of fishes that will eat nothing but the larvae of mosquitoes, and if this came about man might indeed look forward to freeing the world of this winged pest. It is estimated that in India alone 1,000,000 natives die of malaria every 12 months. In 1900 the United States

registered 14,900 deaths from this same disease, and it has been computed that the value of the lives lost and the time lost through sickness due to malaria amounts in the United States to \$100,000,000 a year. If the money values of the lives and time lost through malaria could be worked out for the rest of the world, the figures would be so staggering as to be almost unbelievable.

Gorgas showed that it was possible to control the mosquito, if there was no lack of money and the whole community worked to that end. Such wonders did he accomplish for the health of the people that it was possible to go for months and not see or even hear a mosquito of any sort, while Panama itself came to be regarded as a health resort. If it is not quite a health resort, at any rate it is a place where whites may now work in comfort, free from the fear of yellow fever. The least laxity of control, however, will inevitably lead to a return of the old conditions.

Had the Americans been obliged to cope with the same conditions as the French, it is doubtful if they would ever have succeeded in accomplishing their wonderful work. All the wealth and power and brains of the United States would probably have been vanquished by the deadly mosquito, if we are to judge by what took place in 1905.

In the middle of July, 1904, soon after work was started on the canal, two of the canal employees were taken ill with yellow fever, and died. No other case was reported during August, and there were only five cases during the next three months. In December the cases rose to six, and gradually the epidemic gathered strength until by the following June there were 62 cases and 19 deaths. In all there were 246 cases and 84 deaths, the mortality being roughly 1 in 3.

The workers were panic stricken. They fled from the danger zone as fast as they could. Nothing would tempt them to stop. They packed their belongings and crowded the boats sailing for home. Not another passenger could the boats carry. If boats had been available, it is possible that the engineers and health authorities would have been left without men to carry on the work at all. As there were not enough boats to remove all the workers, most of them had to stay behind, and these went in fear of their lives and envied those lucky ones who had managed to get away.

As Gorgas himself wrote in 1907:

"I do not believe that our present freedom from yellow fever is in any way accidental. Our work here, I think is another evidence of the great obligation mankind is under to the Army board, of which Maj. Walter Reed was chairman, and Lazear and Carroll were members, for establishing the fact that the stegomyia mosquito was the transmitter of yellow fever. Without this knowledge I do not believe we could have done any better than the French, and, judging from the alarm that was caused by the comparatively mild epidemic which we had among our employees in 1905, I doubt, in case we were having the same amount of yellow fever that the French had, whether we could keep a sufficient force of white employees here to carry on the work. And even if we could keep white employees here under such circumstances, I doubt whether public sentiment in the United States would allow the canal to be built at such a sacrifice of human life."

The gate to the west was opened by the key of knowledge which Lazear gave his life to gain for humanity. What Manson said of the filaria applies with equal force to malaria and yellow fever:

"Man harboring the parasite is the reservoir, the mosquito is the carrier of the parasite. \* \* \* The parasite passes part of its existence in man and part in the mosquito; both man and the mosquito are necessary for the complete development of the parasite. Therefore if the mosquito is destroyed, the life cycle of the parasite is destroyed, and the disease must of necessity cease."

The conquest of yellow fever is a romance of heroism and high endeavor.

In 1908, January 31, Theodore Roosevelt, then President, submitted to the chairman of the Senate Committee on Pensions a memorandum from the Surgeon General of the United States Army, Dr. Robert M. O'Reilly, in support of the widows and children of Drs. James Carroll and Jesse W. Lazear, for whose benefit bills granting pensions to said widows and children was then pending in the

Senate; and the same are herewith printed for the information of the House:

JANUARY 31, 1908.

THE CHAIRMAN OF THE SENATE COMMITTEE ON PENSIONS:

I call your particular attention to the accompanying memorandum from the Surgeon General of the Army in behalf of the widows and children of Dr. James Carroll and Dr. Jesse W. Lazear. I earnestly hope the pensions can be provided for in both cases.

THEODORE ROOSEVELT.

The following is the memorandum prepared by the Surgeon General, Robert M. O'Reilly, and gives a comprehensive history of the services in these investigations of the officers named in the bill:

MEMORANDUM FOR THE PRESIDENT IN BEHALF OF THE WIDOWS AND CHILDREN OF DR. JAMES CARROLL AND DR. JESSEE W. LAZEAR

When the yellow fever commission, composed of Walter Reed, James Carroll, Jesse W. Lazear, and A. Agramonte, assembled in Habana, they had no thought of investigating the connection of the mosquito with the spread of yellow fever. This idea came to Doctor Reed after the commission had demonstrated that the claim of Sanarelli in favor of the bacillus icteroides was without foundation. The final determination to investigate the mosquito theory was arrived at during an informal meeting of the commission at Columbia Barracks early in August, 1900. To Doctor Lazear, who was familiar with mosquito work, was assigned the duty of breeding and infecting the mosquitoes, while Doctor Carroll was to continue the bacteriological work in which the commission had been engaged.

Before the mosquitoes were ready for the experiment Doctor Reed was called to Washington to prepare for publication the abstract of the report of the board appointed in 1898 to investigate the spread of typhoid fever in the volunteer camps in the United States, of which board he was president.

It was during his absence that the inoculations by means of infected mosquitoes were begun. The first experiment was made on August 11, but was unsuccessful, as sufficient time had not elapsed since the mosquito had bitten a yellow-fever patient to render it infectious. On August 27 Doctor Lazear applied to Doctor Carroll a mosquito which had been fed on four yellow-fever patients. The result was a very severe attack of yellow fever, in which for a time his life hung in the balance. This was the first successful experiment case. The fever developed on the 31st of August, on which day Doctor Lazear applied the same mosquito which bit Doctor Carroll to another volunteer.

This man came down with a mild but well-marked case.

On September 13, Doctor Lazear, while on a visit to Las Animas Hospital, allowed himself to be bitten by a mosquito of undetermined species. Five days thereafter he came down with further exposure with yellow fever which progressed steadily to a fatal determination. These three cases established in the minds of Reed and Carroll the proof of the mosquito theory and formed the basis of their paper, "The etiology of yellow fever—a preliminary note," read before the American Public Health Association at Buffalo in October, 1900. Doctor Reed immediately returned to Cuba to conduct a second series of experiments, which began November 20, 1900, at an experimental camp near Quemados, called Camp Lazear, and embraced 14 cases, of which the last was taken sick February 10, 1901. All of these cases recovered.

The third series of six cases was produced by Doctor Carroll during the fall of 1901 to settle certain undetermined facts as regards the etiology of the disease. The first of these cases came down with the fever September 19, 1901, and the last October 23, 1901. None of them resulted fatally.

After this brief history of one of the most brilliant and far-reaching medical discoveries, attention is invited to a few facts concerning the three principal members of the commission and to their untimely and lamented deaths.

Maj. Walter Reed, surgeon, United States Army, president of the commission, died in Washington from appendicitis November 23, 1902, at the age of 51. At the time of his death the Secretary of War had said in his report, which was then in press but not yet given out:

"The brilliant character of this scientific achievement, its inestimable value to mankind, the saving of thousands of lives, and the deliverance of the Atlantic



seacoast from constant apprehension, demand special recognition from the Government of the United States.

"Doctor Reed is the ranking major in the Medical Department, and within a few months will, by operation of law, become a lieutenant colonel. I ask that the President be authorized to appoint him assistant surgeon general with the rank of colonel."

Gen. Leonard Wood said of him in an address delivered at a memorial meeting of scientific men in Washington, D. C., shortly after his death:

"I know of no other man on this side of the world who has done so much for humanity as Doctor Reed. His discovery results in the saving of more lives annually than were lost in the Cuban War, and saves the commercial interests of the world a greater financial loss each year than the cost of the Cuban War. He came to Cuba at a time when one-third of the officers of my staff died of yellow fever, and we were discouraged at the failure of our efforts to control the disease.

"In the months when the disease was ordinarily worse the disease was checked and driven from Habana. That was the first part in nearly 200 years that the city had been rid of it. The value of his discovery can not be appreciated by persons who are not familiar with the conditions of tropical countries. Hereafter it will never be possible for yellow fever to gain such headway that quarantine will exist from the mouth of the Potomac to the mouth of the Rio Grande. Future generations will appreciate fully the value of Doctor Reed's services."

In a letter from Professor Welch to the Secretary of War he said:

"Doctor Reed's researches in yellow fever are by far the most important contributions to science which have ever come from any Army surgeon. In my judgment they are the most valuable contributions to medicine and public hygiene which have ever been made in this country, with the exception of anesthesia. They have led and will lead to the saving of thousands of lives."

A bill prepared in this office for a pension for his widow, equal in amount to his monthly pay, was passed, but the amount was so cut that while it kept the wolf from the door it did not provide an adequate and comfortable income.

To supplement this pension a fund of \$25,000 has been raised by the Walter Reed Memorial Association, the interest of which will be given to Mrs. Reed during her lifetime, and the principal, after her death, will be devoted to some form of memorial.

The second member of the commission was Dr. James Carroll, at that time acting assistant surgeon, United States Army. Doctor Carroll was born at Woolwich, England, June 5, 1854. He entered the military service June 9, 1874, and served as a private, corporal, sergeant, and hospital steward from that date to May 21, 1898, when he was appointed an acting assistant surgeon. He was appointed first lieutenant and assistant surgeon in the Medical Corps October 27, 1902, and was advanced to the grade of major by special act of Congress approved March 2, 1907, in recognition of his work in Cuba as a member of the yellow-fever commission. He died in Washington, D. C., September 16, 1907, after a protracted illness, which he always attributed to the severe attack of yellow fever he had in September, 1900.

Doctor Carroll was Doctor Reed's colleague and efficient assistant in all the experiments which led to the scientific demonstration of the agency of the mosquito in the propagation of yellow fever. As expressed by Dr. Howard A. Kelly, Doctor Reed's biographer, "While the experiments were planned by the master mind of the chief, the accuracy with which they were carried out and the care by which all possible precautions were taken to exclude every source of error are due to Doctor Carroll quite as much as to Doctor Reed." As stated above, the third series of experiments were performed by Doctor Carroll alone, Doctor Reed having been refused permission to return to Cuba for the purpose. These experiments completed the demonstration of the mosquito doctrine of yellow-fever infection. They proved among other things, that the filtered blood serum of a yellow-fever patient is still capable of conveying the disease, and, therefore, that the specific agent was either a virulent toxin or an organism so tenuous as to elude the search of the microscope.

Doctor Carroll left a wife and seven children without adequate means of support. It is presumed that his widow will receive the pension allowed by the Government for a major of the Army and \$2 a month for each of the five minor children.

Dr. Jesse W. Lazear was the third member of the commission. Doctor Lazear was a native of Baltimore and a graduate of Johns Hopkins University, afterwards getting his professional degree at Columbia University and Bellevue.

At the time he incurred the attack of yellow fever from which he died, in the course of these experiments, as above mentioned, he was 34 years old. He left a wife and two young children, the younger a little son born a few months before his death, whom he never saw. Mrs. Lazear receives from Congress a pension of \$17 a month, with \$2 additional for each of two minor children. A battery in Baltimore Harbor has also, by direction of the Secretary of War, been named in his honor. This is all the recognition that he has so far received from the Nation.

The services of Doctor Carroll and Doctor Lazear, under the leadership of Doctor Reed, in making possible the control and expiration of yellow fever, thus bringing about the saving of thousands of lives and millions of treasure, have done so much for humanity and reflected honor and glory upon the American medical profession that it is believed Congress will not hesitate to take action for the relief of their widows and children when all the facts are clearly brought before it.

In contrast to the seeming indifference of this Government to reward distinguished achievements in medicine, let it be remembered that the English Government gave to Jenner, the discoverer of vaccination, grants amounting to £30,000, and that he also received £7,383 from a subscription in India.

Bills have been introduced in the present Congress to give a suitable pension to Mrs. Carroll and Mrs. Lazear, and it is believed they will receive favorable consideration if the President will exert his great personal influence in their behalf.

R. M. O'REILLY,

*Surgeon General, United States Army.*

Accompanying S. 6350, granting pensions to the widows and children of Dr. James Carroll and Dr. Jesse W. Lazear, is found the following highly instructive and valuable scientific discussion of the researches made into the cause, prevention, and treatment of yellow fever, and the same are herewith printed for their great scientific and historic value:

S. 6350. This bill proposes to increase the pension of Jennie M. Carroll, widow of James Carroll, late major and surgeon, United States Army, and also Mabel H. Lazear, widow of Dr. Jesse W. Lazear, late acting assistant surgeon, United States Army, to \$125 per month each, in special recognition of the eminent services of the said Maj. James Carroll and Dr. Jesse W. Lazear in discovering and demonstrating upon their own persons the truth of the theory of the transmission and propagation of yellow-fever infection by mosquitoes, and therefore by reason of such discovery and demonstration it has been made possible to practically eliminate the scourge of yellow fever that had heretofore ravaged the southeastern coast of the United States and the West Indies Archipelago, resulting in the saving of thousands of lives yearly that heretofore had been sacrificed to that dread disease.

The officers named in the bill were appointed to serve under Maj. Walter Reed on a commission to investigate the yellow-fever epidemics in Cuba in 1900 and 1901. Maj. Walter Reed was the head of the commission, but his duties required him to be in Washington the greater part of the time, and the actual work of making the experiments and demonstrating the truth of the theory was carried on in Cuba by Major Carroll and Doctor Lazear. The work of that commission, headed by Major Reed, is set out in detail in Senate Document No. 118, Fifty-seventh Congress, second session, and is in part as follows:

"The first work by Major Reed bearing on the causation of yellow fever was in 1899-1900, when he overthrew the claim of the distinguished bacteriologist, Sanarelli, to have discovered the bacillus of yellow fever, by his demonstration that the *Bacillus icteriodes* (Sanarelli) was an organism widely disseminated in this country and having no causative relation to that disease. He began the special work, with which his name will always be inseparably associated as one of the benefactors of mankind, in June, 1900, when he went to Cuba as president of a commission to study the infectious diseases of Cuba, with special reference to yellow fever. The other members of this commission were Acting Asst. Surgs. James Carroll, Jesse W. Lazear, and A. Agramonte. The time was most opportune for such investigation, as the disease was at that time prevalent both in Habana and in the little town of Quemados, near the camp of the American troops, and it was plainly evident that the energetic measures of the American military government to clean up the towns, disinfect, and enforce other sanitary measures were without effect in preventing the spread of this particular disease. Major Reed

became convinced that proper sanitation was not all that was needed, and that some other agent than unclean conditions was responsible for the spread of the disease.

"The transmission of malaria by a certain species of mosquito had been recently demonstrated by the English military surgeon, Ronald Ross. The theory had also been advanced both by a Mobile physician and by Doctor Finlay, of Habana, that a mosquito was the agent for the transmission of yellow fever; but these theories, being unsupported by scientific demonstration, received no more attention than the vast number of others which had been at one time or another advanced with regard to this mysterious and deadly disease.

"Doctor Reed's attention was attracted by a paper on the spread of yellow fever in Ormond, Miss., by Dr. H. R. Carter, of the Marine Hospital Service, in which it was shown that although the period of incubation of the disease was 5 days, 15 or 20 elapsed before a house became infected after a patient sick with yellow fever was carried into it. He inferred that the difference between the time of incubation and the time required to infect a building was due to the fact that the infective agent passed through a stage of development in the body of some biting insect as an intermediate host, and he at once determined to conduct his experiments along that line. It was evident to his mind that the solution of this question, which meant so much for the human race, could never be satisfactorily determined without experiments on human beings, and he went to General Wood, the military governor of Cuba, to ask permission to conduct such experiments and for a sum of money to liberally reward volunteers, who should submit themselves for experiment. General Wood promptly granted both, with a ready appreciation of the importance of the matter and the force of Doctor Reed's arguments, which will entitle him to no small measure of the glory of this discovery.

"Meanwhile, during a temporary absence of Doctor Reed in the United States, his assistants, Dr. James Carroll and Dr. Jesse W. Lazear, who had offered themselves as the first volunteers for these experiments, had demonstrated that mosquitoes would convey yellow fever. Doctor Carroll, who was the first experimental case, suffered a very severe attack, but recovered. Doctor Lazear was not infected at this time, due to the fact that the conditions necessary to the transmission of the disease by the mosquito were not yet understood, but he was bitten while working in the yellow-fever ward somewhat later, and died a martyr of science, working in behalf of humanity. This was the only fatality which occurred in these experiments. The fourth member of the commission, Doctor Agramonte, did not participate in the mosquito work of the commission until a later date, nor did he share their dangers, as he was a Cuban and immune.

"The efficient control of the spread of yellow fever is a matter of such vast practical importance, both from the hygienic and commercial point of view—not only for the countries where this disease prevails as an epidemic, but also for those in which, after importation, it may assume epidemic proportions—that it has seemed appropriate to bring together in this paper a summary of the work thus far accomplished by the United States Army commission on the island of Cuba during the years 1900 and 1901, in order that English and colonial readers who have not, perhaps, had access to the original contributions published in different American journals, may be able to form an intelligent opinion concerning the permanent value of this work. It will also afford opportunity for recording the more recent confirmatory observation made by others concerning the mode of transmission of yellow fever discovered by the commission, and for calling attention to the results already obtained by the United States Army Medical Department in the suppression of this disease, especially in the city of Habana, through the enforcement of sanitary measures based on these later researches.

"The American commission was organized in May, 1900, and began its investigations during the following month (June), being equipped with suitable laboratory facilities for practical work, both at the military garrison of Columbia Barracks, near Quemados, Cuba, and also in the city of Habana. As yellow fever was already prevailing at the time of our arrival in Cuba, suitable material for the scientific study of this disease was immediately available.

"Before giving the results of our investigations, it may be well to recall the situation as regards the etiology of yellow fever at that time. Briefly, it may be said that the claims of all investigators for the discovery of the specific agent of yellow fever—since modern bacteriological methods had come into use—had been disproved by the exhaustive observations of Sternberg, published in 1890, except that made by Sanarelli for a small, motile bacillus isolated by him from

the blood drawn during life in 2 of 6 cases of yellow fever, and from the blood and organs after death in 7 of 12 cases of this disease (58 per cent) studied at Montevideo and Rio de Janeiro, Brazil. The results obtained, however, by those who had promptly undertaken to investigate Sanarelli's claim for the specific character of bacillus icteriods seemed to show a lack of agreement such as has never been reported, as far as the writer can recall, in connection with the supposed specific cause of any of the other acute infections.

"Under these circumstances it seemed to the members of the commission of the first importance to give their entire attention to the bacteriological study of the blood of those sick with yellow fever and of the blood and organs of yellow fever cadavers, having especially in view the isolation of bacillus icteroids. We were thus able during June, July, and August to take repeated cultures from the blood during life in 18 cases of yellow fever, adopting the usual method employed in withdrawing blood from a vein at the bend of the elbow, and transferring the blood at once in quantities of 0.5 cubic centimeter to each of several tubes containing 10 cubic centimeters of nutritive bouillon, which were afterwards incubated at 37° C. for a period of one week. In seven cases, four of which were designated as "mild" yellow fever and three as "well-marked" yellow fever, only one culture was made from the blood in each case, viz, in two cases on the first day, in one case on the second day, in three cases on the third day, and in one case on the fourth day. In the remaining 11 cases diagnosed as "severe" yellow fever, of whom four died, more frequent cultures were taken from the blood, these varying from two to six cultures on as many different days of the disease. In two of the fatal cases cultures were made each day from the commencement of the attack and including the day on which death occurred.

"The negative result of these numerous cultures taken from blood of cases of yellow fever, as regards the presence of bacillus icteroides, was reported in a "Preliminary note," presented at the meeting of the American Public Health Association, held in Indianapolis, Ind., October 22-26, 1900. To these 18 cases we can now add 6 other cases, or a total of 24, from which blood cultures have been made during life with negative results.

"The importance of this negative finding as regards the growth of any specific bacterium will be better appreciated when it is seen, as I shall soon have occasion to point out, that yellow fever may be produced in nonimmune human beings by the subcutaneous injection of a small quantity (0.5-2 cubic centimeters) of blood withdrawn from the venous circulation of a patient suffering with this disease.

"In addition to the results above recorded, the careful study of 11 autopsies was equally barren as to the presence of any particular microorganism, although the quantity of material with which our tubes were inoculated was greater than is usually made use of at autopsies.

"In a word, then, the careful bacteriological study which the commission had made in cases of yellow fever had given no indications as to the presence of the specific agent of this disease. The same may be said concerning the result of numerous microscopic examinations of fresh and stained specimens of blood which he had in the meanwhile studied with the view of finding possibly some intracellular or extracellular body. Apparently no body, bacterial or protozoan, which could be brought into view with a one-twelfth Zeiss immersion objective was present in the blood of these cases.

"Although displaced from the order in which the following observations were made, it will be best to present at this time the results of the experiments which were later carried out by the commission on nonimmune human beings by means of the subcutaneous injection of blood, withdrawn during the active stage of the disease, as these results bear so directly upon the subject which we are now considering, viz, the etiology of yellow fever.

"The only reference I can find in the literature relative to an attempt to convey yellow fever in this way is cited by Sternberg, who states that at Vera Cruz, Mexico, in 1877, he saw Doctor Ruis inject into a nonimmune individual a hypodermic syringe of blood drawn from a case of yellow fever on the eighth day of the disease. The result was negative; as was also the result of two other attempts related to him by Ruis.

"Our observations, undertaken for the purpose of ascertaining whether an attack of yellow fever could be induced in a second individual by the injection of a small quantity of blood, embrace experiments made on 12 American soldiers and Spanish immigrants, all nonimmune individuals.

"These observations may be divided into the following classes:

- "(1) Injection of the fresh blood taken from a vein at the bend of the elbow;
- (2) injection of partially defibrinated blood; (3) injection of partly defibrinated



blood heated for 10 minutes at 55° C.; (4) injection of blood serum previously diluted with sterilized water and filtered slowly through a Berkefeld laboratory filter.

"The following table gives the results of these several inoculations:

TABLE I

Num- ber of case	Quantity and material used	Day of disease	Date of inoculation	Result	Date of attack
I	2 cubic centimeters fresh blood-----	Second-----	Dec. 26, 1900	Negative----	
II	do-----	do-----	Jan. 4, 1901	Positive----	Jan. 8, 1901
III	1.5 cubic centimeters fresh blood-----	First-----	Jan. 8, 1901	do-----	Jan. 11, 1901
IV	0.5 cubic centimeter fresh blood-----	Second-----	Jan. 22, 1901	do-----	Jan. 24, 1901
V	1 cubic centimeter fresh blood-----	do-----	Jan. 25, 1901	do-----	Jan. 28, 1901
VI	0.75 cubic centimeter partially defibrinated blood-----	Third-----	Oct. 15, 1901	do-----	Oct. 20, 1901
VII	1.5 cubic centimeters partially defibrinated blood, heated for 10 minutes at 55° C.-----	do-----	do-----	Negative----	
VIII	Same as No. VII-----	do-----	do-----	do-----	
IX	do-----	do-----	do-----	do-----	
X	1.5 cubic centimeters of filtered blood serum-----	do-----	do-----	Positive----	Oct. 19, 1901
XI	Same as No. X-----	do-----	do-----	do-----	Do.
XII	do-----	do-----	do-----	Negative----	
	2 cubic centimeters fresh blood-----	Fourth-----	Oct. 22, 1901	Positive----	Oct. 23, 1901

"By an examination of this table it will be seen that of the seven individuals who received subcutaneously the fresh or partially defibrinated blood in quantities of 0.5-2 cubic centimeters, six (85.7 per cent) developed an attack of yellow fever within the usual period of incubation of the disease.

"These results are of very great interest as demonstrating that the specific agent of yellow fever is present in the blood, at least during the first, second, and third days of the attack.

"Another important point brought out by these experiments was that the blood which conveyed the disease did not contain any bacterium which would grow on our usual laboratory media.

"In order to establish this fact, as soon as blood had been injected into the nonimmune subject, additional blood was at once withdrawn in considerable quantity and transferred to tubes of nutritive bouillon. In one instance, where 2 cubic centimeters of blood had been drawn into the syringe, 0.5 cubic centimeter of this sufficed, when injected, to produce a severe attack of yellow fever, after 73 hours' incubation, while the remaining 1.5 cubic centimeters, transferred immediately to four tubes of bouillon gave no growth, except that from one tube we isolated on the fourth day *Staphylococcus pyogenes citreus* found by us to be a common skin-contaminating organism in Cuba.

"Table I further shows that the specific agent contained in the blood is destroyed or attenuated by heating the latter at 55° C. for 10 minutes, so that the injection of 1.5 cubic centimeters of this heated blood was harmless (Cases VII, VIII, and IX), while the injection of 0.75 cubic centimeter of the same blood unheated sufficed to promptly induce an attack of yellow fever in a control individual (Case VI).

"Of not less interest was the fact brought out by these observations that yellow fever can be produced by the injection of a small quantity of bacteria-free serum filtrate, obtained by passing the diluted serum through a Berkefeld laboratory filter (Cases X and XI), and further that the blood of a case of yellow fever, thus produced, when injected into a third nonimmune subject will promptly bring about an attack of this disease (Case XII), thus demonstrating that the specific agent of yellow fever can find its way through the pores of a filter which ordinarily serves to prevent the passage of all known bacteria.

"I have elsewhere, in conjunction with one of my colleagues (Carroll), discussed the facts here presented more at length and will limit myself, therefore, to the remark that these experiments appear to indicate that yellow fever, like the foot and mouth disease of cattle, is caused by a microorganism so minute in size that it might be designated as ultramicroscopic.

## "THE PROPAGATION OF YELLOW FEVER

"Prior to the time at which the foregoing observations were made the commission had already turned its entire attention to the possible solution of the problem of the propagation of yellow fever, being induced thereto not only by the fruitlessness of the investigations made thus far along bacteriological lines, but also by reason of certain facts which seemed to call for a better interpretation than had hitherto been accorded them.

"Without entering into details, I may say, in the first place, the commission saw, with some surprise, what had so often been noted in the literature, that patients in all stages of yellow fever could be cared for by nonimmune nurses without danger of contracting the disease. The noncontagious character of yellow fever was therefore hardly to be questioned.

"In the second place, it had been observed that patients discharged from the wards during early convalescence could be brought into intimate association with nonimmune individuals without thereby establishing fresh foci of the disease. This did not seem to indicate that any specific agent was present in the excreta of the sick.

"Again, it has been noted that in certain cases of this disease no growth had been obtained on the ordinary laboratory media, either by frequent cultures from the blood during life or from the blood and organs after death.

"Further, in the course of an investigation which the commission were able to make during the last week of July, 1900, concerning the origin and spread of a small epidemic of yellow fever that had appeared in a military garrison numbering about 900 men, at Pinar del Rio, Cuba, they had seen that by reason of the false diagnosis of 'pernicious malarial fever' which had been given to these cases no disinfection of bedding or clothing had been carried out, and yet there was no indication that this neglect had contributed in the least to the spread of the disease; nor had any harm come to those nonimmunes who had slept in the beds vacated by the sick or washed the supposedly infected garments of those who had recovered or died of this disease.

"Putting these various data together, it seems probable that more progress might be made if attention should be turned to the mode of transmission of yellow fever, especially as our own observations had caused us to seriously doubt the usually accepted belief of the conveyance of this disease by means of fomites. Then, too, the endemic curve of yellow fever in the city of Habana, and its well-known epidemic curve in the United States, appeared to be more intimately associated with and more affected by the rise and fall of the annual temperature curve than was to be seen in any of the acute infections except malarial fever.

"The peculiar behavior of this disease (if I may use the expression) in rapidly spreading in certain localities when introduced, as contrasted with its failure to propagate itself in other places where the conditions for its increase seemed just as favorable, seemed to point in the strongest manner to the necessity for some special or intermediate host in the dissemination of its specific cause. If malarial fever, a disease so much affected by temperature conditions, required the agency of a special genus of mosquito for its propagation, as had in recent years been so brilliantly worked out by Ross, Grassi, Bastianelli, and others, it did not seem unreasonable to suppose that yellow fever, a disease so plainly controlled by seasonal conditions, might also depend on some agent for its spread. Influenced by this line of reasoning the commission began during the second week of August, 1900, its observations relative to the propagation of yellow fever by means of the bite of a certain species of mosquito, *Stegomyia fasciata*.

"The work along this line was carried forward so rapidly that within 30 days 11 individuals had been bitten by infected *stegomyia*, of whom 2 developed well-marked attacks of yellow fever within the usual period of incubation and under such circumstances as to positively exclude in one case any other possible source of infection. One of these cases was that of Dr. James Carroll, contract surgeon, United States Army, a member of the commission.

"Appreciating fully the importance of this discovery, and in order to exclude all other possible sources of infection in our future observations, it was now determined to establish a special experiment station where further observation could be made on nonimmune human beings, both as to the propagation of yellow fever by means of the bite of the mosquito as well as by exposure to the most intimate contact with infected clothing and bedding, and this under the strictest enforcement of military quarantine. With the approval and assistance of the military governor of the island of Cuba, this experiment station was ready

for occupancy on November 20, 1900, and was continuously occupied until March 1, 1901.

"As the results obtained at this station have already been published in full elsewhere, I will here only present a brief account, first of the experiments with fomites and afterwards of those made with infected mosquitoes.

#### "ATTEMPTS AT INFECTION BY FOMITES

"For this purpose there was erected at Camp Lazear a small frame house, consisting of one room, 14 by 20 feet, and known as 'Building No. 1,' or the 'infected clothing and bedding building.' The cubic capacity of this house was 2,800 feet. It was tightly sealed within with tongued, and grooved boards, and was well battened on the outside. It faced the south and was provided with two small windows, each 26 by 34 inches in size. These windows were both placed on the south side of the building, the purpose being to prevent, as much as possible, any thorough circulation of the air within the house. They were closed by permanent wire screens of 0.5 millimeter mesh. In addition, a sliding glass sash was provided within and heavy wooden shutters without; the latter intended to prevent the entrance of sunlight into the building, as it was not deemed desirable that the disinfecting qualities of sunlight, direct or diffused, should at any time be exerted on the articles of clothing contained within the room. Entrance was effected through a small vestibule, 3 by 5 feet, also placed on the southern side of the house. This vestibule was protected without by a solid door, and was divided in its middle by a wire-screen door swung on spring hinges. The inner entrance was also closed by a second wire-screen door. In this way the passage of mosquitoes into this room was effectually excluded. During the day, and until after sunset, the house was kept securely closed, while by means of a suitable heating apparatus the temperature was raised to 92° and 95° F. Precaution was taken at the same time to maintain a sufficient humidity of the atmosphere. The average temperature of this house was thus kept up at 76.2° F. for a period of 63 days.

"November 30, 1900, the building now being ready for occupancy, three large boxes filled with sheets, pillowcases, blankets, etc., contaminated by contact with cases of yellow fever and their discharges, were received and placed therein. The majority of the articles had been taken from the beds of patients sick with yellow fever at Las Animas Hospital, Habana, or at Columbia Barracks. Many of them had been purposely "comfortable" and a much-soiled pair of blankets, removed from the bed of a patient sick with yellow fever in the town of Quemados, were contained in one of these boxes. The same day at 6 p. m., Dr. R. P. Cooke, acting assistant surgeon, United States Army, and two privates of the Hospital Corps, all nonimmune Americans, entered this building and deliberately unpacked these boxes, which had been tightly closed and locked for a period of two weeks. They were careful at the same time to give each article a thorough handling and shaking, in order to disseminate through the air of the room the specific agent of yellow fever, if contained in these fomites.

"These soiled sheets, pillowcases, and blankets were used in preparing the beds in which the members of the Hospital Corps slept. Various soiled articles were hung around the room and placed about the bed occupied by Doctor Cooke. From this date until December 19, 1900, a period of 20 days, this room was occupied each night by these three nonimmunes. Each morning the various soiled articles were carefully repacked in the aforesaid boxes and at night again unpacked and distributed about the room. During the day the residents of this house were permitted to occupy a tent pitched in the immediate vicinity, but were kept in strict quarantine.

\* \* \* \* \*

"December 19 these three nonimmunes were placed in quarantine for five days and then given the liberty of the camp. All had remained in perfect health, notwithstanding their stay of 20 nights amid such unwholesome surroundings.

"During the week December 20-27 the following articles were also placed in the house, viz, pajama suits, 1; undershirts, 2; nightshirts, 4; pillow slips, 4; sheets, 6; blankets, 5; pillows, 2; mattresses, 1. These articles had been removed from the persons and beds of four patients sick with yellow fever, and were very much soiled, as any change of clothing or bed linen during their attacks had been purposely avoided, the object being to obtain articles as thoroughly contaminated as possible.

"From December 21, 1900, till January 10, 1901, this building was again occupied by two nonimmune young Americans, under the same conditions as the preceding occupants, except that these men slept every night in the very garments worn by yellow-fever patients throughout their entire attacks, besides making use exclusively of their much-soiled pillow slips, sheets, and blankets. At the end of 21 nights of such intimate contact with these fomites they also went into quarantine, from which they were released five days later in perfect health.

"From January 11 till January 31, a period of 20 days, 'building No. 1,' continued to be occupied by two other nonimmune Americans, who, like those who preceded them, have slept every night in the beds formerly occupied by yellow-fever patients and in the nightshirts used by these patients throughout the attack without change. In addition, during the last 14 nights of their occupancy of this house they had slept each night with their pillows covered with towels that had been thoroughly soiled with the blood from both the general and capillary circulation on the first day of the disease in the case of a well-marked attack of yellow fever. Notwithstanding this trying ordeal, these men have continued to remain in perfect health.

"While the experiments with fomites were being carried out in building No. 1, certain nonimmune individuals who were lodged in tents, in a separate part of the camp, were being subjected, with their full consent, to the bites of mosquitoes which had previously fed on the blood of cases of yellow fever occurring in the city of Habana. Thus, during the period from December 5, 1900, to February 7, 1901, we had subjected to this method of infection 12 nonimmune subjects who had previously passed their full record of quarantine in this camp. Of these, 10, or 83.3 per cent, experienced attacks of yellow fever and always within the period of incubation of this disease.

"The following table gives the necessary data concerning these observations:

TABLE II

Number of case	Days in quarantine	Inoculation		Method of inoculation	Period of incubation in hours	Result	Order of occurrence	Date of occurrence
		Hour	Date					
I	15	2 p. m.	Dec. 5, 1900	Mosquito	81½	Positive	I	Dec. 8, 1900
II	9	4 p. m.	Dec. 8, 1900	do	137	do	III	Dec. 13, 1900
III	19	10.30 a. m.	Dec. 9, 1900	do	83½	do	II	Dec. 12, 1900
IV	21	4.30 p. m.	Dec. 11, 1900	do	91½	do	IV	Dec. 15, 1900
V	32	12 m.	Dec. 21, 1900	do	55	do	V	Dec. 25, 1900
VI	31	10 a. m.	Jan. 8, 1901	do	—	Negative	VI	—
VII	22	11 a. m.	Dec. 30, 1900	do	94½	Positive	VII	Jan. 3, 1901
VIII	69	8.30 p. m.	Jan. 19, 1901	do	95½	do	VIII	Jan. 23, 1901
IX	74	10.30 a. m.	Jan. 25, 1901	do	—	Negative	IX	—
X	6	9.30 a. m.	Jan. 31, 1901	do	74½	Positive	X	Feb. 3, 1901
XI	78	11 a. m.	Feb. 6, 1901	do	78	do	XI	Feb. 9, 1901
XII	25	2 p. m.	Feb. 7, 1901	do	70	do	XII	Feb. 10, 1901

"The positive results obtained, therefore, by this mode of infection stand in striking contrast to the negative experiments made with fomites. Indeed, cases VIII and XI of Table II had each slept 21 nights in the garments of yellow-fever patients while occupants of building No. 1. As they had remained in perfect health at Camp Lazear for yet 30 days longer, they were at the expiration of this time bitten by infected mosquitoes solely for the purpose of testing their immunity and with the result that an attack of yellow fever promptly followed in each case.

"It should be borne in mind also that of the nonimmune residents at Camp Lazear, while all lived under the same hygienic conditions, only those individuals developed yellow fever who were purposely bitten by contaminated mosquitoes or injected with the blood of those sick with this disease. Moreover, the precision with which the infection of the individual followed the bite of the mosquito left nothing to be desired in order to fulfill the requirements of a scientific experiment.

"Case V of Table II is of special interest when taken in connection with the failure to induce the disease by contact with fomites.

"This individual having been quarantined for 32 days at Camp Lazear, volunteered to enter a newly erected building in which 15 contaminated mosquitoes had just been freed. His first visit was at noon, December 21, 1901, and the length



of his stay 30 minutes. At 4.30 p. m. the same day he again entered this building and remained 20 minutes. The following day at 4.30 p. m. he for the third time visited this room and remained 20 minutes. During each of these visits he was bitten by mosquitoes. He did not enter the building again nor was he exposed to any other source of infection. Nevertheless, at the expiration of 3 days and 23 hours, or at 6 a. m., December 25, 1900, he was suddenly seized with an attack of yellow fever, which proved to be severe in character. That the infection was occasioned by the bites of contaminated mosquitoes was plainly shown by the immunity from the disease enjoyed by two nonimmune 'controls' who, protected only by a wire-screen partition, had been present at each of the subject's visits and who, under the same conditions of security against the bites of the infected mosquitoes, continued to sleep in and breathe the common atmosphere of this room for yet 18 nights.

"To the positive cases contained in Table II, which were produced at Camp Lazear, we are now able to add four other cases of yellow fever occasioned by the bites of infected mosquitoes, thus making a total of 14 cases, in each of which, happily, recovery followed.

"A very important point brought out by these observations in that an interval of about 12 days or more after contamination appears to be necessary before the infected stegomyia is capable of conveying the disease to a susceptible individual. Repeated experiments made with insects which had bitten yellow-fever patients 2 to 10 days previously were always negative, although these same insects were proven capable of conveying the disease after having been kept until 17 to 24 days had elapsed. Our observations further demonstrate that mosquitoes that have been kept for periods varying from 39 to 57 days after contamination are still capable of conveying the disease, and, further, that infected stegomyia may survive for a period of at least 71 days. This will explain how the contagion of yellow fever clings to a building, although it has been vacated for a period of two or more months.

"Bearing in mind that the observations by means of blood injections (Table I) were only undertaken after we had succeeded in demonstrating that the disease could be conveyed by the bites of infected stegomyia, it will be seen that our study of the method of propagation of yellow fever at Camp Lazear sufficed to prove very definitely that, while the natural mode of transmission of this disease is through the bites of infected mosquitoes, yellow fever may also be conveyed, like malarial fever, by the injection of a small quantity of blood taken from the viens of an individual suffering with this disease.

"Per contra, our observations show that notwithstanding the common belief in this mode of transmission, yellow fever can not be induced in the nonimmune individual even by the most intimate contact with contaminated articles of clothing and bedding.

"Although the investigations made at Camp Lazear were only concluded one year ago, already confirmatory evidence of the strongest character has been furnished in a series of experiments carried out by Guiteras at the inoculation station of the sanitary department at Habana.

"I may be pardoned for quoting the paragraph with which Guiteras begins his contribution. He says:

"The favorable results by the United States Army commission in their experiments with yellow fever, the continued series of mild cases resulting from these experiments without a death, suggested very naturally the continuation of their work on a larger scale, not with a view to control or confirm the conclusions of the commission, for anyone who had followed their work with unprejudiced attention must have concluded that their solution of the problem of the etiology of yellow fever was final, but rather in the hope of propagating the disease in a controllable form, and securing among the recently arrived immigrants immunization with the minimum amount of danger to themselves and the community."

"Of a total of 42 individuals inoculated by Guiteras, 25 were rejected by him by reason of having been bitten by insects that had been applied to cases of fever about which the diagnosis was in doubt. The following table, therefore, only includes 17 persons who were bitten by stegomyia that had previously fed

on unmistakable cases of yellow fever at intervals of 14 to 36 days before being applied to the nonimmune subject:

TABLE III

No. of case	Date of inoculation	Mode of inoculation	Result	Period of inoculation
1.....	Feb. 23, 1901	Mosquito.....	Positive.....	3 days 10 hours.
2.....	Aug. 4, 1901	do.....	Negative.....	
3.....	do.....	do.....	do.....	
4.....	Aug. 7, 1901	do.....	do.....	
5.....	Aug. 8, 1901	do.....	Positive.....	4 days 5 hours.
6.....	do.....	do.....	do.....	3 days 3 hours.
7.....	Aug. 7, 1901	do.....	Negative.....	
8.....	Aug. 9, 1901	do.....	Positive.....	5 days 3 hours.
9.....	Aug. 10, 1901	do.....	Negative.....	
10.....	do.....	do.....	do.....	
11.....	do.....	do.....	do.....	
12.....	Aug. 13, 1901	do.....	Positive.....	3 days 19 hours.
13.....	do.....	do.....	Negative.....	
14.....	Aug. 14, 1901	do.....	Positive.....	3 days 21 hours.
15.....	do.....	do.....	do.....	5 days 21 hours.
16.....	Aug. 22, 1901	do.....	do.....	3 days.
17.....	Aug. 24, 1901	do.....	Negative.....	Do.

"A more complete confirmation of the results obtained by the American commission could not be furnished than the data contained in the foregoing table, since they show that of 17 individuals who were bitten by infected *stegomyia fasciata*, 8 (47 per cent) developed the disease. Most unfortunately in three of these cases very grave symptoms ensued, such as black vomit and suppression of the urine, which eventuated in the death of the patients. I may add that in the hand of Guiteras fomites failed to exert any effect on nonimmunes.

"Whether other species of mosquitoes than *stegomyia* are capable of conveying the parasite of yellow fever has not as yet been determined by the commission, nor have we been able to ascertain whether the parasite passes from the mother insect to daughter insects. The experiments which we have thus far been able to make for the purpose of determining these important points, although negative, have been too few in number to warrant any definite expression of opinion.

#### "THE PREVENTION OF YELLOW FEVER

"The definite determination of the way in which yellow fever is transmitted from the sick to the well furnishes a solution at last of that much-vexed problem of how to prevent the spread of the disease. Even in the absence of more definite knowledge concerning its specific agent—knowledge greatly to be desired from the scientific standpoint—we are now able as sanitarians to direct our efforts along certain well-defined lines, with a feeling of security heretofore unknown.

"From the point of view of prevention the situation may be briefly summed up in the following conclusion, which was presented by the American Army commission to the Pan American Congress of 1900, viz: 'The spread of yellow fever can be most effectually controlled by measures directed to the destruction of mosquitoes and the protection of the sick against the bites of these insects.'

"This conclusion was the logical outcome of the observations that had been made by the commission at its experimental station near Quemados, Cuba.

"The importance of the discovery that yellow fever is transmitted by the bite of a certain species of mosquito did not fail to attract the prompt attention of the military governor of the island of Cuba, himself a physician and formerly a distinguished member of the Medical Department of the United States Army. By his direction the theory was at once subjected to a practical test in the city of Habana, in which city yellow fever had not failed to make its yearly appearance during the past 140 years.

"Under the efficient management of the chief sanitary officer, Surg. Maj. William C. Gorgas, United States Army, the sanitary regulations were so far modified as to require that every patient having yellow fever should not only be quarantined but that his room should be protected with wire screens, so as to prevent the possibility of mosquitoes becoming infected by sucking the blood of the patient. As a second important measure, a systematic destruction of all mosquitoes in other rooms of the patient's house as well as in adjoining houses

was at once begun, the fumes of pyrethrum being relied upon to stupefy the insects, after which they were carefully swept up and burned. In other words, Surgeon Major Gorgas, relying upon the well-known slow progress of yellow fever, sought to destroy all mosquitoes infected or noninfected within a given radius of each case, whilst at the same time he effectually excluded all mosquitoes from access to the sick. If a secondary case occurred, the same hygienic measures were vigorously enforced along the lines indicated.

"As an illustration of what has been accomplished by these newer sanitary regulations, I may state that counting from the date when they were put into force, viz, February 15, 1901, Habana was freed from yellow fever within 90 days, so that from May 7 to July 1, a period of 54 days, no cases occurred. Notwithstanding the fact that on the latter date and during the months of July, August, and September the disease was repeatedly introduced into Habana from an inland town, no difficulty was encountered in promptly stamping it out by the measures of sanitation intelligently applied both in the city of Habana as well as in the town of Santiago de las Vegas, whence the disease was being brought into Habana."

Maj. Walter Reed died in Washington November 23, 1902, from acute appendicitis, and his widow was given a pension of \$125 per month by special act of Congress in recognition of the services of her husband in the yellow-fever investigations. At the beginning of the present Congress a bill, S. 1157, was introduced by Senator Dick granting a pension of \$125 per month to Mrs. Jennie Carroll, and a like bill, S. 1168, was introduced by Senator Knox for Mrs. Mabel Lazear. These bills were called to the attention of President Roosevelt, and the following letter to the chairman of the Senate Committee on Pensions shows his attitude toward the proposed legislation:

In a medical journal entitled "International Clinics, Series 36" for the month of June, 1926, will be found an article by Paul de Krief, setting forth the experiments conducted in connection with yellow fever.

In our judgment, these heroes of the fight against yellow fever are entitled to the everlasting gratitude of the people of this Republic and that gratitude should be shown not only by honoring their memories in print and with spoken words, but by a substantial recognition of our obligation to assist in the support of their dependent loved ones and, for that reason, we respectfully urge the passage of the pending bill in favor of Dr. Robert P. Cooke.

From H. R. 16669, we take the following extract in order to show the names of all those who engaged in the experiments concerning yellow fever. Of course, we feel that each individual case should be passed upon specifically, in order to ascertain the disabilities suffered by the individual and the condition of his present health and his general financial circumstances. The list is as follows:

Maj. Walter Reed, Maj. James Carroll, John R. Kissinger, Levi E. Folk, Clyde L. West, James L. Hanberry, Charles G. Sontag, Warren Gadsen Jernegan, William Olsen, Wallace W. Forbes, John H. Andrus, Edward Weatherwalk, James Hildebrand, Thomas M. England, late of the Hospital Corps, United States Army; William H. Dean, late of Troop B, Seventh Cavalry, United States Army; Albert W. Covington, Paul Hamann, late of Twenty-third Company, Coast Artillery, United States Army; Jesse W. Lazear, Aristides Agramonte, Robert P. Cooke, late contract surgeons, United States Army; John J. Moran, late civilian clerk, United States Army; and John R. Bullard, a volunteer.

