

SOME EFFECTS OF HIGH ALTITUDE ON MAN

BY L. G. C. PUGH AND M. P. WARD

[The authors have published more technical accounts in the medical press ; see, e.g., *The Lancet*, December 1, 1956.—EDITOR.]

THE 1951 Mt. Everest Reconnaissance Expedition, the 1952 Cho Oyu Expedition, and the 1953 Everest Expedition form a closely linked series. They provided unusual opportunities for observing the effects of altitude on men taking part in successive expeditions, as well as the modifying influence of factors such as improved acclimatisation and nutrition and the use of oxygen equipment.

The early part of the three expeditions was much the same. The first seventeen days were spent marching 140–160 miles through the Himalayan foot-hills at heights ranging from 4,000 to 12,000 ft., after which a main base camp was established at 12,000–13,000 ft. The next two and a half months were spent mainly at heights between 18,000 and 22,000 ft. ; but, whereas the 1951 and 1952 expeditions went straight to 18,000 ft. and did not come down again for several weeks, the Everest party devoted nearly a month to preliminary acclimatisation, making several short visits to 18,000 ft. and returning in the intervals to 13,000 ft. to rest. This phase of the Everest 1953 expedition was followed by a month spent at 18,000–22,500 ft. establishing camps and transporting stores up the Khumbu glacier. The final phase on the Lhotse face and South Col (26,000 ft.), including the ascent to the summit (29,002 ft.) lasted about fourteen days. The 1951 and 1952 expeditions did not go above 23,000 ft.

The Everest party had considerably more experience of high altitude than had the 1951 and 1952 parties, which included a high proportion of 'first-timers'. Of the twelve members of the Everest team three had taken part in both previous expeditions and three others in one of them ; and four of the remaining six had previous Himalayan experience.

Heights up to 12,000 ft.

No adverse effects were noted during the approach marches. Climbing-rates of 2,000–2,500 ft. an hour were usually maintained on long ascents and were unimpaired up to 12,000 ft. Above 8,000 ft. there was an increase in pulse-rate during sustained climbing, but one did not become aware of increased breathing until reaching 12,000 ft. Cheyne-Stokes breathing in men who were asleep was observed at heights as low as 10,000 ft. During the first twenty-four hours after

the main base had been set up complaints of headache were not unusual and there were signs of irritability, but these effects soon passed off.

Heights up to 20,000 ft.

On the way up to 18,000 ft. most newcomers to the Himalayas suffered rather severely with shortness of breath, weakness, and fatigue; and climbing was a great effort. Some had acute symptoms—e.g., headache, loss of appetite, nausea, and vomiting. Band, in 1953, found he got considerable relief by over breathing, which he did on the advice of Evans, a very experienced climber who was hardly affected by these heights. Men who had been in the Himalayas before were much less affected than newcomers. For example, Lowe, in 1953, recorded that he had virtually no altitude symptoms at 19,000 ft., whereas the previous year (his second visit to the Himalayas) he had suffered severely with headaches, anorexia, and lassitude on his first day at this altitude. Shipton, the leader of the 1951 and 1952 expeditions, seemed to be quite unaffected by altitudes below 20,000 ft.

On the Cho Oyu expedition, however, one of us (G. P.), on joining the main party at 17,000 ft. a few days after their arrival there, was struck by their blue appearance, the absence of the customary gaiety and conversation at meals, and reduction of casual activity in camp. The Sherpas appeared to suffer no ill effects; nor did they show any sign of fatigue after carrying 60-lb. loads all day. At this phase of the Cho Oyu expedition respiratory troubles and diarrhoea began to reduce the efficiency of the party; at one time half the climbers were sick. The impression gained during the next four weeks on Cho Oyu was that the physical performance of the Europeans continued to be inferior to that of the Sherpas. (The climbers themselves were, however, unwilling to admit this afterwards.) Appetites remained poor, and there was an average weight-loss of 11 lb. in twenty-six days. Some of the climbers developed cravings for foods such as tinned salmon and pineapple cubes, which were unavailable, and preferred to go without rather than eat food that was distasteful to them. Their appetite for sweet foods, on the other hand, increased; the consumption of sugar rose to 12 oz. per man per day, compared with 6 oz. on the approach march. They also drank a good deal, the average fluid intake being 3–4 litres a day. Later in the expedition, after a rest at lower altitude, the physical performance of the party improved, appetite returned, and tolerance of the bulky native diet increased.

On Mt. Everest the following year the general health of the party was much better. Respiratory troubles and diarrhoea developed during the acclimatisation phase, but there was practically no sickness on the mountain itself. Although there were initial lassitude and depression of appetite at the Base Camp at 18,000 ft., these symptoms passed off

within a fortnight, and thereafter the party felt well and energetic. Film sequences taken on the ice-fall of the Khumbu glacier showed men cutting steps with precision and climbing with apparently normal rhythm and balance. Subjectively, however, climbing required more effort at that height than lower down, and endurance was reduced.

On all these expeditions one was conscious of increased breathing at rest and during work all the time above 18,000 ft. Cheyne-Stokes breathing could be observed in men at rest and asleep. The sequences often consisted of about six respirations followed by a pause of 10 seconds.

During exercise very high ventilation-rates were maintained. Measurements on men climbing at their normal pace at 20,000 ft. in 1952 yielded values of 74–123 litres a minute (at 37° C. observed pressure, saturated). Respirations were 40–50 a minute during sustained climbing and up to 60 a minute during maximal effort. In association with the continual increased rate of breathing some men developed a bruised aching feeling round the lower margin of the ribs, resembling the pain of chronic muscle fatigue.

After about a fortnight at 18,000 ft. the initial disinclination for mental effort passed off, and one could do complicated mental work accurately, although more slowly and with greater effort than at sea level. One also needed more sleep at these altitudes: most people slept ten to twelve hours a night, except at first, when sleep was interfered with by restlessness and by paroxysms of breathlessness.

From 20,500 ft. to 22,000 ft. (Western Cwm)

In the Western Cwm on Mt. Everest individual differences in tolerance of altitude began to be obvious. Climbers also noticed wide variation in their performance and well-being from day to day and even within a day. Going for too long without food caused unusual fatigue, which could be relieved immediately by taking sugar. The same thing happens in the Alps, but the beneficial effect of sugar seemed much more striking at these altitudes than there. Mental activity was not seriously impaired. Westmacott claimed to have solved two-thirds of *The Times* crossword puzzle in one afternoon. Gas analysis was done by one of us (G. P.) for six hours a day. Subsequent checking revealed few mistakes in the calculations. One had to be careful, however, to write down observations and figures immediately because of forgetfulness. Supplementary oxygen at 18,000–20,000 ft. had relatively little effect in acclimatised men at rest and caused only a minor reduction in breathing, but during climbing there was a 20–50 per cent. reduction in ventilation though little increase in speed: endurance, however, was much improved, and one had a feeling of increased energy and strength.

The average daily intake of food was about 3,900 calories, compared with 3,000 calories or less the previous year. European-type 'compo' rations were used, supplemented with fresh meat, eggs, and potatoes. Pressure-cookers and special stoves made it possible to prepare appetising meals at heights where cooking is otherwise too slow and expensive of fuel to be practicable, owing to the low boiling-point of water (80° C. at 20,000 ft.). In four weeks spent in the Western Cwm and above, the average weight-loss was only 4 lb.

Previous parties on Everest became severely emaciated at these altitudes.

From 22,500 ft. to 26,000 ft. (Lhotse Face)

In this range of altitude the struggle against weakness, fatigue, and shortness of breath was severe, and the beneficial effect of oxygen became increasingly apparent. Individual variation in tolerance of altitude was even more obvious than it had been on the ice-fall and in the Western Cwm. Lowe, who with a Sherpa, Ang Nyima, worked for nine days on the route between 22,000 ft. and 25,000 ft., said that it was only at the end of this time that he was beginning to deteriorate. The two newcomers, on the other hand, became exhausted and had to be sent down to Base Camp (18,000 ft.) to rest.

There was considerable impairment of the mental faculties at these heights. This was brought home to the climbers by the fact that oxygen increased the awareness and enjoyment of their surroundings. On seeing film sequences the climbers were impressed with the slow feeble strokes of the ice-axe, of which they had been unaware at the time. Routine jobs were done successfully, but tasks that required thought and initiative were done with difficulty. Ward, for example, successfully took samples of alveolar air at Camp 7 (24,000 ft.). This was a somewhat complicated procedure, but one which he had often practised. On trying to mend a primus stove he had great difficulty in finding and correcting a simple fault.

26,000 ft. (South Col)

The account which follows is based on notes taken down by us at Camp 4 and at Base Camp immediately after the assault. The Swiss Foundation for Alpine Research had warned us of the discrepancies which might occur between accounts written down on the spot and stories subsequently told by climbers after their return home.

The effects noted on the South Col were those of mental and physical depression, with retardation of thought and action, impairment of insight, and impoverishment of effort. As an example of retardation, Bourdillon described taking $1\frac{1}{2}$ hours to go through the procedure for detecting faults in the closed-circuit oxygen apparatus,

which 5,000 ft. lower down took him only 20 minutes. There was an immense increase in the effort required to initiate thought or action ; but once an activity had been embarked on it could be carried through to the end. A course of action planned ahead, such as arrangements for supporting the assault parties, was carried out meticulously, but the capacity for adaptive behaviour seems to have been much impaired. This was in evidence even at Camp 7 (24,000 ft.) :

On returning there the day after his climb to 28,700 ft. Bourdillon collapsed and lay exhausted outside his tent. The sight of him lying there provoked nothing more than the comment ' Poor old Tom, he's had it '. Lower down an attempt would undoubtedly have been made to help him. It is also probable that Bourdillon, in view of his profoundly exhausted condition, would have been given oxygen for sleeping during the night (May 26) after his climb to South Summit (28,700 ft.), if this contingency had been envisaged and the appropriate plan made beforehand.

Impairment of insight and judgment is illustrated in Hillary's account of Hunt's condition on the morning of May 27 :

Hunt had been three days on the Col by this time and was, in their view, clearly incapable of remaining there longer. He himself, however, was determined to stay on to direct the assault parties, and it was not without some argument that he was persuaded to go down by Lowe, who, having just come up from Camp 7 (24,000 ft.), was relatively fresh and unaffected by the altitude. Lowe and Hillary both described Hunt's condition as resembling drunkenness, yet, in spite of his reeling, unsteady gait when roping up with Evans, Bourdillon, and Ang Nyima for the descent to Camp 7, he regarded himself as fit to lead the party down in safety. Although, in his own account of the situation (Hunt 1953), Hunt has described great weakness and fatigue, there seems little doubt that he was not fully aware of the severity of his condition.

On the South Col, as at lower altitudes, blunting of thought was brought out by the contrast on using oxygen ; the climbers again described how, when breathing oxygen, they took an active interest in their surroundings and enjoyed their climbing.

Only one of four Sherpas (excluding Tenzing) was fit enough to carry on above the South Col. The others were too weak to start or were prostrated with vomiting. One reason for this was that they did not have oxygen at night. Of the Europeans, Bourdillon seemed to fare the worst. During the night of his return from the ascent with Evans to the South Summit (28,700 ft.) he thought he was going to die. Next morning he kept falling down on the short ascent to the top of the Col and complained of weakness and tingling of his legs. With oxygen he was able to continue and got down safely to Camp 7.

With the exception of Noyce, who slept well without it, the Europeans used oxygen for five to six hours each night for sleeping. Oxygen

brought an immediate feeling of warmth, sound sleep, and greatly improved recovery from fatigue. During climbing, in addition to the increase of energy and the relief of breathing, which had been noted at lower altitudes, oxygen greatly improved the rate of climb. Evans and Bourdillon on closed-circuit oxygen, climbed from 26,000 ft. to 27,500 ft. at the rate of 930 ft. an hour, making their own track and carrying loads of 43 lb. This was judged to be an Alpine standard of performance in view of the conditions, and contradicts the statement that oxygen has relatively little effect on performance in acclimatised men. Hillary and Tenzing on the second assault used open-circuit oxygen at 4 litres a minute over the same route and climbed at 620 ft. an hour in a track prepared for them by their support party. Thus the effect of open-circuit oxygen on the rate of climb was less than that of closed-circuit oxygen, in which oxygen is breathed at sea-level pressure.

No ill effects were experienced on turning off the oxygen, so long as the climber rested a few minutes to recover his breath before taking off his set. Sudden failure of the oxygen-supply during climbing caused acute dyspnoea, weakness, dizziness, and, in two cases, incontinence of urine : it had been previously thought by some that sudden failure of the apparatus might cause unconsciousness. Slow failure was apt to pass unnoticed : the climber would be brought to a halt by increasing fatigue and breathlessness, without realising that his set was at fault.

27,900 ft. and above

The final camp on Mt. Everest was placed at about 27,900 ft. Hillary and Tenzing spent from 2 p.m. to 5 p.m. levelling a platform and pitching the tent. They worked steadily without extra oxygen, pausing every few minutes to rest. They used oxygen for about four hours during the night, and next day (May 29) reached the summit on 3 litres of oxygen a minute. On the summit Hillary took off his oxygen set and spent ten minutes taking photographs. He remembered to increase the shutter speed of a camera in case of freezing. He walked about on the level without difficulty. After about eight minutes he began to feel weak and fuddled ; so he put himself on oxygen again.¹ On the descent the oxygen supply ran out just as they reached the South Col. They noticed little difference, except that walking uphill was harder. Lowe has recorded, however, that they were walking very stiffly when they got back to the Col, although their condition was much better than that of any other returning party.

The condition of the men returning from very high altitude was surprisingly good. There was no evidence of cardiac dilatation as

¹ Von Gunten and Reist used no oxygen for one hour on the summit of Everest in 1955.

reported by Hingston on the 1924 expedition ; nor was there evidence of dehydration.

Hillary, though very tired, was not exhausted. He ate 2 omelettes (4 eggs) and a third of a tin of salmon (8 oz.) shortly after arrival at Camp 4 (21,200 ft.) and two hours later had a further meal, consisting of potatoes, corned beef, and biscuits. He would hardly have done this had he been in a state of exhaustion.

DISCUSSION

Lack of Oxygen

The effects of altitude experienced on Himalayan expeditions are those of chronic rather than acute lack of oxygen. Although few people escape acute symptoms altogether, the fully developed picture of acute mountain sickness, characterised by headache, irritability, nausea, vomiting, cyanosis, fever, tachycardia, and dyspnoea and lasting one to three days, is rarely if ever observed. The principal effects experienced by Himalayan parties over 18,000 ft. are lassitude, retardation, impairment of appetite, increased rate of breathing, Cheyne-Stokes breathing, and, during exercise, heaviness and weakness of the limbs, breathlessness, and reduced endurance. Usually no symptoms are experienced up to 12,000 ft. This is mainly due to the slow ascent because, although persons in good health can ascend from sea level to about 10,000 ft. in a day and stay there without discomfort, about one person in two has symptoms at 12,000 ft. if he stays there more than twelve hours.

Between 15,000 ft. and 18,000 ft. acute symptoms are particularly liable to develop in parties ascending for the first time from 12,000 ft. This is explained by the fact that the oxygen-pressure is by this stage considerably reduced (being half sea-level value at 19,000 ft.) and by the fact that at this altitude parties move up their camps 2,000–3,000 ft. a day and thus expose themselves rather rapidly to fairly large falls in barometric pressure. The acute symptoms, however, pass off in a few days, and climbers then feel reasonably fit. Complete acclimatisation to 18,000 ft., if it ever takes place, must take a long time. Even after a month at 18,000 ft. the party on Everest in 1953 were impressed with the striking increase in well-being and energy on going down to rest at 16,500 ft. Stobart, who returned to the district the following year in search of the 'abominable snowman', informed us that his party continued to improve over several months spent at 16,000–18,000 ft. This confirms the experience of the International Physiological Expedition of 1935, who observed that, even after six weeks at 17,000 ft., their acclimatisation was poor compared with that of the local inhabitants.

Since altitude symptoms take several hours to develop, relatively unacclimatised persons may be able to climb from 12,000 ft. to 18,000 ft.

with impunity, provided they return to a lower altitude to sleep. On the other hand, if they attempt to remain continuously at 18,000 ft. at an early stage, they suffer severely from the effects of altitude and deteriorate considerably before they eventually become acclimatised. The importance of not sleeping too high before acclimatisation is recognised by mountaineers in the Andes but has not been sufficiently appreciated by Himalayan climbers.

From 18,000 ft. up to 22,000 ft. the more acute symptoms of oxygen lack may not be much in evidence. This is explained by the fact that parties have usually spent some time at intermediate altitudes before establishing camps in this zone. The reduction in capacity for work prevents them from placing their camps more than 1,500–2,000 ft. apart. Moreover the curve relating barometric pressure to altitude is beginning to flatten off; consequently the change of pressure with altitude is less than in the 12,000–18,000 ft. zone.

Above 22,000 ft., when climbers are beginning to reach their limit, acute symptoms again make their appearance. At 26,000 ft. climbers may feel so ill that they think they are going to die. Contributory factors are exhaustion from excessive physical work, dehydration, and lack of food.

Although the effects of altitude on the South Col in 1953 were undoubtedly severe, the condition of most of the party appears to have been a good deal better than that of previous parties at comparable altitudes. This is attributable to adequate food and fluid and the use of oxygen equipment. The beneficial effects of oxygen in relieving fatigue and preventing deterioration were considered by the climbers to be at least as important as its effect on climbing. Climbers now consider that, for peaks up to 28,000 ft. in height, they can get on without oxygen for climbing, so long as they have it for sleeping.

Other Modifying Factors

The intense heat and glare on Himalayan glaciers between 18,000 and 22,000 ft. on calm fine days is considered by some to be almost as important a cause of headache and lassitude as is lack of oxygen. Measurements of skin-temperature on the 1953 expedition confirm the intense heating effect of the sun's radiation. Skin-temperatures of 114° F. were recorded under clothing on the shoulders exposed to the direct sunlight compared with normal values of 94° F. on the chest, which was in the shade. Without the sun, however, the cold is intense, and protective equipment is necessary. The effect of sugar in relieving fatigue and the increased appetite for sugar at great heights are of interest in view of the fact that experiments on animals have shown that mild hypoglycaemia sensitises the cerebral cortex to the adverse effects of lack of oxygen.

Individual Variation

Every Himalayan expedition has been impressed by the variation shown by different people in their tolerance of altitude and in the rate and degree of acclimatisation. They have also noted that the ability to acclimatise improves with each visit to the Himalayas, with the result that the old hand is usually much less affected than the newcomer by altitude. In spite of this, acclimatisation does not persist long after the climber's return to sea level ; indeed climbers have had mountain sickness while climbing in the Alps within one or two months of returning from the Himalayas.

Age

The factor of age seems to be far less important in connection with acclimatisation than the factor of previous experience. Shipton, one of the most experienced of Himalayan climbers, seemed to be quite unaffected on Cho Oyu by altitudes up to 20,000 ft., although he was aged 45. Young men in their early twenties often suffer considerable distress at 20,000 ft., particularly if it is their first visit to such an altitude. On the Swiss expedition in 1952 the youngest Sherpa to reach the South Col was 17 and the oldest 47. It seems as if, in their case, there was no correlation between age and performance at altitude. The early thirties seem to be the best age for very high altitude ; older men also do well but are probably at a disadvantage beyond a certain altitude.

Physical Training

Climbers emphasise that, to acclimatise properly, one must ' keep going ', yet they do not generally undertake any special training to ensure that they are in good physical condition before an expedition starts. Since the war few British climbers have had the opportunity of building up the stamina for which Alpine guides are noted. It is perhaps for these reasons that we do not find British climbers doing eighteen-hour days at altitudes of over 18,000 ft., as is reported of certain professional Continental climbers.

The experience of Buhl, an Austrian professional guide, is a case in point ; he spent nearly forty hours climbing from a camp at 22,600 ft. to the top of Nanga Parbat, 26,658 ft., and back in 1953. During his ascent he spent a night on a ledge just under the summit, with no protection. Though slightly frostbitten he is still doing hard climbs in the Alps.

Limit of Altitude for Complete Acclimatisation

The greatest altitude at which men are known to live permanently appears to be about 17,500 ft. A mining settlement at this altitude,

situated on Auconquílcha in the Andes, was visited by the International Physiological Expedition of 1935. Attempts on the part of the mining authority to induce the miners to live at a higher altitude failed : after a few weeks they refused to continue to occupy a camp prepared for them near their work at 19,000 ft. because of insomnia, loss of appetite, and inability to enjoy their food. On this basis physiologists incline to the view that 18,000 ft. represents the limit at which full acclimatisation is possible.

The only people to visit places higher than 20,000 ft. are mountaineers. Many mountaineering expeditions have spent up to four weeks at 20,000 ft. without ill effects apart from loss of weight, although lassitude and impairment of capacity for work are always present at these altitudes. Bauer's expedition to Kangchenjunga in 1931 remained six weeks at 20,000 ft. and higher, and reported feeling well at the end of it in spite of great loss of body-weight.

The time spent above 20,000 ft. decreases rapidly with each further increase of altitude (see table) and is determined by mountaineering requirements, weather, and questions of supply and maintenance as much as by physiological limitation.

LONGEST TIME SPENT AT VARIOUS ALTITUDES ABOVE 22,000 FT. ON EXPEDITIONS TO MOUNT EVEREST

Altitude (ft.)	Time	Climber	Year
23,000	11 days	Odell	1924
22,000-24,600	11 days	Lowe	1953
25,700	5 nights	Birnie	1933
27,400	3 nights	Smythe	1933

Members of pre-war Everest expeditions claimed that some degree of acclimatisation was possible between 20,000 ft. and 23,000 ft. Somervell described how, on the 1922 expedition, he and his companion made three ascents from 22,000 ft. to 23,000 ft. at intervals of about three days and found the ascent easier on each occasion :

The first time ' each step was a hardship, every foot a fight, until at last we lay almost exhausted on the top (North Col 23,000 ft.). After a day or two below at Camp 3 (21,000 ft.) we went up again. The ascent this time was hard work but not more than that, and after the col had been reached Morshead and I were sufficiently cheerful to explore the way leading up to Everest. A day or two later we again ascended, and never really noticed more discomfort than was occasioned by breathlessness.'

On the 1924 expedition Odell, who seemed at first to acclimatise slowly, eventually became one of the fittest men at altitude. He spent

eleven days at 23,000 ft. and climbed up to 25,000 ft. on three occasions. He reported climbing above 23,000 ft. more easily at the end of this period than at the beginning.

Deterioration at Altitude

By 1933 the view was generally accepted that partial acclimatisation was possible up to 23,000 ft. but was accompanied by physical deterioration shown by rapid loss of weight and by eventual intolerance of altitude with failing appetite, insomnia, increasing lassitude and weakness, and inability to recover from fatigue. It was recognised that little if any acclimatisation was possible above 23,000 ft., and deterioration was more rapid and severe the greater the altitude reached. Men staying above 25,000 ft. returned very emaciated and exhausted and took days or weeks to recover.

No Himalayan expedition has remained longer than five to six weeks at 20,000 ft., and it is not known for certain how long men could remain at that altitude. Conversations with members of the 1953 Everest expedition showed a general agreement that five or six weeks must be near the limit consistent with reasonable health and vigour. The length of time a man can stay at any given altitude varies greatly with the individual.

In the past, dehydration and lack of suitable food have accelerated deterioration, especially at the higher altitudes, but even on the 1953 expedition, when nutrition was properly cared for, deterioration still took place. Although a man may feel well for a time and may even seem to improve over the first few days, eventually his appetite begins to fail, he has difficulty in sleeping at night, and he feels increasingly lethargic by day. Eventually he can no longer work and has to go down.

Hunt, on returning from three days on the South Col, was so exhausted that for two days afterwards he had the voice and appearance of an aged man. Hillary stated that he took far more out of himself as a result of his ascent to the summit than he had done on any of his previous Himalayan expeditions, and it was only by the end of the return march to Katmandu that he felt himself getting back to normal.

Some Other Effects of Altitude

Examples of apparent impairment of judgment are not hard to find in Himalayan literature :

On the 1924 Everest expedition Odell, who was by far the best acclimatised and one of the most experienced mountaineers, was left behind, while Mallory made the second assault with Irvine, who was not even a trained mountaineer.

On the Italian expedition to K2 in 1954 the assault party ran out of oxygen some way below the summit and struggled on to the top still wearing their empty oxygen sets—it did not occur to them to remove them (Compagnoni and Lacedelli 1955).

Several instances of gross disturbance of cerebral function have occurred on Mt. Everest. On the 1933 expedition one of the party at a certain stage had the delusion that the medical officer intended to kill him. Smythe, while climbing alone at 28,000 ft., saw 'dark objects in the sky like kite balloons' and was convinced that he had a companion with him. Shipton had aphasia at 23,000 ft. after returning from his attempt to reach the summit with Smythe :

'It took us a very long time to get down from the North Col the next day. Immediately after we had started McLean became ill. He could hardly walk and had to be nursed carefully down the slopes. When we reached the bottom we found that a party had been sent up from Camp 3 to meet us with tea. When we had assembled to drink this, I suddenly found that I was suffering from aphasia and could not articulate words properly. For example, if I wished to say "Give me a cup of tea", I would say something entirely different—maybe tram-car, cat, feet. . . . I was perfectly clear-headed ; I could even visualise the words I wanted to say but my tongue just refused to perform the required movements. . . . I think it was a form of migraine, a theory that is supported by the blinding headaches from which I suffered throughout that night. However, I was well again in the morning.'

After-Effects

Sufficient time has now elapsed to follow members of the early Everest expeditions in their subsequent careers, and it seems doubtful if any of the eight climbers who have climbed to 28,000 ft. without oxygen suffered any permanent ill effects of the kind described in persons who have suddenly been exposed to atmosphere at 25,000 ft. or above in aircraft.

All these men have had careers of distinction and have reached posts that could hardly be attained by men with any significant degree of mental deterioration. Norton became a general ; Somervell was a successful surgeon ; Odell and Wager held professorial chairs ; Shipton and Smythe, the latter now deceased, continued their careers as writers and explorers ; Wyn Harris became a colonial governor ; and Longland became a director of education.

One case of after-effects in a climber who spent five nights at 25,000 ft. has been noted. This climber was an A.D.C. at Government House in Calcutta, and as part of his duties he had to introduce guests to one another at social functions. Before going to Everest he could remember and instantly recall the names of some one hundred guests ; after returning he found his ability to do this was impaired, and he had to use a list.

Technique of Acclimatisation

Knowledge of the physiological changes taking place in the body during acclimatisation has so far contributed to the mountaineer little information of value about the best methods of arranging the stages of his ascent so as to acquire the best possible acclimatisation in the shortest possible time. A large body of empirical information, however, exists on this subject. It has been built up over many Himalayan expeditions and was collated and analysed during preparation for the Everest expedition.

The pre-war Everest expeditions approached the mountain by six weeks' march across the Tibetan plateau at 13,000 ft. with passes at 15,500 and 18,000 ft. In spite of this preliminary period of acclimatisation, in the 1933 and subsequent expeditions it was found advisable to spend several days at intermediate camps on the mountain between Base Camp at 16,500 ft. and the North Col at 23,000 ft. to maintain their fitness and to avoid the acute altitude symptoms, such as headaches and vomiting, from which the earlier expeditions had suffered. Ruttledge, the leader of the 1933 expedition, held the view that climbers would stand a better chance of climbing Everest if they spent the whole winter in Tibet at 13,000 ft. or higher.

Other mountaineers were led by the successful ascent of Mt. Kamet (1931) to doubt the value of prolonged acclimatisation. (Kamet (25,443 ft.) was climbed within a fortnight of establishing the Base Camp at 15,500 ft. after three weeks' approach march at altitudes mostly below 10,000 ft.) Moreover, Sherpas, who live permanently at 12,000–13,000 ft., are by no means immune from altitude symptoms on ascending to 19,000 ft. and have not proved superior to Europeans at altitudes over 25,000 ft.

Post-war British expeditions approaching the Himalayas through Nepal have, on the whole, dispensed with preliminary acclimatisation and gone straight up to 18,000 ft. or higher within a few days of reaching their main base at 13,000 ft. and have not come down again until after the assault. The experience gained on the Cho Oyu expedition was that such a policy reduces the chances of success in climbing peaks higher than 25,000 ft. because of its effect on the cohesion and efficiency of a climbing party. The less tolerant climbers, particularly newcomers, suffer fairly severely from altitude symptoms, and infections take their toll at a critical stage when every man is needed. The strain of climbing is greater, and altitude deterioration sets in at lower altitudes and is more severe, than in parties who have had more time in which to acclimatise. Finally, the effects of oxygen lack on the mind—the impairment of will and judgment and the lack of insight—are likely to be more dangerous in poorly acclimatised parties.

The plan adopted with success on the 1953 Everest expedition was

to set aside a month for preliminary acclimatisation after the approach march, and to make several short visits to 18,000 ft., returning in the intervals to 13,000 ft. to rest. When the party finally went up to Western Cwm they were much fitter than the party on Cho Oyu and had lost on an average only 2 lb. in weight compared with 11 lb. over the same period the year before. They had also got over the stage of infections and remained free from illness on the mountain (apart from altitude symptoms).

As already mentioned a party led by Stobart spent six months in the Everest region in search of the 'abominable snowman'. Stobart reported that their acclimatisation at 16,000-18,000 ft. went on improving all the time they were there.

Mountaineering parties, however, seldom have more than three or four months at their disposal, and partial acclimatisation is as much as they can hope to achieve.