Jonas Salk, the People's Scientist

Algis Valiunas

At the age of forty, Jonas Salk became the most beloved scientist in America. He was probably the most beloved scientist the world has ever seen. Einstein may have been more famous, but very few understood what he had done. He was much loved, but in the way hobbits or leprechauns are loved, fancifully, as a bearer of benign, alien magic. J. Robert Oppenheimer was as famous as Salk, and millions were grateful for what he did, yet his achievement also made him notorious—downright malignant in the eyes of many, the malignancy growing as the monstrosity of Imperial Japan has receded from public memory. But everyone knew and understood what Jonas Salk had done with the vaccine for paralytic poliomyelitis that bears his name, and everyone loved him for it unreservedly, with the exception of a good many other scientists, who were grossly outnumbered by the adoring multitude.

In the United States during the early 1950s, according to Paul Offit's book *The Cutter Incident*, a public opinion poll showed that the fear of polio ran second only to the fear of nuclear megadeath. Such polling results reflect in part the public relations skills of the National Foundation for Infantile Paralysis. In 1952, the year of a large polio epidemic that killed over three thousand people, ten times as many died from pneumonia and seventy times as many from cancer. Nevertheless, there was reason enough for widespread fear of polio. At a time when the risk posed by many of the most deadly infectious diseases, such as syphilis, tuberculosis, and bacterial pneumonia, had lately been radically reduced by antibiotics, most viral infections, such as polio, remained unstoppable. The incidence of polio had been on an upward trend through the 1940s; each new summer brought an epidemic, and most of the casualties were children and adolescents.

Several historians of the illness and the vaccine that helped wipe it out cite the recollections of an unnamed nurse who worked at Pittsburgh's Municipal Hospital, where Dr. Salk had his research laboratory. She remembers ambulances waiting in line outside, up to seventeen new admissions daily, doctors who snatched what sleep they could in their scrubs on cots, and nurses who found it hard to go home.

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> To leave the place you had to pass a certain number of rooms, and you'd hear a child crying for someone to read his mail to him or for a drink of water or why can't she move, and you couldn't be cruel enough just to pass by. It was an atmosphere of grief, terror and helpless rage.

One learns from Jeffrey Kluger's *Splendid Solution: Jonas Salk and the Conquest of Polio* (2005) that during the peak season of 1953, there were 391 new polio patients admitted to Municipal Hospital, nearly all of them children, and 323 were paralyzed. David M. Oshinsky, in his book *Polio: An American Story* (2005), cites an interview with Salk's eldest son, Peter, who remembers that his father "made a point of walking through that [polio] ward. People would approach him in tears. 'Please, Dr. Salk, please save our child.' There was a pathos to this, a sadness that never left his mind." Jonas Salk devoted his medical career to research, but he was a physician with superabundant fellow-feeling, and he knew that not even the best doctors could save every child.

Some paralyzed patients recovered completely on their own. Others regained partial use of afflicted limbs and might rely on leg braces or crutches for the rest of their lives, the established clinical approach at the time—albeit inimical to the rehabilitative methods of "Sister" Elizabeth Kenny, a nurse from Australia then famous in her own right for championing what is now known as physical therapy. Then there were those patients with paralyzed respiratory systems who were consigned to the hellish salvation of an iron lung, a premature burial for the barely living. Better perhaps to enjoy the full measure of death brought on by bulbar polio, which zeroed in on the brain's medulla oblongata (which regulates breathing and swallowing) and frequently finished the job in short order. No wonder then that Jonas Salk was hailed as the supreme incarnation of medical genius, and even revered by some as the appointed representative of divine mercy.

He grew up wanting to be a miracle worker, to perform heroic feats of compassion, to minister to suffering humanity in a way that would bring his own spirit comfort and might win him lustrous renown. As Charlotte DeCroes Jacobs writes in the excellent biography *Jonas Salk: A Life* (2015), "Every day he prayed he would do something good for mankind. His brothers called him 'Little Jesus.'" That was an ambiguous honorific at best, especially for a young Jew, but this not unaffectionate abuse hit the target dead center: Salk wanted to be a savior. His understanding of his privileged duty represented Judaism on the moral heights, devoted to *ma'asim tovim*—good deeds—and specifically to *tikkun olam*—repairing

the world. "For Jews, acts of goodness define a person. For Jonas, *ma'asim tovim* was not an option; it was an obligation."

From early childhood, the sight of human misery hit Jonas hard and left a lasting mark. He remembered years later the Armistice Day parade in New York City in 1918, and the distressing spectacle of soldiers with a missing arm or leg. The lethal influenza pandemic that same year imprinted memories of horse-drawn carts bearing coffins through the streets. The aftermath of the 1916 polio epidemic haunted him with recollections of schoolmates struggling with leg braces like prisoners clapped in irons. The world was a vale of tears, and the endless procession of human tribulation gathered force in Salk's soul until the relief of man's estate became his chosen life.

For Salk, as for many other doctors and for certain great political leaders, the problem of evil was not a theological conundrum but a practical imperative, a call to immediate action. To suffer with those he saw suffer meant he had to do something—something decisive, something marvelous—to reduce the prodigious sum of human pain.

Virus, Dead or Alive

Jonas Salk was born in 1914, and his adolescent inclinations were literary and philosophical. Of his high school education at the intellectually exclusive Townsend Harris Hall in Manhattan, a public school focusing on the Great Books and offering only one physics course and no chemistry or biology, Salk remembered, "I was not interested in science. I was merely interested in things human." The human things of interest expanded to encompass science at the City College of New York, which he entered before he turned sixteen, and where he became a pre-med student.

But getting into medical school was a close-run thing. With his all-too-human grade point average and his Jewishness stacked against him—under an unspoken quota system, only the very best of the best Jewish students stood a chance of admission to most medical schools—Salk was rejected nearly everywhere he applied. The only school to offer him a place was the University and Bellevue Hospital Medical College (today called the New York University School of Medicine).

There he distinguished himself. His first-year biochemistry professor saw such promise in his answer to an open-ended exam question that he offered Salk a year-long fellowship as a research and teaching assistant. Salk hesitated to interrupt his medical course of study, but he needed the money to help finance the rest of his education; so he accepted. Devising an improved technique to separate bacteria from their culture broth earned

him his first published paper at the age of twenty-two. His supervisor thought Salk, with his abilities and interests, might do better to pursue a Ph.D. rather than an M.D. Jacobs writes: "He declined. He perceived how easily one could become absorbed in some chemical puzzle and lose sight of the human element. And that is what drove him."

After he heard two contradictory lectures, his intellectual and moral passions conjoined in the question of whether anti-viral vaccines could be made from killed viruses (these are known as inactivated vaccines), or whether only vaccines made from live viruses would confer immunity. Live vaccines were the standard: The three anti-viral vaccines then available—for smallpox, rabies, and yellow fever—used attenuated live viruses to produce a mild infection that would guard against severe infection. Live vaccines carry a risk, albeit a small one, of causing the infection they are meant to prevent. Even today, a live-virus version of the polio vaccine that is used in the developing world—though not in the United States, where Salk's killed-virus vaccine is now standard—continues to cause occasional small outbreaks of polio, as happened this summer in the Democratic Republic of the Congo.

But Salk believed live vaccines needn't be the rule. There were effective vaccines against tetanus and diphtheria—both bacterial infections—that employed chemically inactivated microbial toxins, which nevertheless provoked antibody response. As Jacobs explains, "Jonas wanted to test the hypothesis that one could kill a virus, destroying its infectivity, while retaining its ability to stimulate antibody production."

Under the supervision of Dr. Thomas Francis, Jr., the new bacteriology chairman, Salk showed that laboratory mice vaccinated with influenza virus killed by ultraviolet light produced the corresponding antibodies. Thus he established the principle upon which he would found his life-saving work. He had yet to graduate from medical school. He would go on to do so with the highest honors.

Salk did his two-year internship at Mount Sinai Hospital—"like playing ball for the New York Yankees," in one doctor's words—where he demonstrated such address in the operating room that a staff surgeon coveted him for his practice. Virology, however, was his field of choice, and when several prestigious university hospitals and research institutes turned him down—they were looking for Ivy League gentiles—he contacted the more ecumenical Francis, now the founding epidemiology chairman of the University of Michigan's new School of Public Health.

His former supervisor came through. In 1942, with a $2,100 fellowship to study viral immunology from the National Foundation for Infantile

Paralysis, and a draft deferment as an influenza researcher essential to the national defense, Salk headed off to Ann Arbor, where Francis had been appointed by the secretary of war as chief of the Commission on Influenza.

The Flu Breakthrough

The Spanish influenza pandemic of 1918–1920 had killed fifty to a hundred million worldwide, compared to 15 to 19 million in the Great War. At least half a million Americans died of the illness, or of the pneumonia that was its frequent complication, including about forty thousand soldiers. The etiology of influenza remained unsettled until the early 1930s, when Rockefeller Institute researchers showed that a virus caused the disease in pigs, and British scientists then proved that human flu was also viral. Only when electron microscopes were put to use in biology nearly ten years later would the virus be made visible.

Thomas Francis did not need to see the virus, though, in order to begin fighting it. By 1935, at the Rockefeller Institute, he and a colleague had come up with a vaccine ready for human trial, and had shown that the inoculation produced antibodies; it remained to be seen whether the vaccine actually shielded against the flu.

When Salk showed up in Michigan, Francis was preparing for a field trial, which meant "vaccinating a large number of individuals and comparing their rate of infection with that of a control group that did not get the vaccine," Jacobs writes. Two state hospitals for the profoundly mentally ill provided the guinea pigs for the experiment. Under Salk's direction, eight thousand helpless madmen were injected either with the vaccine or a saline placebo; the test showed a significant elevation in antibody levels among the vaccinated, but as there was no flu going around that season the trial was moot.

As Jacobs writes, the logical next step was to infect a much smaller cohort of mental patients with virus,

> spraying mist made from dried, infected mouse lung tissue into their nostrils. Deliberately infecting institutionalized patients was accepted practice at the time. It wasn't until 1947, following the Nuremberg Trials, that human subjects were protected by a set of ethical principles. One can only guess that Salk felt the prospect of fifty thousand or more young soldiers dying from influenza justified their actions.

Whatever Salk may have thought about the benefits of experimenting on these patients, and however accepted the practice of deliberate infection

may have been at the time, he did exploit the defenseless here. Half the infected, unvaccinated patients contracted the flu, while only 16 percent of the vaccinated did, which at the expense of the unprotected patients showed that the vaccine worked capably under experimental conditions.

The 1943 epidemic of Type A influenza gave Salk and Francis the chance to show that the vaccine also worked against wild virus. It did so remarkably well. Twelve thousand five hundred army trainees took part in another blind trial, and only two percent of those vaccinated came down with the flu during the outbreak. Moreover, the psychiatric patients who had received the vaccine more than a year earlier remained free of the disease. Thus the case for the killed-virus vaccine was strengthened: It conferred long-lasting immunity, thereby upending the predictions of most microbiologists, who had been confident that whatever protection it might provide would be short-lived.

At the University of Michigan, where a good number of students had been vaccinated, a further benefit became apparent. The infection rate there was significantly lower than in the general population, for the vaccine's success among the inoculated cohort inhibited general contagion and ensured that fewer students overall got sick; the primary meaning of the term "herd effect" had changed, from an offense against Nietzschean nobility to a valuable epidemiological discovery.

Salk was thinking continually about improvements to the flu vaccine. In *Breakthrough: The Saga of Jonas Salk* (1965), Richard Carter writes that Salk broadened the experimental vaccine's effective reach in 1943, after discovering that an apparent outbreak of atypical pneumonia at an army base was actually flu caused by the Weiss strain, which the vaccine did not protect against. As Salk told Carter in an interview, "If the next epidemic is going to be caused by the Weiss strain, your vaccine will be useless if there are no Weiss strain viruses in it. To avoid surprises of this kind, and the failures so often ascribed to flu vaccines, you must cram your vaccine with every strain you can lay hands on."

As Jacobs tells the story, Salk was also experimenting with adjuvants, chemicals added to the vaccine to increase its immunological power, thereby reducing the necessary concentration of virus in the vaccine. Too heavy a viral load can be pernicious, even fatal: Salk was moved to work ever harder on adjuvants by the case of a three-year-old girl who he determined had died from a virus overload hours after a vaccination.

Yet even as Salk was doing essential work, he was offending against academic propriety. His striking a deal with the pharmaceutical manufacturer Parke, Davis and Company to provide exclusive information on

vaccine development in exchange for royalties on any subsequent sale of the vaccine outraged Francis. His writing a piece for *Parents Magazine* on flu vaccine outraged many. Pandering to the masses, seeking the limelight, was beneath the dignity of a serious researcher. Educating ordinary people about medical arcana they could not possibly understand, however much even limited information might improve their lives, was unconscionable grandstanding in the eyes of the peerage.

Salk's standing in scientific circles would suffer as his public profile grew more prominent. When in the course of events universal fame alighted on him like divine grace and made him every bit as wondrous to the crowd as Joe DiMaggio, the council elders closed ranks against the insufferable showboat. Little Jesus was cute, but only as long as he was little. Big Jesus would have to take his lumps.

The March on Polio

Pittsburgh would be the unlikely site of Salk's transfiguration. In 1947, "in love with… the prospect of independence," as he put it, Salk took a post as director of the Virus Research Laboratory at the University of Pittsburgh Medical School, an institution distinguished for its mediocrity in a city notable for its dilapidation. He took the job sight unseen, and his first viewing of his new laboratory dampened his enthusiasm, to say the least: a basement space of forty by forty feet in the sometime morgue of Municipal Hospital.

To commandeer the facilities necessary for his work and his dignity required formidable energy and adroit bureaucratic finagling. In both respects Salk showed himself a master, massaging the bosses like a seasoned pol, letting them know of significant cost overruns after the fact, getting what he wanted when he wanted it. Eventually his lab space would encompass six thousand square feet on three floors of the hospital.

His stated intention from the outset was to investigate influenza, measles, and the common cold. But Harry Weaver, the research director of the National Foundation for Infantile Paralysis (NFIP), had different plans in store for him. A recruiting visit in December 1947 from Weaver would launch Salk in a new direction and prove epoch-making.

The NFIP was a fundraising juggernaut, the *sine qua non* of the conquest of polio. The kingpin of the operation, Basil O'Connor, was the former Wall Street law partner of the most famous polio victim, Franklin Delano Roosevelt. Following the precept of the filmmaker John Ford, vaccine historians "print the legend" that the two men first met when

O'Connor helped the fallen paralytic up from the floor after he slipped in the lobby of a Manhattan office building. Some of the writers are less inclined to believe this account than others.

Whatever the true story, O'Connor and Roosevelt together became a powerhouse for the cause. They organized a vast number of charity balls across the country, held annually on President Roosevelt's birthday, to save Warm Springs, the Georgia spa with soothing waters that he hoped for a time would restore him to full-bodied health. The first ball, as described by David Oshinsky, saw "fifty-two white doves…released in Grafton, West Virginia, to mark the president's age," skiers in New Hampshire forming "a huge 'R' for Roosevelt with exploding red flares," and "a tribal dance on the Blackfoot Reservation" in Montana. The balls raised large sums both for Warm Springs and for polio victims in the local communities that held them.

In 1938 Roosevelt founded the nonprofit NFIP, choosing O'Connor as the director. Its mission was to discover a cure and to provide superior care for victims of the illness. O'Connor's masterly canniness would "turn polio into the country's number one health threat, uniquely dangerous on the one hand, eminently beatable on the other."

Public generosity on a vast scale helped administer the beating. In its first year, the Foundation held a fundraising campaign called the March of Dimes. The Lone Ranger, Jack Benny, Bing Crosby, and other Hollywood celebrities made their pitch to the public, and 2,680,000 dimes were mailed to the White House. The NFIP's fundraising apparatus would be known as the March of Dimes henceforth. When the Roosevelt dime was first issued in 1946, the director of the U.S. Mint noted that enough of them should be produced to cover the polio drive.

The first official poster child also made his debut in 1946, and the press zoomed in on his "wistful look" and "enormous eyes." There was a before-picture of him as a very sick three-year-old in a neck brace and there was an after-picture of him as a robust six-year-old on the march, with the caption, "Your dimes did this for me!" (He was not in fact as healthy as the after-picture suggested.) Collection boxes at movie theaters and the nationwide Mothers' March on Polio became prime sources of income. The March of Dimes took in just shy of two million dollars in its first year. By 1954 the figure was almost $67 million, equal to the donations to the seven other major health charities combined.

The money was well spent. As Oshinsky writes, in the year the NFIP was founded, "less than ten percent of the nation's families had any form of health insurance," and "the expense of boarding a polio patient…

actually exceeded the average annual wage." Through 1955 the NFIP gave $233 million to patient care, providing more than eighty percent of polio patients with serious financial assistance.

And there were of course the researchers to support. NFIP grants to Salk alone from 1949 to 1953 totaled nearly a million dollars. The Foundation spent two million dollars on research in 1953, while total federal funding of polio research that year was less than $75,000. O'Connor wanted polio to be a public concern with strictly private funding, and Oshinsky cites a characteristic rant of his that government backing of medical science would constitute dire inroads for a "Communistic, un-American . . . scheme."

The triumph of the National Foundation for Infantile Paralysis exemplified the American democratic faith in non-governmental associations for civic benefit that Alexis de Tocqueville eulogized in *Democracy in America*: "There is nothing, according to me, that deserves more to attract our regard than the intellectual and moral associations of America. . . . In democratic countries the science of association is the mother science; the progress of all the others depends on the progress of that one." The NFIP's fundraising and its direction of money to the best researchers made the heroic science of Salk and others possible.

Type, Type, Type

When Harry Weaver, the Foundation's research director, paid a visit to Salk in 1947, the NFIP was hoping to mount a decisive campaign for a polio vaccine. Salk would be the NFIP's made man. For the first year's work he received a grant of nearly $150,000, more than any other Pittsburgh faculty member had ever gotten for anything. He expected the extravagant funding for this tedious undertaking would help to pay for his true cherished ambition: the universal flu vaccine. The detour into polio was just a means to this end.

The prerequisite to the campaign against polio was virus typing. The numerous strains that researchers had isolated from patients over the years needed to be sorted according to type. When various strains belonged to a particular type, this meant they were similar enough that they would be susceptible to the same vaccine. But the number of polio types was then virtually unknown. When the NFIP typing project began, Johns Hopkins and Yale researchers had identified just two.

Figuring out how many types there were would be grunt work. As Jane S. Smith writes in *Patenting the Sun: Polio and the Salk Vaccine* (1990),

the job was "dauntingly, staggeringly, stupefyingly dull. Its main attributes were constant repetition of the same small procedure, endless waiting for results, painstaking attention to detail and method—and a clear certainty that no glory lay at the end of all the effort." No polio researcher of any prominence would condescend to do such manual labor; the acknowledged eminences who laid out the project and the procedures to be followed left the ignoble task to experienced, unambitious mechanics and inexperienced, highly ambitious would-be eminences, such as Salk. He was expected to be a dutiful follower, and that he appeared so courteous and agreeable in his work came as a very pleasant surprise to Weaver.

Using a method known as serum neutralization, Salk would inoculate monkeys with type 1 virus, then after six weeks collect their blood serum, with its antibodies against type 1. He would combine this serum with virus of an unknown type, then inject it into the brains of uninfected monkeys. Then he would see whether the serum with its antibodies against type 1 protected the monkeys against infection from the unknown virus. If the monkeys stayed healthy, that meant the unknown virus was type 1; if they sickened, the unknown virus was type 2 or 3. The procedure was unwieldy, time-consuming, and hard on the lab monkey population.

There had to be a better way. Salk turned his mind to improving on the method, which had been developed by Albert Sabin of the University of Cincinnati, one of the eminences of the typing project. Trying the mineral-oil adjuvant he had successfully used in the influenza vaccine, he found that it also enhanced the immunizing force of polio virus, multiplying a hundredfold the ability of the injection to produce antibody response. "This had major implications for human vaccination," as Jacobs writes.

However, when Salk disclosed his discoveries in January 1950 and suggested procedural changes, the Committee on Typing rejected his plan. The overseers had set the procedures already, and "no one wanted to change" them, Jacobs reports. He got a second chance when Weaver received an urgent typing request from the Public Health Service and Salk convinced him that mineral oil would speed the job—he had in fact been using the adjuvant for a while without Weaver's knowledge. Soon Weaver was deluged with researchers' requests for adjuvant information, and the committee did approve its use for typing.

The committee required additional convincing on another, more significant innovation that Salk proposed. Salk would tell biographer Richard Carter of the opposition he encountered from the committee:

> They were again discussing the problem of viruses of low infectivity or, as we call it, low infectious titer. Some infectivity experiment or other was being analyzed. And I asked, "How much *antigen* [virus] is actually present in the suspension of mouse or monkey spinal cord?" I was asking, you see, whether it had occurred to the committee that a virus of low infectious titer might provoke formation of as much antibody as would a closely related virus of higher infectious titer. I was suggesting that our purposes might be served better by testing an unknown virus' capacity to immunize, rather than worrying about its capacity to infect.

Sabin, renowned for his arrogant unpleasantness, greeted Salk's suggestion with a feline hiss: "Now, Dr. Salk, you should know better than to ask a question like that." The protocol had been set and no neophyte was going to tell the experts how to go about their business.

Salk handled the hostile crowd with conciliatory circumspection but pressed his point. To type each strain under the current regimen required some forty monkeys, while to do so under his proposal would take only fifteen. The researchers could save invaluable time, avoid some of the endless bother, and spare a wilderness of monkeys. The committee voted him down. Salk told Carter of his trials at the hands of his colleagues:

> The typing program was to take three years, but our laboratory had the whole thing solved before the end of the first year. Everything that happened during the last two years was merely confirmatory. What could I do? I couldn't slap those people in the face and call them dumb bunnies and shriek that they were doing their job ass-wise. Even if I could have, I would not have wanted to. They had their way of looking at things and I had mine and it was incumbent on me to try to win them over.

He would petition Weaver graciously but insistently until Weaver gave in and granted permission to try the innovative procedure on several strains. Salk had been trying his own method on the side for a spell anyway—"there was no reason why I could not also do the work in my own way, and I did," he told Carter. He now seized the chance to prove his point. As Jacobs writes, "After Salk proceeded to analyze seventy-four strains…, getting the same results in record time, the group agreed to try his technique."

Hurried along by Salk's prodding, typing was at last concluded in 1951, with the expenditure of $1.3 million and the lives of some twenty thousand monkeys, with whose "struggles, dodges, and antics" the

scientists were tired of coping. They found that type 1 was the most common, accounting for over eighty percent of cases, while types 2 and 3 made up about ten percent each. Type 1 accounted for the familiar epidemics of paralysis associated with the disease, while type 2 was a milder virus that often caused no symptoms at all. Type 3, the rarest form, was also the most deadly, as it was the most likely to cause dangerous infections of the medulla oblongata that could paralyze the diaphragm, leaving patients unable to breathe.

But what was most important about the results of the typing project for the purposes of the later work on immunization was that the polio family was found to be, as David Oshinsky puts it, "remarkably, *conveniently*, small." Though Sabin expressed some doubts, Salk was certain. Compared to the protean scourge of influenza, Salk was "quite unimpressed by the differences among the poliomyelitis viruses," which exhibited in fact "a remarkable homogeneity" in structure. The implication: Polio might be susceptible to a single vaccine that would work against all three types of virus.

Mass Production

Salk was instrumental also to overcoming the other chief impediment to success: the difficulty of safely cultivating enough virus to mass-produce a vaccine. Oshinsky provides perhaps the clearest and most succinct account.

Virus grows only in living cells, and in 1936 Sabin and Peter Olitsky of the Rockefeller Institute had grown polio virus for the first time in tissue culture, which is to say *in vitro*—in a flask, as opposed to *in vivo*, in a living organism. They had used tissue from two human fetuses, three to four months old, obtained from Caesarean sections in a nearby hospital. (The original paper leaves unclear the circumstances of the C-sections and how the researchers obtained the fetuses.) Patient safety, however, appeared to be an intractable problem, for the two researchers had been able to grow the virus only in the fetuses' nervous tissue, and the injection of human nervous tissue can cause encephalomyelitis, a brutal inflammation of the central nervous system. Vaccines made with virus grown in nervous tissue were thus quite dangerous.

However, contrary to the prevalent belief among researchers at the time, nervous tissue was not the sole viable culture medium for polio. That restriction happened to be true for the particular strain that Sabin and Olitsky had used, but not for most other strains. John Enders of Harvard

and the Children's Hospital of Boston suspected that polio's abundance in the gastrointestinal tracts of patients meant that it could be grown in tissue other than nervous. In 1949 his lab grew all three types of polio virus on skin, muscle, and kidney tissues from human fetuses.

Salk saw the importance of this advance right away, and he simplified Enders's complicated technique, instead using minced monkey kidneys and testes and a mix of nutrients to grow the virus in test tubes. Mass production of vaccine would now be possible. Enders's work would earn him the Nobel Prize for Medicine and Physiology in 1954.

The indispensable preliminaries were over. To the men who ran the NFIP, Basil O'Connor and Harry Weaver, Salk was fast becoming the favorite son who could do no wrong—"the poster scientist for the March of Dimes," in Jacobs's phrase. In 1951 the NFIP held the first meeting of the Committee on Immunization, with Salk now taking his place among the eminences.

He was an adept popularizer, a natural go-between who made the complex science not only intelligible but even fascinating to a public eager and anxious for the latest word on polio. When Weaver wanted someone to talk to a reporter from *Good Housekeeping*, or allow a Foundation photographer in his lab for a day, or address a nationwide audience on the radio, Salk was the man for the job. He even responded courteously to letters from the public telling him that polio was caused by anxiety or cats.

Salk's unaffected empathy also charmed O'Connor, who did not succumb easily. In 1951, O'Connor's eldest daughter, who was recovering from severe paralytic polio, was with him, Enders, and Salk aboard the *Queen Mary* on a transatlantic crossing. The genuinely warm solicitude with which Salk treated her made O'Connor realize what moved the doctor in his research, and what an impressive asset he could be to the Foundation. Speaking to Richard Carter years later, O'Connor came as close as he ever would to unabashed rhapsody:

> Jonas is in touch with the world. I don't mean that he's worldly. He's not. In some ways he reminds you of a girl who's never been in a bar before. But he is a human scientist, or call him humane or humanitarian or humanistic. He is aware of the world and concerned about it. He sees beyond the microscope.... He's a generalizer and a synthesizer.... These were the reasons, along with his friendly, modest ways and his unmistakable sense of honor and rectitude, that I liked Jonas. Before that ship landed I knew that he was a young man to keep an eye on.

Before long, not just O'Connor but the world would have its eyes on Jonas.

The Vaccine

The work at hand consumed Salk. He abandoned his influenza research in order to focus all his energies on polio prevention. The production of antibodies—proteins that emerge in the blood in response to intruders, fending off infection—was the keystone. There were two known methods to provide antibodies, which Jacobs describes:

> People could be actively immunized to produce their own through inoculation (with either weakened live or killed virus). Alternatively, gamma globulin, the fraction of blood serum that contains antibodies, could be obtained from patients who had already had polio and injected into healthy people, imparting what was called "passive immunization." Salk intended to pursue both approaches. He even considered immunizing cows and hens so the public could acquire antipolio antibodies from milk and eggs.

Gamma globulin, which provided immunity only for a few weeks, might be used to stem an outbreak but had no promise as a universal, long-term preventive. With a handsome grant that restricted Salk to vaccine development, Weaver convinced him to forget passive immunization and to concentrate on beating polio once and for all.

Salk began by selecting a virus strain of each type that was capable of raising antibody levels high and keeping them there for a long time. For type 1, he chose a strain that had been isolated by Thomas Francis from a patient in Ohio; for type 2, a strain isolated by Rockefeller Institute researchers from the spinal cord of a British soldier in the Middle East Forces who had been killed by polio; and for type 3, a strain isolated by Salk himself from the stool of a paralyzed ten-year-old boy at Municipal Hospital.

Shutting down the virus's infectiousness while preserving its antigenicity was Salk's next concern. He used formalin, a type of formaldehyde, to inactivate the virus. Sometimes blind chance determines the speed and direction of scientific or medical advance. Salk feared that an experiment had gone hopelessly awry when the electricity shut off in the cold room and ice began to melt, but he discovered serendipitously that 1 degree Celsius, the temperature of melting ice, was highly effective for inactivating virus using formalin. The killed virus, in theory, would not run the risk of live vaccine—reverting to virulence, thus causing the disease that the vaccine was intended to prevent.

By June 1952, during the largest polio epidemic the United States had seen, Salk was ready for the first human trial for his vaccine, on

polio victims at the D. T. Watson Home for Crippled Children outside of Pittsburgh. Salk had picked this particular place for his first trial because it was sufficiently isolated from colleagues and reporters; he wanted to keep the trial from the eyes of the public until it was over. And the director of the home was herself interested in Salk's work and concerned about the state of polio research, and she saw to it that parents were asked for consent. The children would of course not derive any medical benefit from these trials. Salk was testing for side effects first and foremost, as well as for antibody production, and so polio victims seemed like the ideal first subjects, since there was presumably no risk of their accidentally contracting the disease. As Oshinsky explains, Salk first determined which type of polio the children had suffered from by checking which antibodies were present in their blood, and then injected them with a killed-virus vaccine derived only from that type, to ensure that they would not be put at risk of infection by a different type of polio. None of the subjects showed adverse effects, and all showed elevated antibody levels.

But these subjects already had antibodies against the particular type of polio they had contracted. So Salk had to test again, this time in a riskier trial with children who had not had polio—and thus had no acquired immunity—but had already been crippled by other causes. This way the safety of the vaccine could be tested again on children—the population who was most susceptible to contracting the disease and who would need to receive vaccination—while not risking the paralytic effects of polio, should any of the children accidentally get the disease from the vaccine. Of course, if they did, their existing paralysis would do nothing to prevent the other possible effects of polio, including fever and acute illness, winding up on an iron lung, or death. In the event, none of the twenty-seven came down with polio from the vaccine.

And the vaccine worked. As Jacobs describes, "He took blood samples from the children two weeks following vaccination, returned to his lab, and mixed their serum with Types 1, 2, and 3 polioviruses. Then he inoculated cultures of monkey kidney cells with the mixtures. Instead of dying from infection, the kidney cells thrived." Salk would remember this as the transformative revelation: "It was the thrill of my life. Compared to the feeling I got seeing these results under the microscope, everything that followed was anticlimactic." He would repeat the trial with a larger cohort of sixty-three mentally disabled children at the Polk State School, whose director believed it had a number of advantages for a trial: the children were isolated for many years from the rest of the population and its diseases, and detailed health records could easily be kept. This trial also succeeded.

Ethical Questions

Whether the polio trials were ethical remains a live question. A fine line separated heroic boldness from moral deformity.

First, there was the problem of consent. In the case of the mentally disabled children housed at the Polk school, many had no family members to speak for them. In these cases, permission had to be obtained from the state's Department of Welfare, through a drawn-out series of negotiations between the director of the school and the NFIP's lawyers. However careful that process, we might expect that distant state bureaucrats would not advocate for the children as aggressively as family members would have. Moreover, although there is no tangible indication that any of the overseers saw the children as disposable, the trials took place in an era when vulnerable people were often the first choice for medical experimentation. Given that Salk had earlier infected adult mental patients with the flu, we might wonder whether the prevailing attitude toward institutionalized people affected the polio trials.

Then there were the risks of administering an untried vaccine. On the one hand, Salk took extensive precautions, doing all that he could to minimize potential harm—which was more than could be said of many of his contemporaries and indeed of his own earlier experiments. On the other hand, these precautions might not have been enough. Any number of things might still have gone wrong. As Salk later told a journalist, "When you inoculate children with a polio vaccine for the first time, you don't sleep well for two or three weeks."

All medicine, experimental or otherwise, involves some risk of harm. The essential question is whether test subjects also stand to benefit medically from an experiment. This was clearly the case for the children who had not yet had polio, who would potentially gain protection from the disease. Somewhat paradoxically, the children who *had* already had polio constitute the more morally ambiguous case. Salk was specifically testing them for the risk of side effects, while they would not be able to receive any benefit from the trials—meaning that they were treated as experimental subjects rather than as patients.

Jane Smith, with her customary brio, offers this context for the experiments:

> As Jonas Salk has often remarked, it would be impossible to repeat his polio work today, when such ventures need to be passed by human-subject review boards and peer review boards and various other qualifying agencies. In 1952 you got the permission of the people involved

> and went out and did it, and then wrote up your results in a scientific journal. If something terrible happened, the blame would be on your head and the blood on your hands, and of course your career would be over—but in the planning stages, at least, life was a great deal easier for the medical experimenter than it has since become.

Salk's work may not be altogether impossible today. But, as Smith suggests, institutional review boards protecting the rights and welfare of research subjects would certainly make the process much more laborious for a researcher, as would the more detailed requirements for acquiring informed consent from "the people involved"—the parents and guardians—and in some cases from the children themselves. Medical trials, particularly with children and mentally disabled individuals, require the most careful ethical considerations, including assessments of the risks and potential benefits to the subjects. What is indeed impossible today is to make these assessments single-handedly.

It is also worth noting that Salk did what he could to get the vaccine right before the trials because the patients in these studies mattered to him. At the Watson Home, Smith writes, "they were all in love with Dr. Salk, who could quiet the most fearful child, listen patiently to the most tortured question, remember everybody's name, and joke with them about their birthdays and parties and their favorite movie stars." It would not be going too far to say that the children loved him because he obviously loved them. He never forgot that every child's life was in his hands.

It was an era of harrowing epidemics, and Salk had to think of the fate of unknown thousands as well as to feel for the dozens of children in his immediate care. Not everyone involved in the eventual production of the Salk vaccine would be so scrupulous as he, and the consequences were tragic. Carelessness amounting to recklessness on the part of pharmaceutical manufacturers, as we shall see, marred and threatened to undo his triumph.

The Final Sprint

Salk knew his trials would seem dubious to some colleagues and perhaps to the public, and he conducted them on the sly, with only Weaver's knowledge. When he presented the results to the Committee on Immunization in January 1953, his colleagues were skeptical. Albert Sabin had some kind words for Salk, noting that the stimulation of antibodies in the patients from such small doses of vaccine was "truly a new discovery that none of us could predict," but went on to tear down Salk's findings and methods. He flayed him for choosing the wrong viral strains and abused

him for using the possibly carcinogenic adjuvant mineral oil. Other committee members worried about allergic reactions, organ damage, and other potential dangers.

Salk had reason to worry he would be condemned to further lab work, world without end. Yet some members then began to push for a definitive field trial. Salk himself questioned the wisdom of such an undertaking at this point; he just wasn't ready. But Weaver and O'Connor were well ahead of him, and after a leak to the press, headlines announced momentous events in the offing. The predictable media storm ensued.

To bring the prematurely exultant public down to earth, Salk suggested that he and O'Connor discuss the work in a nationwide radio interview, which happened in a March 1953 CBS broadcast titled "The Scientist Speaks for Himself." The radio audience, however, misconstrued his guarded optimism about the prospective vaccine as the assurance of imminent salvation.

Scientists and doctors fumed. The glory hound was seeking public approbation rather than judicious professional critique. Physicians were placed in the awkward position of trying to satisfy the public outcry for vaccine magic when the doctors themselves were no better informed than their patients. An article by Salk in the *Journal of the American Medical Association* obfuscated more than it clarified, "at times resembling a stream-of-consciousness piece," as Jacobs puts it. And Salk appeared as the article's sole author, "with the collaboration" of four associates, who ought to have received more credit as co-authors.

The popular worship was underway, but among the scientific ranks numbered many unbelievers. Richard Carter reports that detractors protested the intolerable halo and started mocking Salk as Jonas E. Christ. The unwilling divinity himself rebelled at the newly coined term "Salk vaccine." "It drove Salk wild," Carter writes:

> The rabies vaccine was rarely called the Pasteur vaccine. The yellow-fever vaccine was never called the Theiler vaccine. Nobody outside the scientific community could name the men who had developed whooping cough, diphtheria, influenza, tetanus, typhoid, or encephalitis vaccines.

Salk was getting more credit and adulation than he thought he deserved, and he pleaded with O'Connor to end the Foundation's use of the eponymous phrase. O'Connor agreed, but where the populace was concerned the matter was out of his hands.

Salk was soon to have his doubts about the NFIP. In June 1953 the Foundation announced a field trial for the fall, and Salk found out about

it in the newspaper. The insult must have seared him. O'Connor did what he could to placate Salk, telling him nothing would proceed without the scientist's approval. Weaver was not so magnanimous. Maneuvering his way around the refractory Committee on Immunization, he organized the Vaccine Advisory Committee, essentially to do his bidding; he excluded Salk and the other dawdlers and loaded the new committee with men in a hurry. But the speed demon Weaver soon found himself at odds with his superior (the more cautious medical director, Hart Van Riper), and Weaver soon resigned.

Salk would now be at odds with Joseph Bell, the new scientific director of the trial. Bell advocated a double-blind study, using a flu vaccine as placebo so that those not receiving the polio vaccine would still get something of medical value. Salk wanted observed controls, in which second-grade students would receive the vaccine voluntarily while their first- and third-grade schoolmates who did not receive any injection would serve as the control cohort. He believed that cleaving to the customary double-blind research protocol would be immoral, lamenting to O'Connor in a lengthy letter, "I would feel that every child who is injected with a placebo and becomes paralyzed, will do so at my hands." The "sacrifice of humanitarian principles on the altar of rigid methodology," he continued, was against the Hippocratic spirit.

Bell would resign when the Vaccine Advisory Committee rejected his proposal for using a flu vaccine as placebo, while Salk continued to advocate for a trial with observed controls. In the end Thomas Francis, the man who had originally recruited Salk to the NFIP, oversaw the field trial, and there would be both a double-blind trial with placebo and a smaller observed-control trial. Furthermore, the mineral oil adjuvant, presumed dangerous though it was not, was eliminated in favor of a water-based solution. The protracted wrangling and Salk's preliminary studies with some 7,500 subjects led to the trial's delay until April 1954.

The Big Trial

As the planned trial date neared, opponents sought further delay and tried to muscle the Salk vaccine out of business. Albert Sabin wanted to put off the trial effectively for years. Speaking to the American Medical Association convention and testifying before Congress, he assailed both the ineffectiveness and the peril of Salk's killed-virus vaccine. There was no proof that the Salk vaccine conferred long-lasting immunity, Sabin contended, and the type 1 strain Salk had worked from was so virulent

that if any live virus remained in the vaccine, children could be doomed. Only the weakened live virus oral vaccine Sabin himself was working on would really do everything a vaccine was supposed to do. Sabin would never waver in that conviction.

Meanwhile, the gossip maven Walter Winchell, a force in the newspapers and on radio and television, attempted to discredit the upcoming trial: "Attention, everyone! In a few moments I will report on a new polio vaccine—it may be a killer!" The broadcast of April 4, 1954, three weeks before the scheduled trial, did all in Winchell's considerable power to induce mass hysteria. Vestiges of live virus had contaminated the Salk vaccine, he averred, monkeys inoculated with it had died of polio, and hundreds of thousands of schoolchildren were in imminent danger of paralysis or death. Winchell had cunningly smudged the truth until it was unrecognizable.

The NFIP fought back hard, insisting, "Any product that contains live polio virus is not the vaccine developed by Dr. Jonas E. Salk." Salk had determined that in preparing two lots of vaccine, two drug manufacturers had not adhered to the protocols he had set. As Carter writes, the manufacturing company Eli Lilly "had neglected to filter the virus fluid before exposing it to Formalin—an error that Lilly did not plan to repeat. The Parke, Davis lot had been treated with Formalin too briefly to inactivate all the virus, an error that Parke, Davis did not plan to repeat." Safety tests also established by protocol had caught the errors, as they were designed to do. There was no danger to the human population. Salk attested that he had just vaccinated his own children. Even Sabin said Winchell had been "irresponsible"—though Sabin continued to stump against the field trial.

Despite numerous less-than-responsible warnings in the press, "most of the public believed in a savior named Jonas Salk and enrolled their children in the trial," Jacobs writes. The largest clinical trial ever would proceed as planned on April 26, 1954, with nearly 1.5 million subjects, over six hundred thousand of whom would receive the vaccine (the rest were controls). The vast majority of these received the complete series of three injections of Salk's vaccination, one a week after the original shot, the second a month later, all into the upper arm.

Jacobs hails the superb logistics of the trial, which showed the NFIP in full glory, mobilizing tens of thousands of physicians, nurses, elementary school principals and teachers, and hundreds of thousands of volunteers. "When someone at the Foundation suggested hiring trained personnel to do a task, O'Connor refused. He insisted the trial be conducted by those

who had demonstrated loyalty to the March of Dimes." The NFIP spent over $34 million on the preliminary research, the trial, and 27 million doses of vaccine to be ready for use in 1955 should the trial prove its effectiveness.

Just shy of a year later, on April 12, 1955, Thomas Francis announced the results of the trial at the University of Michigan. Salk had little idea what Francis was going to say until he'd said it. The findings were striking: In both the double-blind and the observed-control studies, the vaccinated groups had developed paralytic polio at about one-third the rate of the control groups. On average across the different types, Francis reported, the vaccine was eighty to ninety percent effective.

A Hero's Fame

The moment belonged to Jonas Salk. The audience of over a thousand gave him a standing ovation as he took the stage. He duly thanked the many people who had made this success possible—though he would justly be faulted for his failure to mention each of his laboratory associates by name. Then, in the face of the unbelievers, he subtly but unmistakably confirmed the rightness of his long-held faith in the killed-virus vaccine, accounted for the trial vaccine's imperfection with recent data showing that the antiseptic merthiolate in the solution had reduced its effectiveness, and pointed to the coming day when the vaccine might be perfectly effective.

An infuriated Francis would in private dress Salk down for that final prediction. But that day would in fact come. As Salk had said in a debate with Sabin at the International Poliomyelitis Conference in Rome months earlier, "The ultimate objective is not merely a reduction in the amount of crippling and death from poliomyelitis, but rather elimination of these as a cause of fear." Today the fear is very nearly gone.

There were over a hundred reporters at the event. Word got out everywhere and fast. Jubilation was general: the scourge had been whipped. Every front page headline and every newscast proclaimed the victory. Church bells and fire sirens made a joyful noise. Many observed a moment of silence in schools and workplaces. Others gathered in places of worship to pray in thanks. People wept openly.

That evening Salk appeared on Edward R. Murrow's television talk show *See It Now* and made the glorious remark that would epitomize his generosity of spirit for years to come. Asked who held the patent on the vaccine, he replied, "Well, the people, I would say. There is no patent.

Could you patent the sun?" Salk told Richard Carter that at a reception after the television show, strangers were

> arguing about my future as if I were beef on the hoof or had just swum the English Channel or something. It all seemed unreal, the sort of thing that would surely end and be forgotten as suddenly as it had begun. But Ed Murrow knew better. When we found ourselves alone for a moment he said, "Young man, a great tragedy has just befallen you." When I asked what he meant, he answered, "You've just lost your anonymity."

Everyone wanted a piece of him, as Carter and Jacobs relate in detail. The governor of California tried to enlist Salk as a mental health consultant. The mayor of New York intended to throw a ticker tape parade and bury him in confetti. A hospital planned to rename itself the Jonas E. Salk Memorial Hospital, to which an exhausted Salk quipped, "Memorials are for dead people. I'm only half dead at this time." A statue of the hero was proposed. Biopic offers from Hollywood poured in; Marlon Brando was pitched as the lead. The Academy Awards wanted him in a dignitary's chair at their ceremony. He got invited to Harry Truman's seventy-fourth birthday party.

But Salk turned down all such come-ons. Fame of this order was not for him. When Amarillo, Texas gave him a new car, he sold it and returned the proceeds to provide vaccine for Amarillo's children. Of course, some honors he could not refuse. President Eisenhower decorated him with a medal. Oslo, Norway commissioned his portrait. And the State of Pennsylvania established a $25,000-a-year professorial chair in preventive medicine at the University of Pittsburgh, named it for him, and appointed him its first occupant.

Debacle, Defeat, and Posthumous Victory

The serious work of mass immunization was proceeding, but that was now out of the hands of Salk and the NFIP and in less caring and capable ones. The first problem was that Oveta Culp Hobby, U.S. Secretary of the Department of Health, Education, and Welfare, had complacently assured an anxious Basil O'Connor that the marketplace would do a fine job of supplying the full demand for vaccine. But, as Jacobs writes, "the American system of free enterprise gave rise to chaos." There were widespread shortages and rampant price gouging.

Though each shot cost only two dollars, some parents were forced to pay as much as $21 for the series of three inoculations—almost $200 in

today's dollars. Despite Hobby's assurance that first- and second-graders would receive the first vaccines, manufacturers gave their employees, friends, and families priority. Cutter Laboratories' president wrote to his stockholders, "I want to be sure that you as a Cutter shareholder also have the opportunity to have your children or grandchildren under eighteen years of age immunized." Efforts by the government to reassure the public that there would be enough vaccine hardly helped, with panic and anger spreading as polio season began.

Things would get bleaker still, and Salk would be in the spotlight again, most uncomfortably. In late April 1955, two weeks after the national celebration, reports started coming in of paralysis in children who had just been vaccinated. As the cases multiplied, including parents, siblings, and friends of vaccinated children, it became evident that live virus had contaminated certain lots of vaccine from Cutter Laboratories.

Everyone involved denied responsibility and searched for someone else to blame. O'Connor faulted the federal government for withholding facts from the public, and Thomas Francis insisted that his responsibility had only been the evaluation of the trial, not the actual production of the vaccine. The government claimed it was only responsible for licensing the vaccine, and the manufacturers pointed out that they had followed the approved protocols, though Salk insisted that there must have been some error on their part. Cutter, joined by other manufacturers, was quick to blame Salk's inactivation theory, arguing that it worked only for small quantities of vaccine, not large ones. Journalists began writing about the "Salk Snafu," and the irrepressible Sabin chimed in with the "Salk Accident."

U.S. Surgeon General Leonard Scheele convened Salk and others to help find out what had gone wrong. They soon discovered that Cutter had failed to follow Salk's demanding protocols for inactivating the viruses, or even its own less stringent guidelines. As Jacobs explains, Salk had used—and directed all manufacturers to use—a compressed asbestos system to filter the virus solution before and after inactivation with formalin. Cutter had used a faster but less effective glass filtration system, and had not troubled to filter the solution more than once. They had also reduced from Salk's protocol the number of times during the process they tested the rate of viral inactivation.

Despite the explanation from Salk and his fellow investigators of what had gone wrong, the surgeon general's report attributed no blame to Cutter and did not mention the actual cause of contamination. Apparently satisfied that the surgeon general had "saved the vaccine from annihilation,"

in Jacobs's words, Salk did not quarrel with the misleading report. But he would subsequently have to fend off an attempt by Sabin, John Enders, and others to put a permanent halt to the use of the Salk vaccine. The situation was heartbreaking for Salk, who would tell a friend, "I cannot escape a terrible feeling of identification with these people who got polio." Because of Cutter's cost-cutting recklessness, 260 people contracted the illness.

Salk's undeserved disgrace and despondency would not last. His vaccine proved a godsend. By 1961 polio was all but gone from the United States.

Even so, as David Oshinsky demonstrates, "The 1960s would belong to Albert Sabin, the way the 1950s had belonged to Salk." In 1957 the Soviet health ministry invited Salk and his wife to come to Russia, but she did not want to go and so he turned down the offer; he later regretted the blown opportunity to establish the Salk vaccine firmly in the Soviet Union. An early trial of Sabin's vaccine there showed perfect results, as one would get in a Politburo election. By 1960, the Soviet Union decided to administer Sabin's vaccine, effective without any booster dose, to every person under the age of twenty—nearly eighty million people. The same year, the Sabin Oral Sundays field trial vaccinated two hundred thousand people in and around Cincinnati. In 1961 the American Medical Association called for the Sabin vaccine, not yet licensed, to replace the Salk vaccine.

Salk's bitter resistance was futile. The Sabin vaccine, cheaper and easier to deliver, took the world; only the Netherlands and Scandinavia, where the government produced and administered vaccine, stayed with the Salk vaccine.

Sabin crowed. He belittled Salk's achievement as "kitchen work," which anyone could have done. When awarded the National Medal of Science in 1970 for developing "the vaccine which eliminated poliomyelitis as a major threat to human health," Sabin observed with malicious gaiety that the tribute said "*the* vaccine." Honors went to Sabin that never came to Salk, most notably membership in the National Academy of Sciences, which also enrolled Thomas Francis, John Enders, David Bodian, and nearly every other polio eminence.

Salk would eventually achieve a posthumous victory over his rival, albeit a grim one. For one in every four million doses of the Sabin vaccine caused paralytic polio by reversion to virulence, however vehemently Sabin denied it. But after the 1955 Cutter fiasco there were no cases of accidental polio with the Salk vaccine. In 1996—the year after Salk's death—the Centers for Disease Control declared the Sabin vaccine the

sole remaining impediment to wiping polio out in the Western hemisphere, and in 2000 it called for exclusive return to the Salk vaccine in the United States.

Polio has since been all but eliminated throughout the world. The Global Polio Eradication Initiative, with Rotary International taking the fundraising lead, hopes to be able to pronounce the disease gone for good in 2020. Pakistan and Afghanistan have been two major targets, but according to the initiative's current records, Pakistan has had only three cases of polio so far this year, and Afghanistan only eight. Though a few dozen vaccine-derived polio cases were reported in Syria and the Democratic Republic of the Congo in 2017, as of this writing there have been no reported cases of the disease in Syria this year, and only four vaccine-derived cases in the Congo.

Salk's Institute—the Grand Vision

Salk reached the apex of his career in 1955; he still had forty years to live. He would work on developing vaccines for cancer, multiple sclerosis, and AIDS, but while his name attached to such undertakings stirred hopeful public commotion every time, his efforts there amounted to half-hearted dabbling. What he really aspired to be was a double-whammy public intellectual, bringing together natural science and the humanities. He parlayed his polio fame into the founding of an institute that he intended for the pursuit of this rapprochement, but in the end he had to settle for a congenial home for scientific specialists uninterested in his grand synthesis: the Salk Institute for Biological Studies in La Jolla, California.

As Suzanne Bourgeois writes in *Genesis of the Salk Institute: The Epic of Its Founders* (2013), Salk originally thought he might inaugurate a research institute at the University of Pittsburgh, dedicated to virology and immunology. But as discussions proceeded, the Salk name became attached to the institute, displeasing many faculty and administrators who thought Salk was casting too large a shadow over the university. In due course, J. Robert Oppenheimer, an advisor on the project, dissuaded Salk from founding an institute with any university affiliation, which he argued would entangle Salk's schemes in red tape. Leo Szilard, another veteran of the Manhattan Project, steered Salk toward founding an independent institute for molecular biology and put him on to La Jolla, where the University of California was building a campus.

Basil O'Connor, who had renamed the NFIP the National Foundation–March of Dimes and re-dedicated it to combating birth defects, promised

The Salk Institute for Biological Studies in La Jolla, California

Salk he would raise the necessary funds for his institute. Salk considered O'Connor to be, as Bourgeois puts it, "a twentieth-century Lorenzo de' Medici," and expected his friend to come through with boundless largesse. But O'Connor agreed to aid with construction costs only if the institute were named after Salk—a surefire fundraising move, without which O'Connor knew he could never raise the money. Salk found the self-advertisement unseemly and contrary to the general rule that scientific institutes were to be named only after dead scientists. But he needed O'Connor's help, and gave in.

Still, covering the cost of construction became a major struggle. By 1963, some laboratories were up and running, but the campus would never quite live up to what either Salk or its architect, Louis Kahn, envisioned. What does stand there may be what Martin Filler, writing on Kahn in the *New York Review of Books*, calls "a mystic monumentality." The prominent French biologist André Michel Lwoff, less enchanted with its style, has said it looks like a prison.

The self-appointed director and president of the institute, Salk was simply inept as an administrator, landing his brainchild in financial straits that threatened its very existence. As a recruiter, however, he was

brilliantly successful, attracting top-rank scientific talent to his fledgling outfit on the edge of nowhere; he did so by offering his chosen few the freedom to pursue any work they wanted, with freedom from financial constraint—not even any grant proposals to write. Francis Crick, Jacques Monod, and Leo Szilard were charter nonresident fellows, while Jacob Bronowski, Renato Dulbecco, and Salk himself were among the resident fellows.

Salk pinned especially high hopes on the Polish-born Bronowski, a Cambridge mathematician who had worked on bombing efficiency during World War II and had inspected the remains of Hiroshima and Nagasaki in November 1945 to write an official report on the effects of the atomic bombs. That Bronowski greatly admired the anti-Newtonian, which is to say anti-scientific, visionary poet and painter William Blake, enhanced his stature by a cubit in Salk's eye.

Bronowski had written a little book in 1956 called *Science and Human Values*, which attempted to show how the practice of science sustained a host of democratic values, and indeed human dignity itself: "Science at last respects the scientist more than his theories; for by its nature it must prize the search above the discovery, and the thinking (and with it the thinker) above the thought." Noble, panoptic, and woolly in his magniloquence, he exemplified the scientist-as-humanist that Salk aspired to be.

Salk conceived his institute as the vital response to the challenge thrown down by Bronowski, as well as the English scientist-turned-novelist C. P. Snow in his 1959 critique *The Two Cultures*. Like Bronowski, Snow lamented in rather grandiloquent terms the lack of common intellectual or moral interests between scientists and literary types. Salk took Snow's teaching as gospel. In a letter to a friend, he wrote, "It is not only that the gap exists, but that the posture of scientists and artists seems to be back-to-back, rather than face-to-face. As each of them moves forward in his own way, the gap increases."

In the name of the wisdom needed for salvation, Salk convinced Snow to serve as trustee of the institute and convened the Council on Biology in Human Affairs with Bronowski as its director. But Salk was far more impressed with Bronowski than Bronowski was with Salk, whom he derided as "the prophet."

Second-Act Twaddle

Salk wrote four short books during his institute years: *Man Unfolding* in 1972; *The Survival of the Wisest* in 1973; *World Population and Human*

Values: A New Reality, co-written with his youngest son, Jonathan, in 1981; and *Anatomy of Reality: Merging of Intuition and Reason* in 1983. In them, he addresses the plight of late-twentieth-century humanity in the level yet hectoring tones of a soft-spoken secular chiliast: Dusk is approaching, but the owl of Minerva, with the countenance of a wise and gentle doctor, will fly just in time to herald a new dawn.

In *Man Unfolding* the born healer declares that man has effectively conquered inhuman nature. We need no longer fear vitamin deficiencies, tuberculosis, plague, or diphtheria bacilli (he humbly omits mention of polio). Instead, man makes himself sick, and must take the cure or go to the wall. Only a holistic approach, incorporating the various powers of the biologist, the philosopher, and the physician, will alleviate the pain that people inflict on themselves and each other and will liberate untapped energies for unexampled human flourishing.

> How can this be accomplished? All work—and especially new work—is done by those who are inspired, by those who have what Leo Szilard once described as "the divine spark."…It is a spark that will ignite a great flame of understanding and release great power to change life in ways toward which man's hopes have long been directed.

Thus the biologist-physician-philosopher demonstrated yet another of his considerable powers—as a purveyor of hortatory twaddle. In that role he proposes an analogy that he finds richly suggestive, between immunological and psychological phenomena: "Is it conceivable that racial intolerance, as one example of intolerant behavior, may follow laws similar to those which govern the development of immunologic intolerance?" No, but don't let that slow you down. He goes on to declare warfare man's "most important disorder—one that may even be thought of as a self-induced disease."

Salk's overweening hopefulness, redolent with the self-regard of a medical man accustomed to being considered saintly, defies all experience and common sense. He hopes further to inculcate nobility—which he idiosyncratically defines as "doing what is right for the right reason"—in the unpromising material of the democratic soul. That is surely an honorable project, but it requires a teacher of the rarest gifts, a Goethe or a Beethoven or a Churchill, rather than a puffed-up moralizer far out of his depth.

The other three books are no wiser or more elegantly written than the first. To discuss his prophetic writings further would only compound the embarrassment. One can understand all too well why Bronowski did not

find him a kindred spirit, and why the other institute scientists wanted no part of his nonsense and forced him into an early retirement.

One finds in these writings, and in Salk's institute years more broadly, the apparent downsides of the attributes that had served him grandly in his research career and earlier public life. Wooing and winning the multitude had meant alienating fellow scientists, whose contempt for the spotlight all too often concealed bitter envy for the colleague and rival chosen to shine in it. His fellow scientists held him in comparatively low esteem. Yet this may reflect his character more than his work: Had he appeared less gracious, less personable, less deserving in the eyes of the world at large, his colleagues might have been more likely to appreciate his true worth.

Salk's research career illustrates the importance, not to say the primacy, of character in significant scientific achievement. He did the work he did because he was a man among men: one born to be a healer, who cared about every person his work touched, sacrificed his personal happiness for the general welfare, and took justified pride above all in being gentle and kind to those most in need of gentleness and kindness. In his medical work, Salk was a human, humanistic, humanitarian paragon.

But in a would-be public intellectual, these traits verged on self-important silliness, and it seemed only right to scorn him as a showboat. He lived the second half of his life cashing in on the first half. In demand as a celebrity dignitary, he signed on to all the right causes, promoting social justice, ekistics (the study of human settlements), the nuclear-weapons freeze, and the welfare of the children, and occupying seats of authority in imposing foundations whose dilatoriness frustrated the would-be savior. After his first wife divorced him—she was tired of carrying the celebrated virtuoso's cello while he neglected her and their three sons—he married a former mistress of Pablo Picasso. He had many other women on the side, most of them besotted with his world-redeeming soul. He nearly ran the Salk Institute into the ground, but once it had divested itself of Salk it thrived in splendor, as the congenial home of some of the world's finest biologists, including numerous Nobel laureates. Salk himself never won a Nobel, though he was given to saying that most people thought he had, so he didn't mind the oversight.

F. Scott Fitzgerald, drunk and seedy and headed for an early grave, famously warned that "there are no second acts in American lives." It is truer to say that there are, but many don't live up to the promise of the first. Salk's achievement, a triumph of character as well as of mind, ought never be forgotten. The least impressive intellect among the famous scientists of the twentieth century, he was—aside from Marie Curie—the

most impressive human being. Nobody reads his books anymore, and that is as it should be. But the day will come when schoolchildren will ask, "What was polio?," and one can imagine no finer tribute to Dr. Jonas Salk than that innocent question.