The first ascent of Mount Everest

Michael Ward

1993 is the 40th anniversary of the first ascent of Mount Everest—by a British team led by Sir John Hunt. One of the mountaineers, and the expedition doctor, was Michael Ward. He describes in this article the problems that had to be overcome before the mountain could be climbed, and the crucial part in the success played by Dr Griffith Pugh's research, both in the Himalayas and at the Medical Research Council laboratories in London.

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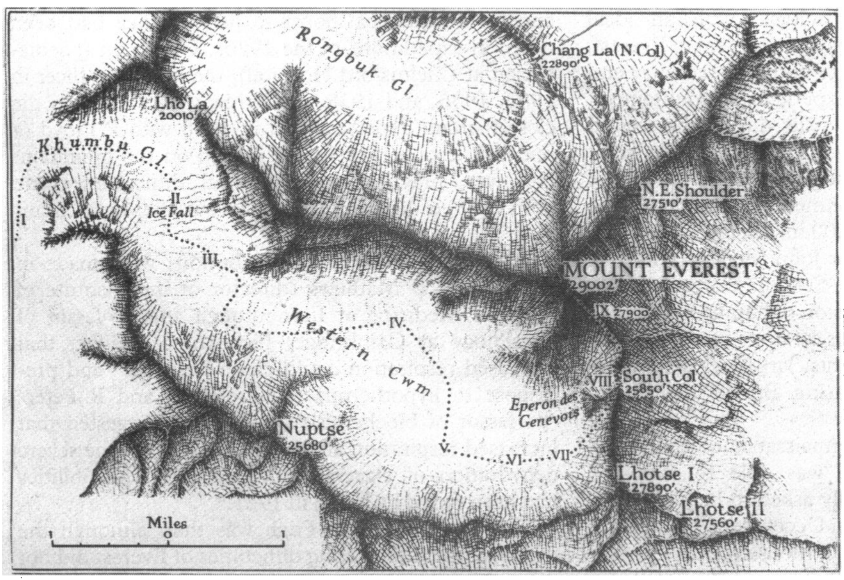
The first survey of the Everest region was carried out by Chinese surveyors between 1708 and 1716 in the course of compiling a map of the whole Chinese empire. Drawn by Jesuits in Peking, this map was published in 1718 and formed the basis of one of the earliest European maps of China, D'Anville's *Nouveau atlas de Chine,* published 20 years later in 1737. The Tibetan name for Everest, Chomolungma, which appears on this map, had been given to the mountain about a thousand years earlier by the inhabitants of the Rongbuk valley, at the head of which Everest lies.

As access to the Himalaya was forbidden the European "discovery" of Everest as the highest mountain in the world occurred in 1848 during a routine survey from the plains of India. The name Everest was given to peak XV to commemorate a distinguished former director of the Indian survey, Sir George Everest, because no local name could be discovered.[1] The survey at that time did not know of the Tibetan name Chomolungma, nor did the Tibetans or the Chinese know that it was the world's highest peak. The Nepalese name Sagarmatha was given to the mountain at a later date.

The problems

The exploration, mapping, and ascent of Everest (8848 m) was a major preoccupation of the Alpine Club and Royal Geographical Society from the time of its first European "discovery" in 1848 until the first ascent in 1953.

Any plan to climb the mountain had to overcome three main problems. The first was politicogeographical: the peak lay on the border of Tibet and Nepal, both "inaccessible countries." Secondly, there was an obvious mountaineering problem. Above all, however, was the third, very considerable medical problem—the hypoxia of extreme altitudes. It was not until this was solved by Dr Griffith Pugh and his colleagues at the Medical Research Council at Hampstead and the answer confirmed in the field in the Everest region in 1952 that the first ascent was made by Hillary and Tensing in 1953.



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Map of the region, showing the route of the successful ascent

Solving the politicogeographical problem

Because Nepal banned access to all Europeans until 1949 the early attempts on Everest in the 1920s and 1930s were made from Tibet. The route from the north was discovered on the first reconnaissance expedition in 1921 and was followed to an altitude of 8600 m by eight mountaineers on seven expeditions between 1921 and 1938. Although the technical climbing difficulties were not extreme, the route was by no means easy. At 8600 m the rock resembles the overlapping tiles on a steep roof and much of it is loose. In some places the shoulder of a climber standing upright brushed the rock above him; often the rocks were covered in snow and verglas (black ice); and a fierce and persistent wind hampered progress. The effects of hypoxia were well described by E F Norton on the 1924 expedition on a climb without supplementary oxygen to the highest point attained on the north side, 8600 m: "Our pace was wretched. My ambition was to do twenty consecutive paces uphill without a pause to rest and pant, elbow on bent knee; yet I never remember achieving it—thirteen was nearer the mark. . . . Every 5-10 minutes we had to sit down for a minute or two, and we must have looked a sorry couple."[2]

Norton also described great thirst. As up to six breaths had to be taken for each step the loss of fluid from the lungs was considerable and led to severe dehydration. The intensely cold, dry air also led to his companion—T H Somervell, a surgeon, developing severe nasopharyngitis. Part of the mucosa sloughed, causing temporary suffocation, relieved by a self induced Heimlich manoeuvre.[2]

In 1949 the political complexion of Central Asia changed: Tibet closed its borders, but a bloodless revolution in Nepal overthrew the hereditary Rana family of prime ministers and put a king firmly on the throne. In 1950 a trekking party, the first to visit the Nepalese side of Everest, included Charles Houston, an American physician and mountaineer, and H W Tilman, a well known British mountaineer and leader of the 1938 Everest expedition. Both were very sceptical of a new route to the summit, but their pessimistic view was not shared by a group of young British mountaineers that included W H Murray (a Scottish author who had just returned from a Himalayan expedition), T D Bourdillon (a rocket physicist who lived in Buckinghamshire), and myself (an RAMC officer attached to the Brigade of Guards in London, doing national service).

The archives of the Royal Geographical Society were searched and cartographic and photographic evidence

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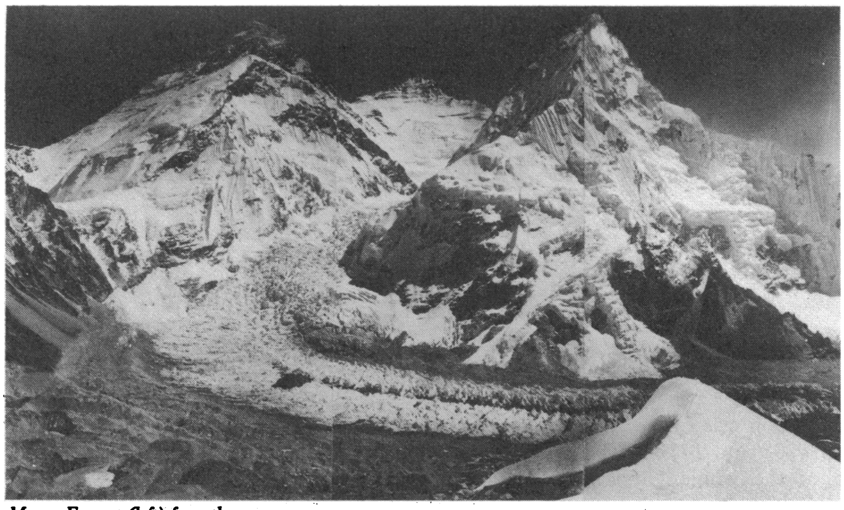
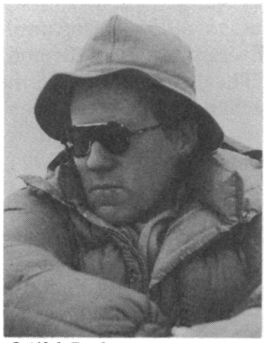
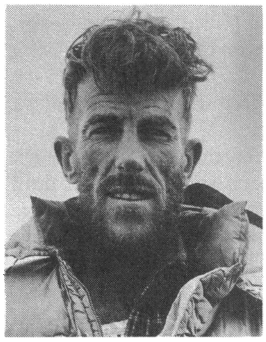


Mount Everest (left) from the west, with the Khumbu glacier in the foreground. The south col is towards the middle of the photo



Griffith Pugh



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Edmund Hillary

obtained of a possible route to the summit from Nepal. This information came from a flight over Everest in 1933, two clandestine flights in 1945 and 1947, and photographs taken from two places on the Tibet/Nepal watershed during expeditions in the 1920s and 1930s. A map of both the north and south sides of Everest had been compiled from this information and was available but in 1951 had not been published. This information was not available to the Houston-Tilman party, which was based in the United States.[3]

Despite scepticism in Britain, permission was obtained from the Nepalese government for a reconnaissance expedition to visit Everest in the autumn of 1951. Before it left Britain the members asked E Shipton, who had been on four expeditions to Everest from Tibet between 1933 and 1938 and who had just returned from a diplomatic appointment in south west China, to join their party. They were joined in Nepal by two New Zealand mountaineers, E Hillary and E Riddeford. This expedition was successful: it confirmed the existence of a possible route to the summit from the south, Nepal side.

Solving the medical problem

In the early summer of 1951, before the reconnaissance expedition left, Dr R B Bourdillon, a Medical Research Council staff member at Stoke Mandeville Hospital and father of T D Bourdillon, arranged for me to visit Dr Griffith Pugh at the newly formed Medical Research Council division of human physiology at Hampstead to discuss the high altitude problem of Everest.

Pugh was a clinical physiologist with an ideal background for solving the medical problem of Everest, being an Olympic class skier in both crosscountry and downhill disciplines and an experienced mountaineer. He had also worked for two years during the second world war at the mountain warfare training centre at the Cedars in Lebanon, investigating all aspects of the effects of the mountain environment on man, including altitude, as the peaks reach 3000 m. On discharge from the army he went to Professor John McMichael's unit at the Postgraduate Medical School, Hammersmith, until the formation of the division of human physiology in the winter of 1950. This was set up to investigate the effects of extreme environments, largely as a result of the Korean war and increasing British interest in Antarctica.[4]

During the successful reconnaissance of Everest in the autumn of 1951 Pugh was able to start his investigations. He was formally asked to help with the scientific problem of Everest in December 1951.

Because Everest is 300 m—a thousand feet—higher than its rivals its altitude problem had long been recognised as unique. On the early Everest expeditions of 1921, 1922, and 1924 the respiratory physiologists—Barcroft, Haldane, and others—had been adamant that supplementary oxygen should be used. Their opinion was influenced by the death at 8000 m of Croce-Spinelli and Sivel in the balloon Zenith in 1875. Tissandier, the survivor of that disaster, would also have died from hypoxia had he not vented hydrogen, which caused the balloon to descend. Between 1862 and 1886, however, two British meteorologists, J Glaisher and Mr Coxwell, had made repeated ascents by balloon to extreme altitude, and they believed that acclimatisation did occur.[5] In the late nineteenth century W M Conway had climbed to 7500 m in the Karakoram without supplementary oxygen,[6] and Clinton Dent, a physician and mountaineer, stated in 1893 that Everest could be climbed without its help.[7] So too did Alexander Kellas, an extremely experienced Himalayan mountaineer and physiologist, who was a lecturer in chemistry at the Middlesex Hospital Medical College and who had ascended to 6000 m and above more often than any other individual.[8]

Even so, medical scientists were astonished when mountaineers on the early Everest expeditions via Tibet reached a height of 8600 m without the aid of supplementary oxygen. The scientists had underestimated the effects of acclimatisation. In fact, supplementary oxygen had been used, but it had not seemed to confer any benefit in terms of increased climbing rate, and indeed some mountaineers seemed to ascend as fast or faster without supplementary oxygen than those who did use it. One supporter was G I Finch (professor of physical chemistry at Imperial College, London), who went on the 1922 expedition after decompression chamber experiments at Oxford under the aegis of the Medical Research Council.[9] He reached 8200 m on Everest with supplementary oxygen and was convinced of its effectiveness. He also noted that oxygen given during sleep combated fatigue and maintained physical condition. Unfortunately he was not chosen for the 1924 expedition, in which four men—without the aid of supplementary oxygen—climbed to 8600 m, and G Mallory and A Irvine, using open circuit sets, were at a similar height when seen for the last time before their deaths.

During the expeditions in 1933, 1935, 1936, and 1938 mountaineers and scientists made many contributions but got no higher than had expeditions in the 1920s. In 1933 R Greene (physician at the Royal Northern Hospital) developed a very efficient open circuit apparatus and described the use of oxygen in the treatment of frostbite, but supplementary oxygen was not used as the antioxygen lobby was in the ascendant and no unequivocal boost to performance had been noted in expeditions of the 1920s. C Warren (paediatrician at Chelmsford Hospital), the medical officer in 1935, 1936, and 1938, was initially very keen on the closed circuit apparatus and in 1938 with P Lloyd (a scientific civil servant) used it high on the mountain. However, practical and technical difficulties made both change their minds and favour the open circuit sets.

Two other important contributions were made in this period. B Mathews (director of the Institute of Aviation Medicine at Farnborough and professor of physiology at Cambridge) highlighted the fact that increased respiration could cause heat loss[10] and predispose to hypothermia and frostbite, and R Peters (professor of biochemistry at Oxford) suggested that increased respiration also could account for the severe dehydration of extreme altitude.[11] Both possibilities had been raised by Finch in 1921.[12]

The problem facing Pugh was that, although the technical mountaineering difficulties of Everest did not seem insuperable, no mountaineer using supple-

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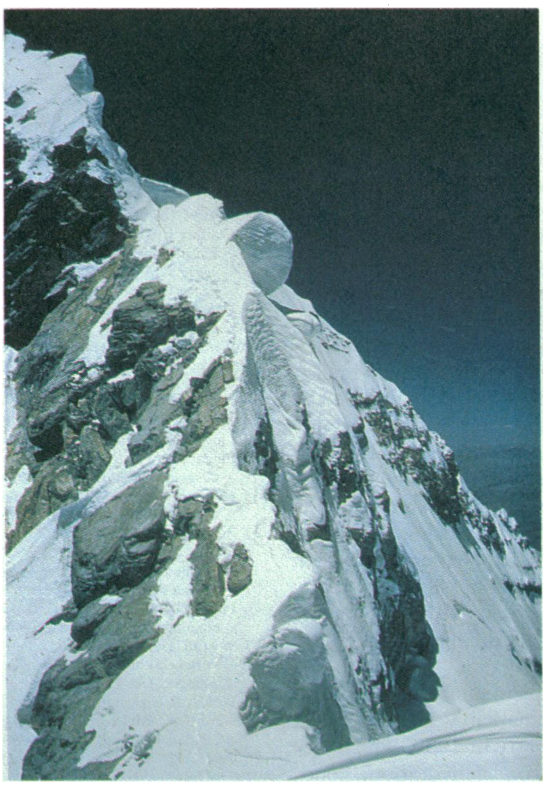
Supplementary oxygen and climbing rate

Expedition year	Altitude (feet (m))	Gross load (pounds (kg))	Rate of climb (feet (m) per hour)	Oxygen apparatus
1922	25 000-27 000 (7620-8230)		320 (98)	None
	25 500-27 200 (7770-8290)	40 (18)	400 (122)	Open circuit, 2·4 l/min
1924	25 300-26 800 (7710-8170)		333 (101)	None
1952	25 800-27 200 (7860-8290)		233 (71)	At rest only
1953	25 800-27 200 (7860-8290)	40 (18)	622 (190)	Open circuit, 4 l/min
	25 800-27 200 (7860-8290)	40 (18)	494 (151)	Open circuit, 4 l/min
	25 800-27 200 (7860-8290)	52 (24)	933 (284)	Closed circuit

mentary oxygen had been given a boost to performance sufficient to enable him to ascend to the summit from a high camp and descend safely in a day. In addition there was no evidence that there existed any mountaineer whose physical performance at extreme altitude was good enough to allow him to accomplish this by acclimatisation alone, despite the fact that the "summit of Everest" had been reached after 40 days' acclimatisation in a decompression chamber at Pensacola Air Base, Florida, in 1946, in an experiment conducted by C S Houston, R L Riley, and others.[13]

The key to the solution of the problem lay in providing supplementary oxygen at a flow rate sufficient to provide this boost. Prewar expeditions had an oxygen flow rate of up to 2·4 l/min when using open circuit sets, but Pugh calculated that this rate compensated only for the weight of the sets, about 18 kg. An additional 2 l/min was necessary to boost performance, and in all a flow rate of 4 l/min was needed.

Without adequate supplementary oxygen at extreme altitudes the body is on a knife edge. The decreasing uptake of oxygen lowers the exercise capacity and decreases heat output, and the mountaineer may cool down, despite being fully clothed, to nearly the environmental temperature, which is seldom above freezing point. Radiation from the sun keeps the body in thermal balance and may indeed cause overheating, but when the sky is overcast or at night the effect of radiation is diminished. At extreme altitude this sequence of events may lead to frostbite, hypothermia, and death. And there are additional hazards: cerebral and pulmonary oedema, together with vascular episodes associated with polycythaemia and dehydration.



The Hillary step, beyond the south summit

Prewar climbers at extreme altitude had suffered from hallucinations due to hypoxia; some had died from cold injury; hemiplegia had been reported; dehydration was extreme, fatigue overwhelming, and loss of weight severe. Muscle wasting was great: F S Smythe in 1933 could almost encircle the muscles of his thigh with the fingers of one hand. Fourteen deaths had been recorded on Everest up to 1952.

The 1952 expeditions

After the successful British reconnaissance of 1951 from Nepal a very strong party of Swiss climbers attempted the mountain in the spring and autumn of 1952. In technical mountaineering terms they were much more experienced than any British party. This was because British mountaineering standards had lagged in the 1930s, and in addition the Swiss had been able to do hard Alpine routes thoughout the second world war. They posed the greatest challenge yet to Everest, and in the spring of 1952 R Lambert and Tensing reached a height of 8500 m, but because of design faults in their equipment they could use supplementary oxygen only at rest, not when climbing. Another attempt in the autumn failed at a slightly lower altitude just above the south col because of the combination of cold and wind producing a temperature of around −100°C on the exposed skin.

While the Swiss were attempting Everest in the spring a British-New Zealand training party went to Cho Oyu (8200 m), about 40 km west of Everest. It was led by Shipton and its purpose was to build up a nidus of climbers who would go to Everest. Pugh was to test oxygen sets, clothing, stoves, tents, and other equipment. He obtained a grant from the Royal Society, and his most important task was to establish a flow rate of oxygen for the open circuit sets that would boost performance at altitude, by increasing climbing rate and stamina and combating fatigue. In May he set up a tented physiology camp at 5800 m on the Menlung La, a pass crossed by Shipton and Ward on the reconnaissance in 1951. He confirmed that a flow rate of 4 l/min (double the rate used on previous Everest expeditions) was necessary to counteract the weight of the sets and increase performance.

Pugh confirmed the benefits of oxygen while sleeping and estimated that 3 litres of water a day would prevent dehydration. He emphasised the need for a high carbohydrate diet and measured the insulating value of tents, sleeping bags, clothing, and boots. His report to the Medical Research Council in 1952[14] formed the basic scientific framework on which the 1953 expedition was organised by John Hunt when he took over as leader in October 1952.

First ascent of Everest, 1953

Pugh's work had produced for the first time a clear, logical, and scientific understanding of human physiology at extreme altitude, and the Medical Research Council powerfully influenced the selection, manufacture, and preparation of all equipment, clothing, and food for the 1953 expedition, of which Pugh was a member. Its advice also played a part both in planning and in the overall tactics in 1953.

On prewar expeditions the advantage of supplementary oxygen had not been decisive, but those who had used it had been satisfied that, even at the relatively low flow rate then used, the higher the altitude the greater the boost to performance. Pugh's work in Cho Oyu in 1952 had confirmed this. The increased flow rate of oxygen that he considered essential would require more oxygen to be carried at a greater pressure in cylinders made of a higher strength and lighter materials (developed during the war). The open circuit

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Headquarters of the Silver Hut Expedition

sets in 1953 with a maximum of three cylinders of oxygen weighed 19 kg, and at a flow rate of 4 l/min the climber at 8848 m would be breathing the same concentration of oxygen as in air at about 6000 m, an altitude at which it is possible to climb at a high standard.

In the meantime Tom Bourdillon, his father, and others were developing a closed circuit oxygen set. Though providing a greater boost to performance than the open circuit set because the climber breathes oxygen at a pressure above that of oxygen in the atmosphere at sea level, its weight—over 23 kg—was considerable as it incorporated the soda lime cannister to absorb carbon dioxide. At extreme altitude this set conserved heat and moisture in the respiratory gases, but being more complicated it was less reliable.

Using these sets C Evans and Bourdillon made the first ascent of the south summit (8650 m) in 1953, climbing at twice the rate of those with open circuit sets. One set then malfunctioned, and they very sensibly turned back, as this failure would mean sudden exposure to extreme altitude with possible coma and death.

The use of oxygen during sleep at 1 l/min above 8000 m was also extremely beneficial in that it ensured a good night's sleep and combated fatigue. Pugh's rules were that 4 l/min should be used on ascent, 2 l/min on descent, and 1 l/min during sleep.

The successful ascent

Many factors contributed to the successful ascent in 1953, but a critical part was played by the use of adequate supplementary oxygen. The relatively smooth and eventless ascent by Hillary and Tensing to the summit contrasts starkly with the description of Norton's climb at 8600 m. The key effect of the oxygen was that it enabled climbers to ascend continually without having to stop every few minutes to repay their oxygen debt, and this increased overall climbing rate.

At about 8750 m the summit of Everest is guarded by a 10 m vertical rock step, now known as the Hillary step, partly covered in hard packed snow. A gap of about 1 m had opened up between the snow and rock and this was climbed by wedging, feet on one side and body on the other. This is a very tiring method of progress, and without sufficient supplementary oxygen it is doubtful if it would have been possible for Hillary and Tensing to have climbed it in 1953. The table shows how effective the use of adequate supplementary oxygen was in increasing climbing rate.[15]

The use of adequate supplementary oxygen also contributed greatly to the remarkably good physical and mental condition of the party in 1953, which was reinforced by Pugh's work on dehydration, food, insulation, and other factors. There were no accidents and only two cases of mild frostbite, which can be attributed to the physical and mental mobility of members of the party as they were able to adjust to and counter events rapidly and correctly.

Everest without supplementary oxygen

Before the Cho Oyu expedition in 1952 there was considerable doubt whether worthwhile scientific results could be obtained on a high altitude mountaineering expedition. However, advances in the design of equipment meant that fairly elaborate physiological work could be undertaken in field conditions. The Silver Hut Scientific Expedition, in which Pugh was the leader of the winter physiological party,[16] was an extension of this fieldwork and examined different stages of the oxygen transport system at high altitude. A laboratory (the silver hut) was placed at 5800 m in the Everest region and occupied for the four winter months. At the end of this period at attempt was made to climb Makalu (8470 m), the world's fifth highest peak, without supplementary oxygen. Much information was gained about high altitude deterioration, high altitude pulmonary oedema, and the vascular disorders of altitude. Pugh confirmed that the barometric pressure in the Himalayas was higher for a given altitude than predicted, confirming observations he had made on Everest in 1952 and 1953. This enhanced the possibility of climbing Everest without supplementary oxygen,[17] first done in 1978 by P Habeler and R Messner. This has been repeated on several occasions since, and some extraordinarily rapid ascents and descents of Everest have been made without supplementary oxygen to avoid high altitude deterioration.[18] The mortality is appreciable, and in all over 100 deaths have occurred on the mountain.[19]

Modern mountaineers have the opportunity to ascend to great altitude on many occasions in one season. They are therefore fitter, better acclimatised, and more efficient than their predecessors. If supplementary oxygen is not used, however, it is essential that they move up and down the mountain rapidly. At sea level an athlete who fails to produce an Olympic class performance may lose a race or a title; near the summit of Everest the loss may be a limb or a life. For most climbers Everest is an "oxygen" mountain.[20]

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