A victory for all mankind

Brought about by hundreds of thousands of health workers from all over the world, eradication is a triumph of international cooperation and of preventive medicine

by D. A. Henderson

For centuries, variola virus stalked the world with impunity causing unmeasured suffering, death and blindness. Today it is confined to glass vials kept under high security in six laboratories. To those who vividly recall the suffering of its victims, to health staff who so diligently conducted vaccination programmes, to quarantine inspectors who carefully examined vaccination certificates, it is difficult to believe that “sporadic” cases are not still occurring somewhere. However, convincing data, diligently assembled by tens of thousands of health staff, now demonstrate that smallpox is a disease which can be consigned to history—the first disease ever eradicated by man.

It was little more than two decades ago, in 1958, that the Soviet Union proposed to the Eleventh World Health Assembly that the countries of the world cooperate in a globally coordinated effort to eradicate smallpox. In that year 63 countries reported 280,000 cases. This is a substantial number of cases but, because of incomplete reporting, it would need to be multiplied by 100 or more to describe the true magnitude of the problem. Data regarding deaths are likewise incomplete, but it is reasonable to assume that at least 20 per cent of those infected died and tens of thousands were permanently blinded. There was, and is, no treatment for smallpox; prevention through vaccination was the only way to cope with this disease.

After further study of the Soviet proposal, the Assembly in 1959 agreed that a global smallpox eradication programme should be undertaken as a matter of urgency. It was thought that, by “vaccinating or revaccinating 80 per cent of the population within a period of four to five years”, smallpox could be eradicated from endemic areas.

During the following eight years, WHO encouraged governments to undertake programmes, solicited contributions of vaccine, encouraged and coordinated studies of vaccine strains, and assisted laboratories in starting vaccine production. Many countries started programmes and some succeeded in interrupting transmission. But not all did or could embark on eradication with their own limited resources. Contributions were far less than the funds required and many countries which interrupted transmission were reinfected by their neighbours. Of greater concern was the discovery that, even when vaccinations were administered to 80 per cent of a population, smallpox often persisted. Health authorities became discouraged and pessimistic. It was one thing to eliminate the disease from countries with a developed health infrastructure, but could this be done in the numerous countries, so recently independent, whose limited health services scarcely extended beyond their urban centres? And could these many countries coordinate their efforts sufficiently for smallpox to be eliminated from large geographical areas?

It was a concerned and less confident World Health Assembly which in 1966 decided that WHO should undertake an intensified eradication programme. Approximately US $2.5 million was included in the Organization’s regular budget to provide for overall programme coordination and for assistance to those countries requiring it. This was a small sum indeed to provide support in 50 countries with a population of more than one thousand million persons. But it represented almost five per cent of WHO’s total budget that year. Hopes were expressed that more substantial voluntary contributions would be made and
that all countries would give the programme a high priority. Some delegates optimistically proposed setting a 10 years goal for eradication, but most believed realistically that better control of smallpox was the best that could be expected.

The intensified programme began in January 1967. That year, 46 countries recorded 131,697 cases, a number representing perhaps one per cent of the true number of cases. Four endemic areas were present. A major reservoir was Africa where virtually all countries south of the Sahara were infected. A second important reservoir of smallpox was in Asia, extending from Bangladesh through India, Nepal, Pakistan and Afghanistan. The third was the Indonesian archipelago and the fourth was Brazil, itself comprising half a continent.

Of primary concern as the programme began was the need for sufficient vaccination devices and vaccine—the guns and bullets of the campaign. Large contributions were made initially by the Soviet Union and the USA; eventually 26 countries became contributors. A detailed manual on vaccine production was produced and vaccine batches were routinely tested to ensure that they met international standards. By 1971, all vaccine in use in the programme met accepted standards and by 1973, fully 80 per cent was being produced in the endemic countries, some of which supplied vaccine to others. In 1967, the jet injector was introduced in programmes throughout the countries of western and central Africa and Brazil. In 1968, field studies conducted by WHO showed that the newly developed bifurcated needle could be used to administer vaccine by a new technique—multiple puncture vaccination. The bifurcated needle soon became the standard method for vaccination.

A second concern from the start was the question of an appropriate strategy. Mass vaccination designed to reach 80 or even 100 per cent of a population had succeeded only in some smaller countries and those with more developed health services. For most of the still endemic countries, a different strategy was required. The decision to emphasize surveillance as an important component of the strategy proved to be the much-needed critical breakthrough. The new strategy called for a systematic two- to three-year vaccination campaign designed to reach 80 per cent of the population in each country. During this time, it was planned for a nationwide reporting system to be developed which would be sensitive enough to detect such smallpox foci as remained and to eliminate them.

Soon after the programme began, it was discovered first in Nigeria, then in Indonesia and Brazil, that effective reporting system could be developed in months rather than years. By isolating the patients and vaccinating their contacts, outbreaks could be rapidly contained. Even in areas where vaccination coverage was poor, smallpox transmission could often be stopped quickly. So increasing emphasis was placed on the surveillance-containment component of the strategy. Special surveillance teams were recruited and trained. They visited each health unit in an area to ensure that each week it submitted a report indicating the number of cases seen. When cases were reported, the teams worked with local health staff to contain the outbreaks, and they visited schools and public places to inquire about

rumours of smallpox. A special “WHO Recognition Card” showing a picture of a smallpox patient was printed and distributed to help them in their search.

The first campaigns started in 1967 and, by 1969, all countries except Ethiopia had started eradication programmes. Ethiopia’s programme began in 1971. In 20 countries of western and central Africa, a USA-assisted programme of smallpox eradication and measles control succeeded in eliminating smallpox in just three and a half years. Brazil’s last case was detected in 1971 and Indonesia’s in 1972. By the summer of 1973, smallpox transmission had been interrupted throughout the whole of Africa, except in Ethiopia. That country plus five countries in Asia remained as the only smallpox infected countries.

However, India, Pakistan and Bangladesh, with a population of more than 700 million persons, presented a special problem. Surveillance-containment measures such as had been successful in Africa and South America proved far less effective in these densely populated areas where people travel frequently and far. A different approach was required. During the summer of 1973, Indian health authorities with WHO staff planned a different surveillance strategy. All health personnel were asked to undertake an intensive search of each village, and later each house, to detect smallpox cases. This would need to be done rapidly to be successful and so the search was planned to be completed during a seven- to ten-
Increasingly thorough. Between searches, detection. But once discovered, the outbreak period. In heavily infected areas this was done each month and, in less infected areas, every second or third month. During the first search in October 1973, thousands of unreported cases were detected. But once discovered, the outbreaks could be contained.

Through careful planning, training and assessment, the searches became increasingly thorough. Between searches, surveillance teams visited schools and markets seeking to learn about cases of smallpox. Containment measures were strengthened. As the numbers began to decrease, a reward for the detection of a case was offered to the first person reporting it and to the health worker investigating it. Similar approaches were soon employed in Bangladesh, Pakistan and Nepal. On 16 October 1975, only two years after the start of this new strategy, the last case of smallpox occurred in Asia—on Bholia Island in Bangladesh. This marked the end of variola major, the severe form of the disease. As 1975 drew to a close, only Ethiopia remained with smallpox. There, variola minor was prevalent, a form of smallpox which killed only one per cent of its victims in contrast to variola major which killed 20 per cent or more.

Ethiopia's programme, besides being the last to begin, faced incredibly difficult problems. Although the country is larger than France and Spain together, the available staff numbered little more that 100 persons. There was almost no health infrastructure. Roads were few and it was estimated that half the population lived more than a day's walk from any accessible road. Civil war and famine compounded the problems. However, with the interruption of smallpox transmission in Asia, more resources could be made available to Ethiopia. Village residents were recruited and trained to serve as surveillance workers and vaccinators; more transport was provided; helicopters were laid on to facilitate supervision. Less than one year later, on 9 August 1976, the last case occurred there.

Unfortunately, coincident with the last outbreak in Ethiopia, smallpox was introduced into neighbouring Somalia. Before fully effective surveillance systems could be established, nomads disseminated the disease throughout the southern part of the country. In May 1977, a national emergency was declared, additional staff were recruited and special assistance was provided by WHO. An intensive surveillance-containment and vaccination programme continued throughout the summer months. More than 3,000 cases occurred, the last of them on 26 October 1977.

Nevertheless, surveillance teams and search workers continued for two years and more in their efforts to discover cases. In many countries, a reward was offered and tens of thousands of cases of chickenpox, measles and other rash diseases were reported by villagers in hopes of collecting a reward. Thousands of specimens were taken and sent to WHO Diagnostic Centres in Moscow and Atlanta, USA. None proved to be smallpox. For the disease to persist in a population, it must be passed from one person to another in a continuing chain of infection. Since there is no animal reservoir and no asymptomatic carrier (person having the disease but showing no symptoms), each person who is a link in this chain must experience the characteristic illness. During the programme, it was found that smallpox never persisted for more than eight months in a country without being detected by the surveillance network. Continuing search during a two-year period, that is, three times this eight-month period, provided additional assurance that the spread of smallpox had stopped.

To confirm that transmission had been interrupted, specially constituted WHO International Commissions visited each country. In 1978, the Director-General of WHO appointed a Global Commission to review the experience in all countries. The Commission completed its work on 9 December 1979, at which time it agreed that there was sufficient documentation to certify worldwide eradication.

The eradication of smallpox means that vaccination everywhere can be stopped and that travellers will no longer need vaccination certificates. The savings throughout the world are estimated to be $1,000 million annually. The cost of this achievement was only $112 million in international assistance, or $9 million spent annually during the 13-year period 1967-1979. This includes all funds spent by WHO plus bilateral and multilateral contributions from 42 countries. It is estimated that globally the endemic countries spent perhaps twice this amount but, in fact, few spent much more than they had hitherto been spending on never-ending smallpox control programmes.

Now the chapter entitled "smallpox" is closed—let us hope for ever. The achievement of eradication is a victory for hundreds of thousands of health workers in many different countries, who staff alone were drawn from 73 different countries. It is a triumph of international cooperation and of preventive medicine. With coordination, cooperation, dedication and imagination it is clear that much can be achieved at minimal cost.

James Magee
A job well done

Today, a new lease of life is at hand for one out of every ten children in West Africa who used to be either killed, left mentally retarded or blinded by smallpox

by Marcella Davies

In Sierra Leone, the WHO-sponsored smallpox eradication programme was unique not only because it was a joint venture between that country's Government and the United States, but because it was a major public health effort on the part of 20 West African countries closely coordinated with worldwide WHO efforts to rid the world of smallpox by 1975. This was a gruelling exercise demanding watchfulness and speed for its success, but all the same it was worth the effort.

Up to some 15 years ago, the whole country was virtually littered with cases of smallpox. All districts, with the possible exception of Kailahun, reported high attack rates. The last severe outbreak, documented for 1957, resulted in 4,246 reported cases with 228 deaths. This trend continued and the situation remained tense until 1965, when there were severe sporadic outbreaks. In November 1967, Sierra Leone experienced a high incidence of the disease in the aftermath of the previous year's epidemic. According to WHO figures, the whole country had more smallpox for its population in 1967—with 1,636 reported cases and 248 deaths—than any other place in the world.

Most of the victims were scattered in remote places with little or no medical facilities. Living conditions were generally poor and the teams had to trek for miles across hilly terrain, marshy swamps and ferryless rivers in order to reach some villages.

Although small-scale vaccination programmes were in progress all over the country, their impact had not been sufficient to change the trend of the infection rate nor the attitude of most people to vaccination. It was commonplace to see a whole village deserted whenever a vaccinator loomed in sight.

The four-year programme developed for Sierra Leone in collaboration with USAID (the United States Agency for International Development) had two aims: the complete eradication of smallpox, and the control of measles by immunizing all susceptible children aged between six months and two years. The first (attack) phase of the campaign for the fiscal years 1968/69 was devoted to mass immunization against smallpox, with a follow-up assessment to ensure 90 per cent coverage. An improved surveillance system was also instituted, with the immediate aims of detecting and containing any
In Africa, the eradication campaign was accomplished by a kind of cooperation that transcended all language barriers and local traditions.

(Photo WHO/J. Ryst)

case of smallpox, and reducing measles morbidity and mortality.

The first step was to arrange meetings with local representatives of medical bodies, other government agencies and volunteer groups as well as influential personalities. Advance teams contacted local chiefs and village heads to establish the places and times of vaccinations and to motivate people to get themselves immunized. Radio broadcasts, mobile address systems, street banners, personal letters and placards were all part of the publicity machinery.

The teams generally used jet injectors to "blitz" major populations, while smaller roving teams using the multiple pressure method were reserved for mopping up as the crowds became thinner. Each person vaccinated was shown how to avoid infection, and had to dip the finger of the right hand in a harmless solution of silver nitrate to facilitate identification by the assessment teams.

To control outbreaks, a fire-fighting team was formed, to throw a vaccination cordon around smallpox cases in areas already vaccinated, or to mop up areas which had been poorly covered. A monthly bulletin, "The Eradicator", gave up-to-date information about the campaign's progress.

A pilot project to document the safety and efficacy of the simultaneous administration of smallpox, BCG and measles vaccine was carried out in Freetown between January and February 1968. The Endemic Disease Control Unit in itself was completely overhauled in an effort to develop team spirit and self-discipline.
Then followed a series of highly intensified training courses to qualify team members as experts in mass vaccination techniques, health education and the care and use of the jet injectors.

In the southern town of Bo, I was closely involved with the inaugural ceremony in my dual capacity as Principal Medical Officer, Southern Province, and Acting Senior Medical Officer, Endemic Diseases Control Unit, Bo. Held on 15 March 1968, the ceremony was a most impressive and colourful event. Shops and markets closed for the occasion and all the roads were choked. There were floats of every description, and most of the paramount chiefs were present resplendent in their native costumes. The vaccination team members wore their field uniforms and displayed their jet injector guns for the public to see. The merriment, dancing and feasting that accompanied this ceremony paid very good dividends. It gave the campaign a good start and acted as a stimulus for the team members.

In the subsequent months we noted that, time and again, explosive outbreaks followed funeral ceremonies of notable people in the villages. At such times large numbers of people converged on the home of a smallpox victim, to pay their last respects. Some took part in washing...
the body while others were in close contact with the victim's family. It was usually after they dispersed to their own homes that these contacts themselves became victims of the disease.

It is an accepted fact that field work of any kind, particularly in countries with a poor road system and difficult terrain, is most strenuous—and Sierra Leone was no exception. On the whole the working conditions were unpredictable and hazardous. Teams were sometimes called upon to perform burdensome and demanding tasks. In Kagboro Chiefdom, Moyamba District, team members narrowly escaped drowning and lost all their belongings when the boat in which they were sailing capsized. At Nomo Faama, terror-stricken campaigners fled for their lives when they sighted an elephant striding through the dark forests. To suit the convenience of peasant farmers during the farming season and to cover areas far from the nearest motorable road, vaccinators were willing to walk up to 35 miles.

Two factors helped to keep the team spirit and morale high; firstly, the feeling of the campaigners that their interests were well looked after by their immediate seniors, and secondly the sense of gratitude and cooperation demonstrated by villagers wherever they went. They were often accorded courtesies usually reserved for distinguished visitors, with entertainment in the form of big feasts and native dancing.

From the start we realized that this type of work could only succeed with good supervision, particularly in the field. We recruited four officers from the health inspector cadre who had received good formal training in public health, and they were given the necessary additional training. They turned out to be very dedicated field leaders. Throughout the campaign I made unannounced visits to the areas where teams were working, to see for myself how they performed and to boost their morale. It was quite rough going during those travels as Sierra Leone had just gained her independence and most of the roads were not motorable. When all is said and done, it was these young heroes who conquered smallpox, and they deserve recognition for a job well done.

Today, a new lease of life is at hand for one out of every ten children in West Africa who used to be either killed, left mentally retarded or blinded by smallpox. In Sierra Leone, the fear of vaccinations which formerly impeded the success of immunization programmes has given way to universal acceptance of the benefits to be derived from vaccines. The experience of the Endemic Disease Control Unit in that campaign has welded them into a strong unit which now forms a sound basis for future prevention and control of the more acute communicable diseases in the country. The successful eradication campaign has been accomplished by a kind of cooperation that transcended language barriers and traditions, working for the good of Africa in particular and all the nations of the world in general.

Above: In Ivory Coast, the hanged bird was a macabre warning to travellers: "We have smallpox in this village—stay away."

Left: One phase in the local production of smallpox vaccine in West Africa.

(Photos WHO and WHO/D. Henrioud)
The will and determination of the people of South-East Asia and their governments, combined with unprecedented international support, succeeded in achieving the goal of smallpox eradication in this Region. The certification, on 14 December 1977, of smallpox eradication in Bangladesh—the last country in Asia to be freed from the disease—was the finale to a decade-long battle. Burma reported the last case in 1969, Indonesia in 1972, Nepal and India in 1975, while Bangladesh reported the last historic case, Rahima Banu, who happily survived, on 16 October 1975. The other countries in the Region had achieved smallpox-free status earlier.

In the past, most of the Region's countries had been reservoirs of the disease. In Indian folklore, it was personified by a deity, Shitala Mata; her annual spring visits were so much a part of Indian life that the disease was often referred to as the "Spring Disease".

By the beginning of this century, governments were trying to extend immunization against smallpox throughout the countries of Asia. This work was intensified after the Second World War. In 1949, the WHO Regional Committee for South-East Asia urged all Member countries to make primary vaccination and periodic re-vaccination compulsory. Through strengthened immunization programmes, Thailand, Sri Lanka and Burma had interrupted indigenous transmission by the late 1950s.

Large epidemics still continued, however, in other countries of the Region. In 1958, one of the peak epidemic years, India had a morbidity rate of 39 per 100,000 population, and in East Pakistan (now Bangladesh), the incidence was reported to be five times as high. The re-introduction of the disease into countries that had arrested transmission still posed a real threat.

Thanks to the combined efforts and dedicated work of national and international health workers, supported by the determined will of the Member governments and substantial external support obtained from international organizations and bilateral agencies, the number of foci of the disease gradually decreased in 1973-1975. By November 1975, there were no cases of smallpox in this part of Asia.

who assumed a principal role in organizing and coordinating country programmes in smallpox eradication. The Regional Office assisted Member countries in implementing the programme, and cooperated in obtaining resources, supplying vaccine, and providing technical advice and consultant services in all managerial and technical matters related to the eradication campaign.

This success reflects the principles of sound management and practical implementation. The campaign had set precise objectives and definite plans of action, and it developed easily applicable techniques for concurrent and independent evaluation. All levels of staff maintained a spirit of dedication, tirelessness, imagination, leadership and acceptance of field work under the most difficult circumstances.

The programme provided valuable lessons in the effectiveness of collaborative efforts between the national health services and international agencies and other organizations. National will and effort were undoubtedly basic requirements and a solid foundation for external inputs.

This success also underscores the importance of maintaining a flexible approach, enabling strategy to be changed in mid-stream, if need be. Thus, instead of pursuing a policy of mass vaccination in an attempt at universal coverage, we adopted the more practical approach of concentrating on problem areas.

The unstinting support in terms of men and material by the governments concerned in the face of resources constraints, the remarkable motivation shown by all those engaged in eradication work, and the unfailing support from international agencies—all these were essential ingredients in what has proved to be the most outstanding achievement in international public health. It shows the way towards implementing other important public health programmes aimed not necessarily at eradicating particular diseases but at effectively controlling them, so that they cease to be public health problems.

I had the privilege to preside over the 1967 World Health Assembly, and in my address to that august body I said: "On smallpox eradication, we have decided to strengthen our resolve to make individual and collective efforts to intensify the fight against this dreaded disease. The eradication of smallpox is within our reach. The achievement of this important undertaking now depends exclusively on our will and determination."

It is indeed very gratifying to note that our Member States showed such a decisive example of will, determination and collaboration, and succeeded in eradicating this age-old scourge from the face of the earth.
India's "war plan"
by Jitendra Tuli
Victory was only possible if everybody concerned put all they had into the efforts. In fact, everybody at the Central, State and district, even village levels, put in more than they had.

It was on a hot, blistering June afternoon in 1973 that the “war plan” that eventually spelt victory over smallpox in India was set in motion. Till then, the relentless war against an enemy that knew no mercy had not been going on too well. If anything, it had become a general’s nightmare. Though there was no dearth of “troops” or “ammunition”, the problem was to get them to the right place at the right time. Naturally, the casualties were heavy—over 16,000 reported dead and more than five times this number maimed and disabled.

It was a desperate situation and, obviously something drastic had to be done, and done soon. This dark and desolate scenario was what a small group of officials studied that afternoon in June. Present at the meeting in Nirman Bhawan, the Central headquarters of India’s Health Ministry in New Delhi, were representatives from the four most badly affected States, senior officials from the Health Ministry itself and WHO. “We decided then that instead of expending our resources against the entire enemy forces simultaneously, we would concentrate on their strongholds”, explains Dr R. N. Basu, now Assistant Director-General of Health Services, Government of India, who in 1973 was the National Smallpox Eradication Programme Officer. And that was how the “war plan” and final campaign against smallpox was launched.

Recollecting those anxiously hectic days (and nights), Dr Basu says that the core of the plan consisted of establishing 28 mobile teams, very much like commando units that would strike at “enemy” strongholds at short notice. These teams consisted of one medical officer, one paramedical worker and a driver. Since the available resources were limited, who was requested to provide 14 epidemiologists while the Government of India agreed to take care of the rest.

Within three months of this decision, the first mobile teams were already in action in Uttar Pradesh and Bihar, two of the worst affected States, as well as in Madhya Pradesh and West Bengal. These teams were a welcome addition to the over 28,000 “troops” already in the field against smallpox, and the regular health staff in primary health centres all over the country.

Even before the “war plan” and intensive campaign went into action, the country was spending over 80 million rupees (US$ 10 million) annually to combat smallpox. The expenditure, largely on personnel, was equally divided between the Centre and the States. What this meant roughly was that there were three or four vaccinators in each primary health centre, and one vaccinator for 25,000 population in the urban areas.

The biggest bottlenecks were bureaucratic procedures, which hindered mobility, delaying teams from reaching an affected area from another district or State. With the mobile teams in action, this drawback was soon overcome. Thus, in the first week of October 1973, the mobile teams organized visits to every village in the four selected, endemic States. These were reconnaissance trips; having identified the “enemy” areas, the troops went into action shortly after. When an active case was found, the entire village was vaccinated and “sealed”.

The intensive campaign saw many innovations. Not willing to take any chances, the health workers would insist that nobody from an infected village could go beyond the village precincts, not even to work in the fields. “But how will we eat?” demanded the villagers. “And certainly not the least important innovation”, was the realization that “managers” who can take an overview of such programmes.

As for the lessons learnt, Dr Basu says that the foremost was that jointly, and with determination, one can achieve goals, whatever the odds. The second was the need to concentrate resources in problem areas, instead of attempting mass, universal coverage. The third, “and certainly not the least important lesson”, was the realization that “managers” who can take an overview of the situation and tackle it with some innovative solutions were necessary for such programmes.

But the key factors in this most remarkable achievement in the annals of international public health were the determination of the health staff and close collaboration between governments and international organizations and agencies. In this instance, collaboration was both in the letter and in spirit, with international staff working shoulder to shoulder with the local health teams.
A goddess defied

"Often, before uneducated villagers would agree to submit, the vaccinators would have to jab themselves in front of the entire community, to prove that there was nothing harmful!"

by Arun M. Chacko

Late in May 1975, at the sleepy little eastern border town of Karimganj, Indian smallpox field workers zeroed in on the railway station and successfully isolated a victim of the disease—Saiban Bibi, aged 30, a woman migrant from Bangladesh. That was the last time any of the several thousand people employed by India's Smallpox Eradication Programme had occasion to use their skills.

It had been far from smooth sailing, and at the outset there was a critical shortage of manpower. Mr L. R. Tiwari, a former vaccination inspector who spent 20 years combating smallpox, told me; "Before 1960, Delhi with 2.5 million people had just one vaccination superintendent and 35 vaccinators. (And the capital has always been more fortunate than the rest of the country.) When the Smallpox Pilot Project was started in 1960, staff strength was raised to 37 inspectors and 176 vaccinators. This permitted a door-to-door survey of the entire population, and every individual got his or her primary vaccination."

But the primary task was not so much reaching individuals as overcoming ignorance and prejudice. Shitala Mata has for centuries been worshipped as the goddess of smallpox, and temples dedicated to her are dotted around the country. Some devotees believed she spilled grain from a basket on her head every time she shook it, and each grain turned into a smallpox pustule. Victims survived if she used water from the pitcher in one hand to clean the split grain, but did not survive if she used the broom which was in the other. Some people worshipped smallpox cases as being blessed by the goddess. Relatives and friends would come miles to pay homage—and merely succeeded in spreading the infection.

So it was not surprising that many refused to be vaccinated against what was considered to be the goddess's generosity. Another vaccination inspector, Aman Hussain, recalled; "When we first went into the field, people got agitated and soon became violent. The police had to intervene."

"The people were agitated about the vaccine, which was believed to come from the cow and was therefore against the Hindu religion", said Mr C. B. Sharma. "Religious groups like the influential business-oriented Jains and the Namdhari Sikhs even started heated campaigns against it. Villagers claimed that their kids died following vaccinations, and undoubtedly some did. However this was because they would rub cow-dung on the fresh vaccination, thus causing tetanus. Or they would immediately suck out the vaccine. But the blame was invariably put on the vaccinator, who received an extremely hostile reception whenever he returned."

Often the vaccinators would first have to jab themselves in front of the entire community, to prove that there was
nothing harmful. Mr Tiwari himself did not complain. But he did remark: “I had to give myself smallpox vaccinations four to five times a year. And every time it worked. We would persuade freshly vaccinated cases to stand around for 15 minutes so the vaccine would dry, and we warned them of the grave consequences of applying cow-dung. When protected kids didn't die in any of the post-1959 smallpox epidemics, opposition to vaccination faded away. There has been no smallpox in those villages and slums for the last 20 years, even though some devotees to Shitala Mata began worshipping the inflamed vaccination scab on the eighth day!”

Over the years, conditions and awareness throughout the country underwent a sea-change. Back in 1958 it would take hours to persuade just one man to take his shot. Field workers would travel miles to track down a case, who might be carried from village to village just in order to dodge treatment. “Today when we go into the fields, we're welcomed”, Dr N. K. Gupta, Delhi's Medical Officer for Communicable Diseases, said with evident satisfaction.

Most crucial to eventual success was the new WHO strategy implemented from 1973. Rather than vaccinate every individual—an impossibility with 650 million people—it was decided to concentrate available resources on areas with smallpox cases. Detection was a critical feature, achieved largely through publicity, with the offer of rewards for anyone finding a sufferer, and house-to-house searches for cases of fever with rash.

“We have now started taking immediate containment measures on the report of any case of infectious disease”, Dr Gupta told me. “Patients are removed by flying squad to the Infectious Diseases Hospital, and their homes and surroundings are immediately disinfected. Anyone who came into contact with the case and those living around are given prophylactic immunization. The area is investigated to find out any source of infection or any additional case. We wait and then try to delimit the area in the event of secondary cases.”

In the light of long years of experience in the field combating smallpox, what would the field workers do to contain the menace of infectious diseases? They unanimously acclaim the measures spelled out by Dr Gupta—not for the sake of agreeing with a superior, but out of a genuine belief in the superiority of the successful WHO strategy.
DEATH OF A KILLER

Smallpox virus escapes in England; 'extinct' disease rears its ugly head

WORLD SUPPORT FOR THE CAMPAIGN

The mass communications media—press, radio and television—lent powerful backing to the campaign. As a result, the public in developed and developing countries alike rallied wholeheartedly to the support of smallpox eradication.
HOW MUCH DID IT COST to send a man to the Moon?

Between 1961, when President John Kennedy gave a directive to set a man on the Moon and bring him back “before this decade is over”, and the successful landing in August 1969 of two men in the Sea of Tranquility and their safe return to Earth, the US space agency NASA is estimated to have spent

US $24,000 million

to wipe out smallpox from the Earth?

Between 1967, when WHO ordered its intensified Smallpox Eradication Programme into action, and 1980, when the Thirty-third World Health Assembly endorsed the final disappearance of this disease from the Earth, the total cost of eradication was

US $300 million

HOW MUCH WILL IT SAVE?

The estimated saving every year to all countries when smallpox vaccination is abolished worldwide is

US $1,000 million

HOW MANY VICTIMS WERE THERE?

In the one year 1967, official health statistic returns showed there were 131,697 cases of smallpox. But the figures showed only a tiny fraction of the real suffering. It is estimated that in that year there were

over 10 million cases of smallpox in the world

HOW MANY PEOPLE DIED?

It is estimated that, in 1967, the death toll was

about two million people

HOW MANY PEOPLE WORKED TO SAVE THE WORLD FROM SMALLPOX?

The total number of national staff, in over 40 countries, who worked in the Smallpox Eradication Programme was

200,000 men and women

The total number of international staff, from more than 70 countries, was

about two million people

HOW MANY SHOTS OF VACCINE?

Estimated total number of doses of smallpox vaccine used in the global programme:

2,400 million

Total produced by endemic countries:

2,000 million

400 million

HOW MANY BIFURCATED NEEDLES?

Between 1967 and 1976 WHO supplied over 40 million needles to the programme. The needle was inspired by the basic sewing machine needle, the loop being ground down to produce the pronged fork. The advent of the bifurcated needle brought major savings in the quantity of vaccine required.

(Photos Len Sirman ©, WHO, and WHO/Center for Disease Control, Atlanta, USA)
Towards
the year 2000

by Dr Halfdan Mahler
Director-General of the World Health Organization

The end of smallpox—but for WHO it is only the end of the beginning. It has been said that if we had known beforehand "the heart-aches and the thousand natural shocks" that awaited us, we would never have undertaken the smallpox eradication programme. Yet no one drew back, neither the leaders of governments, nor the hundreds of thousands of national field workers, nor the small WHO army of international medical and technical officers that went forward like a bright spearhead in country after country against this vicious foe.

For many of those people, the battle against smallpox may prove to be the most significant and uplifting event of their lives. The elements that contributed to final victory are discussed by the men and women, veterans of the campaign, who have written the articles for this special commemorative issue of *World Health*. Those contributors include scientists, public health experts, epidemiologists, managers. Each of them approaches the subject in a slightly different way: leadership, evolving strategy and tactics, effective deployment of scarce resources, active search, accurate case reporting, watertight containment of outbreaks, close surveillance, unstinting administrative backup and round-the-clock laboratory support. What is common to all is a sense of fulfilment, pride of participation in what can justly be called a noble and historic endeavour.

Victory over smallpox has implications that go far beyond the individuals directly concerned, however. It reasserts our ability to change the world around us for the better, through mutual collaboration and mobilization of resources, allied to human energies and the will to succeed. It comes like a freshening wind for a vessel too long becalmed, creating hopeful new impetus as we set our course towards Health for All by the Year 2000.

The present realities of the Third World are simply unacceptable. There is little joy in life nor any kind of justice for a child condemned to disease or early death because of the accident of birth in a developing country. Nor is there any rationale that can defend a system that continues to withhold the gift of health and care from nine-tenths of a nation's population. Smallpox eradication is a sign, a token of what can be achieved in breaking out of the cycle of ill-health, disease and poverty. It comes as a glimpse into the future, an intimation of a viable new order of things, in which world health, meaning health for the world, will have central significance in an upward spiral of economic and social progress.

(Photo WHO/P. Almasy)
SMALLPOX IS DEAD!

October 1979: Jubilant young Kenyans perform a dance of triumph in Nairobi at the ceremony marking the end of smallpox in all Africa. (Photo WHO)
How the seal was set on eradication

Countries reporting smallpox cases in 1967
Finally, there he was: Live Horus, Mighty Bull, Repulser of Millions, Golden Horus, Sovereign, Protector of Egypt, King of Upper and Lower Egypt, Lord of the Two Lands, Son of Re, Ramses V, Pharaoh. After a long flight from Atlanta, Georgia, USA, and a restless night, I had reached the culmination of a three-year-long quest. Permission had finally been granted for me to collect and examine specimens from the mummy of the Pharaoh Ramses V for scientific evidence that would prove he had died of smallpox. Standing in the Mummy Room of the Cairo Museum, I was almost too excited to take photographs.

Soon after it was discovered in 1898, the mummy of Ramses V, who died in 1157 BC, was recognized as bearing evidence of a rash which resembled smallpox. According to Dr C.W. Dixon, this Pharaoh died of “an acute illness at the age of forty”. But it was the rash on Ramses’ embalmed and shrouded corpse that made it probable that he had died of smallpox.

Preceding electron-microscopic studies of non-royal Egyptian mummies by Dr Peter K. Lewin, of the Hospital for Sick Children in Toronto, Canada, and others had revealed sub-cellular structures in some rehydrated tissues with extraordinary clarity. Now there was a new project, to see if there were poxviruses that could still be recognized in the skin of the ancient Pharaoh. Besides Dr Lewin and myself, it was undertaken by Dr Erskine Palmer and Dr James Nakano of the Center for Disease Control’s Special Viral Diagnostic Branch and Viral Exanthems Branch, Professor Mourad A. Sherif of Cairo’s Ain Shams Faculty of Medicine, and others.

By special permission of President Anwar el-Sadat, Professor Sherif and I were allowed to examine Ramses V’s mummy on 8 November 1979. Since this is one of the best preserved royal mummies in the Cairo Museum, museum authorities were understandably reluctant to permit us to actually cut a piece of skin containing one or more of the apparent blisters or pustules. Instead, we collected tiny pieces of skin on the shroud.

On examining the front of the mummy from the waist up, we saw a rash of yellowish blisters or pustules, each of between one to five mm in diameter. The rash is most striking over the lower face, neck, and shoulders, and is also visible on the arms, but there is no rash on the chest and upper part of the abdomen. Earlier photographs, published by G. Elliot Smith, show that the rash is also prominent on the lower part of the abdomen and scrotum. We could not see the palms and soles. Despite the limited areas accessible for inspection, the rash is quite striking and is remarkably similar to smallpox.

Electron-microscopic studies of the pieces of skin we obtained did not reveal evidence of poxvirus. Intact layers of skin and cells were clearly visible in some sections. Thus, the specimens examined appear to be of normal intervening skin rather than of directly affected skin. Ordinarily, the virus is concentrated in the pustules, blisters or scabs of smallpox victims. Other immunologic and virologic studies also did not yield the hoped-for clear evidence of variola virus.

But our failure to see poxvirus in these specimens obviously does not mean that Ramses V did not die of smallpox. And after seeing at first hand the rash on this remarkable mummy, I am almost as convinced that he did indeed have smallpox as if I had actually seen a 3000-year-old poxvirus.
La vaccination garantit la victoire sur la variole et la rougeole.
1519 AD: The ships of Hernan Cortes landed in Mexico, carrying something more deadly than 500 Conquistadores and 23 cannons: the smallpox virus. More than three million people died when a series of epidemics erupted, finally toppling the centuries-old Aztec Empire.

1694: Queen Mary II of England fell a victim to smallpox and died at the age of 32.

1721: Deliberate inoculation (variolation) with smallpox virus had been practised in Africa, China and India for centuries, before being introduced to Europe and North America by Lady Mary Wortley Montagu. The wife of the British ambassador in Turkey, she had observed variolation in Constantinople. The Reverend Cotton Mather learned of the practice from his African slaves and introduced it in Boston.

1774: King Louis XV of France died of smallpox, aged 64. Benjamin Jesty, an English farmer, inoculated his wife and two sons with cowpox to protect them against a smallpox outbreak.

1796: An English country doctor, Edward Jenner, took material from a cowpox sore on the hand of a milkmaid and inoculated it into the arm of an eight-year-old boy on 14 May 1796. Two months later he tried to inoculate the boy with smallpox—and the infection did not take. He announced his findings in 1798; by 1801 more than 100,000 persons had been vaccinated in England and Jenner's pamphlet on the subject had been translated into five languages.

1801: Jenner predicted that "the annihilation of the smallpox—the most dreadful scourge of the human species—must be the final result of this practice".
1803: Efforts were made to promote vaccination throughout the world. One of the most spectacular efforts was made by Charles IV of Spain who in 1803 dispatched vaccine to his dominions around the globe by means of children vaccinated arm-to-arm in succession during the voyages.

1807: Five Red Indian Chiefs wrote a letter of thanks to Dr Jenner. It said: "Brother: Our Father has delivered to us the book you sent to instruct us how to use the discovery which the Great Spirit made to you, whereby the smallpox, that fatal enemy of our tribe, may be driven from the earth. ... We send with this a belt and string of wampum (beads used for money) in token of our acceptance of your precious gift."

1870: During the Franco-Prussian war in Europe a smallpox epidemic broke out. The French army lost 23,400 soldiers to the disease. But the German army had been vaccinated, and only 278 died.

1948: At its first meeting in July 1948, the World Health Assembly (WHA) paid special attention to the problem of smallpox in its deliberations.

1958: The Eleventh WHA, following a motion by the Soviet delegation, decided to step up efforts to eradicate smallpox. The Soviet resolution pointed out that the funds devoted to vaccination against smallpox throughout the world exceeded those necessary for the eradication of the disease.

1967: WHO launched an intensified smallpox eradication programme. A unit set up at WHO's Geneva headquarters began work with WHO Regional Office teams and with national smallpox programmes.

1971: In South America between 1950 and 1967, endemic smallpox was eradicated in all countries except Brazil. In Brazil a huge programme of mass vaccination and case searching, which included the vast Amazon basin, culminated in victory over smallpox in 1971.

1975: In Asia, the campaign strategy had evolved from the concept of mass vaccination to an even more successful approach based on improved case investigation and searches and containment of outbreaks. The last case on the vast Indian subcontinent was Rahima Banu, a three-year-old girl in Bangladesh.

1977: From Asia the focus of the campaign shifted to the Horn of Africa, the last foothold of the disease in Africa and in the world. The last endemic case in Africa, and worldwide, was located in Somalia on 26 October 1977. The patient, 23-year-old hospital cook Ali Maow Maalin, made a complete recovery.

1979: In December, the Global Commission for Certification of Smallpox Eradication—an independent body which consisted of scientists from 19 nations—confirmed that smallpox eradication had been achieved throughout the world.

1980 The Thirty-third World Health Assembly meeting in Geneva officially declares that smallpox has been completely eradicated from the planet.
Can we stop smallpox vaccination?

The cessation of vaccination will not only save thousands of patients who would otherwise have suffered from complications but will also save the world community some $1,000 million a year.

by Isao Arita

As early as 1801, Edward Jenner, the discoverer of smallpox vaccination, wrote that "the annihilation of the smallpox, the most dreadful scourge of the human species, must be the final result of this practice". He was probably the first person ever to predict smallpox eradication, yet one wonders whether even he considered that the practice of smallpox vaccination would come to an end if his prediction came true.

The first official indication that wiping out the disease would also spell the end of smallpox vaccination appeared in 1958, in a resolution of the Eleventh World Health Assembly. This proposed the start of the global eradication programme and suggested that "...with the eradication of smallpox, vaccination and all expenditures involved in its application will be redundant".

The Global Commission for the Certification of Smallpox Eradication, an independent group convened by WHO to consider all issues related to the programme, has delivered its formal judgement that "...smallpox vaccination should be discontinued in every country, except for investigators at special risk". And it added that "international smallpox vaccination certificates should no longer be required of any traveller".

These recommendations were made because the risks of complications from vaccination, however small, certainly exceed the risk of smallpox infection, which is negligible. The only instance in which smallpox vaccination is justified is for personnel who are directly engaged in work that involves handling variola virus or related viruses. Understandably, however, there may be some hesitation about abandoning a practice which has been shown over a long period of time to bring great benefits. So let us look at a few of the major issues bearing on the decision to terminate smallpox vaccination.

Has smallpox really been eradicated?

Minutely detailed documentation of the eradication programme and continued investigation of smallpox suspects has been carried out in 79 countries, including those where smallpox had recently been endemic, where there had been a risk of importations leading to the possible establishment of endemic foci, or where information was inadequate to permit confirmation of freedom from smallpox. All these investigations failed to detect any evidence of continuing smallpox transmission, since the world's last endemic case of smallpox occurred in Somalia in October 1977.

In 1978 and 1979, no fewer than 9,170 specimens were collected for laboratory confirmation by WHO Collaborating Centres from suspected cases in the Horn of Africa and elsewhere throughout the world; not one of them contained the smallpox virus. Furthermore, all the remaining 121 countries and areas submitted to WHO a declaration of freedom from smallpox. These were the countries which had not had endemic smallpox for at least the last ten years and which had effective surveillance systems. This was the evidence that convinced the Global Commission that the WHO programme had indeed reached its goal.

Could virus stocks cause epidemics?

Variola virus stocks in laboratories can be considered to be a potential danger for the introduction of a new
infection of smallpox. The occurrence of smallpox in Birmingham, UK, in 1978 demonstrated this risk. Scientists have been aware of this danger and in recent years, under WHO's coordination, efforts have been made to reduce the number of laboratories retaining variola virus. In 1976, there were 76 laboratories retaining variola virus, but the number has now been reduced to six—one each in China, Netherlands, South Africa, USSR, United Kingdom and United States. All of these laboratories have been inspected by WHO teams of biosafety experts, virologists and epidemiologists. Adequate containment measures have been established by these laboratories and by the national health authorities concerned, and the WHO inspections will continue periodically. In two years' time, when the current priority research projects have been completed, a review will be made to evaluate whether the retention of variola virus is still scientifically justified. Meanwhile, a further reduction in the number of such laboratories is anticipated.

Is there an animal reservoir?

Since the intensified programme began in 1967, there has been an active research programme looking into the question of whether an animal reservoir of variola virus exists. All epidemiological investigations of smallpox outbreaks in tropical areas of Africa, Asia and South America turned up no evidence that such outbreaks originated from a source other than man.

In the course of these investigations, a disease called human monkeypox was first detected in West and Central Africa in 1970. Up to February 1980, 48 cases had been discovered. This disease resembles smallpox clinically, but infected persons do not easily transmit the disease to others. Only four patients seem to have caught the disease from primary cases, and there has been no evidence of spread to a third case. The causative agent is monkeypox virus, which is related to but distinct from variola virus. It appears to be maintained by some monkeys and possibly other animals; it very infrequently causes an infection in humans. The Global Commission indicated that monkeypox does not constitute a threat to the permanence of smallpox eradication. As a further precaution, however, close surveillance of human cases will continue as part of a collaborative study between WHO and countries in Africa to investigate further the natural history of this disease.

Do scabs pose a threat?

It has been shown that variola virus in the scabs of smallpox cases become non-infectious quickly in a tropical climate when they fall off the skin and remain in the patient's home or elsewhere. A similar query arose about the specimens maintained by variolators—people who inoculated material from the skin lesions of smallpox patients into other persons in order to immunize them; this ancient practice was still being carried out recently in some countries of Africa and Asia. Forty-five specimens of scabs were collected from variolators
in Afghanistan, Ethiopia and Pakistan. Only on four occasions was variola virus isolated from these specimens. There was no positive result from specimens which were collected more than nine months before testing. These findings suggest that within a year of collection, variolation material probably becomes inactive. In those countries where variolation was practised, there have been no smallpox cases detected for more than three years despite continued vigorous surveillance.

Can animal poxviruses mutate into smallpox?

Past studies on orthopoxviruses, the group of viruses to which variola virus belongs, have indicated that there has been no evidence that an orthopoxvirus has been or can be transformed into variola virus. Current genetic studies on poxviruses support this observation, and show that, because of the substantial difference between the genetic structure of variola virus and those of other individual poxviruses, mutation of other known poxviruses into variola virus appears to be unlikely.

All these considerations indicate that the risk of smallpox being still present or re-emerging in the world is most unlikely. What about the risk of complications if vaccine is given? Very severe complications that may occur following smallpox vaccination include encephalitis (a frequently lethal disease involving the brain), eczema and necrosis of skin tissue at the vaccination site. The frequency of complications in the past varied according to the type of vaccine virus used, the age of persons receiving the vaccination and the state of health of each individual. However, a very conservative estimate is that, among one million persons vaccinated for the first time, one or two persons will die, and 10 to 20 persons will suffer severe illness.

By the middle of April 1980, 64 countries had already stopped their vaccination programmes, and it is anticipated that all the remaining countries will follow suit. Fourteen countries still required vaccination certificates from international travellers. It is hoped that, by the time this issue of World Health is published, many more countries will have stopped vaccination and those requiring certificates may have fallen to very few. The universal termination of smallpox vaccination will not only save thousands of patients who might otherwise have suffered from complications but will also result in enormous savings in the health budgets of the world community, roughly estimated at around US$1,000 million a year.

Finally, it is reassuring to note that, despite the overwhelming evidence that the world has been freed of smallpox, measures are being taken by countries and by WHO to assure the permanent status of smallpox eradication. The “insurance policy” includes continuing surveillance for suspected cases of smallpox, promotion of research on orthopoxviruses in laboratories and in the field, and the maintenance of a WHO vaccine reserve sufficient to vaccinate 200 million persons in case of an unexpected emergency.
The closing stages

As smallpox diminished, the need for laboratory diagnosis became more acute. While the disease was widespread, it could easily be diagnosed from typical clinical data, but rare outbreaks required specific attention that could only be provided in the laboratory.

by Svetlana Marennikova

In 1966, the Smallpox Prophylaxis Laboratory of the Moscow Research Institute for Viral Preparations became the first of WHO's International and Regional Centres, later to be known as WHO Collaborating Centres. This laboratory was chosen not only for the high qualifications of its staff but also because it was one of the laboratories which had been working on the smallpox eradication programme for many years.

One of the first steps undertaken by WHO after the programme was initiated in 1958 was to draw up the "minimal international requirements" for smallpox vaccine. This involved making detailed tests of the dry vaccines produced in various countries of the world. For these trials, WHO chose a number of laboratories including our own, which was then part of the Mechnikov Research Institute of Vaccine and Serums in Moscow. The trials resulted in a reference preparation of smallpox vaccine which later proved of great importance for vaccine testing and for ensuring that the programme received only high quality vaccines. Similar trials were held to select a reference preparation for smallpox antibodies.

Further studies showed that a number of the important properties of smallpox vaccine (such as neuropathogenicity and reactogenicity when humans are inoculated) do not depend on the techniques used to produce the preparation but on the strain itself. The work done by the Moscow Centre made it possible for WHO to recommend one of the three strains with low or moderate reactogenicity and the best possible combination of other properties, instead of permitting a multitude of poorly studied local strains.

The key role played by laboratory services was acknowledged from the start of the programme, but its significance grew as time went on. When the incidence of smallpox began to diminish, the need for laboratory diagnosis became more acute. This is easy to explain. So long as the disease was widespread, it was not hard, as a rule, to diagnose it from the typical clinical and epidemiological data. On the other hand, rare outbreaks or single cases required specific attention that could only be provided in the laboratory.

Laboratory diagnostic investigations reached their high point once the certification of smallpox eradication had begun; from then on, virtually all suspected smallpox cases were investigated. In 1971, for instance, the number of specimens we investigated totalled 203, but in 1979 there were 2,949.

The principle underlying the diagnostic work was not merely to confirm a smallpox diagnosis or otherwise, but also to clarify the origin of the agent that had caused the infection. This approach required the use of at least two techniques: electron-microscopy of the specimens, which made it possible to establish whether the agent was of the pox or herpes group; and inoculation into the
chorio-allantoic membrane of chick embryos. The latter technique had some particular advantages when viruses of the pox group were isolated, since its very high sensitivity offered us an opportunity to differentiate between closely related members of this group which can cause infection in humans.

The unprecedented upsurge in diagnostic investigations that took place during the certification period, when we sometimes received 318 to 420 specimens a week, required from every person involved not only intense exertion and physical effort but also real self-sacrifice. Just the electron-microscope scanning of material prepared from one patient takes up to 20 minutes, to say nothing of the routine tasks of treating the material, inoculating the chick embryos and estimating the inoculation results. We fulfilled this work thanks to a high sense of responsibility and an awareness of the work's importance.

Diagnostic work calls for a great deal of caution, since all sorts of surprises can occur. A vivid illustration of this was the detection of human monkeypox. In August 1970, in a village of the Equatorial Province of Zaire where smallpox transmission had been interrupted for more than a year, the programme staff unexpectedly discovered a case that, by all its symptoms, was indistinguishable from smallpox. This case caused considerable alarm, since no visible source of infection had been found. Results obtained in the laboratory 48 hours after the inoculation of embryos promised nothing unusual: lesions on the membrane looked like those of smallpox virus. After 72 hours, however, the picture had changed: hardly visible haemorrhages had appeared in the centre of the pocks.

Incredible diagnosis

These changes could easily have been overlooked. Only our previous experience combined with the caution mentioned above, made it possible to establish the diagnosis—a seemingly incredible one: human monkeypox, of which the epidemiology was fully investigated by WHO and national staff at that time. It was incredible because this virus had been generally considered harmless to man. Further investigations with a long series of tests, intended to distinguish monkeypox virus from other poxviruses, subsequently confirmed the diagnosis.

This discovery had three important consequences: the possibility of a spontaneous return of the infection to territories from which it had been eliminated was excluded; a previously unknown human infection had been found; and a number of new scientific and practical questions appeared in connection with this new human infection, and were reflected in appropriate recommendations and subsequent WHO research projects.

The post-eradication period we are now entering, which will be accompanied by the ending of smallpox vaccination and a gradual loss of smallpox immunity in the population, will require vigilance with respect to other poxviruses of potential danger to man. This applies, above all, to the cowpox virus. Our studies have already enabled us to considerably expand the available knowledge about the ecology of this virus. One of the most important factors is its detection in rodents, which we now believe to be a natural reservoir of the cowpox virus. We have also established that a wide range of animals are susceptible to this virus, and in some of them, such as the cat family, it may cause fulminating pulmonary infection, with lethal effect.

Our investigations into the ecology of the cowpox virus are of importance not only for this infection. They will undoubtedly be useful for understanding many unclear questions relating both to the monkeypox virus and to other poxviruses.
How can we be sure?

It is difficult to prove that a disease no longer exists on earth. But a mass of carefully compiled evidence has convinced the Global Commission that Smallpox Target Zero has in truth been attained by Frank Fenner.

The claim that smallpox has been totally eradicated from the earth is a broad one. "How do you know?" and "How can we be sure?" are questions that many people may well ask, particularly those health administrators who are responsible for vaccination programmes.

From the outset of the Intensified Smallpox Eradication Programme, WHO has been aware of the importance of these questions, firstly for the countries where smallpox was endemic as they moved towards eradication, and then for the world as a whole as country after country signalled the all-clear. The mechanisms devised to give the answers are novel ones, simply because mankind has never before faced such questions.

Given the essential tools, namely a good vaccine and an adequate surveillance network, two concepts were of outstanding importance for the achievement of global smallpox eradication. Firstly, international cooperation and, secondly, assessment or quality control. Many individual countries could and did wipe out endemic smallpox without international help, but global eradication could not even have been contemplated without the involvement of WHO as the instrument of international cooperation in health matters.

The role of assessment is less obvious, but it was just as essential. It had to be applied to all phases of the programme, from the quality control of vaccines, so that the vaccinator could have potent material for his work, to the overseeing of work in the field, so that full coverage of the population by vaccination could be assured in the early stages of the campaigns, and the adequacy of surveillance could be guaranteed in the later stages.

As country after country achieved the goal of Smallpox Zero, the question arose as to how the world community itself could be assured of the reality of these achievements. Later, with approaching global eradication, the question took on a new urgency and involved other considerations; for instance, how to maintain variola virus stocks in laboratories, and what measures to take after global eradication. To answer these new questions the same two concepts were evoked, international cooperation and assessment. A system for certifying smallpox eradication in countries or in groups of countries was introduced in 1973 and became ever more elaborate as the programmes proceeded, reaching a peak of intensity with the two most difficult strongholds of the disease—the Indian subcontinent and the Horn of Africa.

This system depended on a series of International Commissions for the Certification of Smallpox Eradication, 21 of which examined the situation successively in 61 countries, beginning in South America in 1973 and ending with Somalia in October 1979. Although the International Commissions were convened by WHO, it was realized from the outset that they must be, and must be seen to be, independent of WHO yet of high standing in international health matters, WHO therefore sought for service on the International Commissions a group of people from several different countries, each a respected authority in public health, epidemiology or virology, and each with at least some experience in smallpox control.

The response of scientists and administrators was enthusiastic; rarely was a request from WHO for service on an International Commission refused. The next important matter to be determined was when the commissions should assess the situation in relation to the last reported case in a country or region, and what preparations should be made. As the situation developed, two different kinds of response seemed necessary. In countries where smallpox had been
recently endemic, it was decided that a minimum of two years should elapse between the last known case of smallpox and the visit of the Commission. During this time intensive active surveillance for smallpox should be carried out, and special reports on the situation and on post-eradication surveillance should be prepared for the Commission.

In other countries, such as those adjoining highly endemic regions, smallpox had been eliminated by national programmes with little assistance from WHO; in many of these certification was delayed for several years after the last known case, but WHO-assisted surveys were carried out before the Commission's visit.

**Intensive preparations**

Especially in countries where smallpox had long been a scourge, the visit of the International Commission was an important event and preparations were as intensive as the activities of the last few years of the eradication programme itself. Detailed "Country Reports" were drawn up, based on the history of the eradication campaign but supplemented by the results of special searches and surveys carried out during the post-eradication period. Active surveillance for fever-and-rash cases continued and intense publicity campaigns made sure that everybody knew about the reward offered for the notification of smallpox cases.

Country-wide "special searches" were sometimes carried out, and as the programme evolved two special kinds of survey developed. One was the facial pockmark survey, especially suitable in countries that had experienced severe smallpox; the other was the chickenpox survey, which proved invaluable in countries where variola minor—the less serious form of smallpox—had occurred.

Severe smallpox can leave two serious legacies in those who survive: blindness and pockmarks. About 70 per cent of people who have recovered from severe smallpox have more than five facial pockmarks that they carry for the rest of their lives. By examining large numbers of persons in various age groups in a population, particularly school and preschool children, and recording histories of the date of the smallpox attack in each pockmarked person, it proved possible to get a retrospective estimate both of the amount of smallpox that had occurred and, most importantly, when it had last occurred. The facial pockmark survey
Above: Somalia—Rewards were offered to anyone notifying a smallpox case.

Left: Bangladesh—Quality control of local production of vaccines.

Right: USSR—Millions of vaccine doses contributed to the success of the worldwide eradication campaign.


was particularly valuable in the Indian subcontinent, some parts of Africa and China.

Variola minor, which has a mortality rate of one per cent or less compared to up to 40 per cent for variola major, leaves much less facial scarring—only about seven per cent of known cases in Somalia had facial pockmarks a year later. However, this form of smallpox can be mistaken for chickenpox, so that surveys of this disease provided a useful indicator of the presence or absence of mild smallpox. In such chickenpox surveys, specimens for laboratory examination were sought from a selection of cases of chickenpox; one from each separate chickenpox outbreak, from severe or fatal cases, and from chickenpox in unvaccinated individuals, as well as from all suspected cases of smallpox. The specimens were sent to Geneva and examined at the WHO Collaborating Centres in Moscow or in Atlanta, USA. More than 5,200 specimens were examined in the periods leading up to certification in Ethiopia and Somalia, without variola virus being detected.

When it was clear that these preparations had been adequate, an International Commission was convened to visit the selected country or region. On arrival, the members conferred with the national health authorities and discussed all the evidence that had been assembled to show that there had been no case of smallpox for at least two years, and then
made field visits. These were designed to assess the efficiency of the surveillance system for smallpox. The question that the International Commission sought to answer was: If there had been a case in the last two years, would it have been detected? The field visits concentrated on difficult or "problem" areas, the location of the last reported case, border districts, and inaccessible areas with poorly developed health services. Then the members met again to go over the country reports once more, with the added information gleaned from the field visits, and the Commission produced its report. In every case the preparations had been so thorough, or such a long period had elapsed since the last known case, that the International Commission was able to certify the country or region free of smallpox.

Global certification

By 1977, when worldwide eradication appeared to be imminent, it was clear that some independent authoritative group was needed to map out the strategies for certifying global eradication of smallpox, to assess the results of International Commissions and other enquiries, to consider such implications of global eradication as the cessation of smallpox vaccinations among the general public and the significance of variola virus stocks in laboratories, and to map out a post-eradication "insurance policy".

The Director-General of WHO called a Consultation on worldwide certification of smallpox eradication in October 1977, consisting of 17 experts from 16 countries, most of them being epidemiologists and virologists experienced in the eradication programme operations and certification procedures. The Consultation made detailed recommendations for a programme for the following year, and recommended the setting up of an "International Commission for the Global Certification of Smallpox Eradication" to provide consultative assistance and to verify this unique event. The Global Commission, as it was subsequently called, was formed early in 1978 and met in December of that year and again in December 1979.

That first meeting of the Global Commission, in December 1978, considered the situation relating to smallpox in every inhabited country and area in the world, and drew up a programme of work which was designed to result in certification of freedom from smallpox from every country by December 1979. It also addressed itself to several problems of special importance in a world free of smallpox: vaccination policy, stocks of variola virus in laboratories, and the possibility that there might be an animal reservoir of variola virus.

The year 1979 was one of intense and carefully orchestrated activity, which succeeded in laying before the December 1979 meeting of the Global Commission reports on the smallpox situation in every country in the world, an expert opinion on the justification and extent of the retention of stocks of variola virus in laboratories, and ideas for a post-smallpox-eradication "insurance policy". In addition to considering all this informa-
tion, the 1979 meeting completed a final report on its activities. And it concluded its intensive four days of work by witnessing the signature, by all members, of a document bearing the words, in six languages: "We, the members of the Global Commission on Certification of Smallpox Eradication, certify that smallpox has been eradicated in every country in the world."

The report, which is about 120 pages long, summarizes the campaigns that led to the eradication of smallpox and the certification of eradication, by country, by groups of countries, and throughout the world as a whole. It also outlines in some detail an insurance policy for the post-eradication era. The report and its recommendations were considered by the Executive Board of WHO in January 1980, and figure on the agenda of the World Health Assembly this month.

It is difficult—perhaps impossible—to "prove a negative," that is, to prove that smallpox no longer exists on earth. But evidence provided by the careful work of national health authorities in every country, of WHO expert consultants and advisers, and of the staff of the Smallpox Eradication unit at WHO headquarters in Geneva, has convinced all members of the Global Commission that transmission of this disease from person to person has been interrupted everywhere in the world. The last case of endemic smallpox occurred in Somalia in October 1977. Smallpox Target Zero has now indeed been reached, and the Global Commission has formally certified that the world is at last free of this appalling disease.

In the next issue

The June issue of World Health, published on the eve of the World Conference of the UN Decade for Women, in Copenhagen, will look at the role of women in the closely interrelated fields of development and health. Contributors from many parts of the world emphasis some of the most striking aspects of women's situation in different cultures and settings.

Authors of the month

Dr. D. A. Henderson, formerly WHO's Chief of Smallpox Eradication, is now Dean of the School of Hygiene and Public Health at the Johns Hopkins University, Baltimore, Maryland, USA.
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Mr. J. Tuli is the Public Information Officer for WHO's South-East Asia Region, based in New Delhi.
Mr. A. M. Chacko is a freelance journalist based in New Delhi.

Mr. J. Talati is the Director-General of the World Health Organization.
Dr. D. R. Hopkins is the Assistant Director for International Health at the Center for Disease Control, Atlanta, Georgia, USA.
Dr. I. Areia is the Chief of the Smallpox Eradication Programme at WHO headquarters in Geneva.
Professor S. Marenkova is Chief of the Smallpox Prophylaxis Laboratory, Moscow Research Institute for Viral Preparations.
Professor F. Fenner, until recently Director of the Centre for Research and Environmental Studies of the Australian National University, is the Chairman of the Global Commission for the Certification of Smallpox Eradication.

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Of the smallpox god Sopona, worshipped by the Yorubas of Nigeria, it was said that "being a very stubborn deity, he would not heed any appeasement."

(Photo WHO)