promised the title of Count, and not obtaining it, asked leave in 1518 to emigrate. The King put him off for some months in the hope that he would change his mind, and in the mean time matters were arranged. D. Manoel was loth to lose a subject who had rendered signal service to the country and brought him great wealth; the Duke of Braganza agreed to cede his towns of Vidigueira and Ville de Frades in exchange for one of da Gama's pensions and a cash payment, and on 29 December 1519 the Navigator realized his ambition to become a peer.

In 1524 King John III. sent him to India as Viceroy to reform the abuses that already afflicted the State from the Governor downwards, and Gaspar Correa has described for us his pomp, incorruptibility, and severity. Knowing the value of splendour, he took out servants, plate, and tapestries worthy of a king, and had a guard of two hundred men in his livery. On landing at Goa he astonished every one by accepting no gift from either Christian or Moor. He removed corrupt officials, and threatened his predecessor, who was one of them, with death if he disobeyed. But in three months the terrible Viceroy had passed away; a carbuncle on his neck, added to the heat of his temper, and untiring work extending to small details, with worry over the succession, killed him in his sixty-fourth year.

Those who would know more and do not understand Portuguese should read 'Vasco da Gama and His Successors,' by K. G. Jayne (London, 1910). Students have the *Roteiro* (in Ravenstein) for the first voyage, Thomé Lopes (in Ramusio) for the second, and Correa for the third.

The portrait here reproduced is considered the most authentic; the original was given by a descendant of da Gama to the late King Carlos, and he presented it to the Lisbon Geographical Society, to which it now belongs.

EDGAR PRESTAGE.

PHYSIOLOGICAL DIFFICULTIES IN THE ASCENT OF MOUNT EVEREST

Major R. W. G. Hingston, I.M.S., Medical Officer to the Expedition of 1924

Read at the Afternoon Meeting of the Society, 10 *November* 1924.

THE primary object of the Mount Everest Expedition was to reach the highest summit on the Earth. Everything else was subordinate to this. Elaborate scientific investigations were impossible, and anything involving complicated apparatus was altogether out of the question. We had to content ourselves with simple experiments and with the records of the experiences of individual climbers. These, nevertheless, may be worth discussion. They will give us some idea of the physiological difficulties involved in an ascent to so great a height.

Alterations in Breathing.—The most obvious of these is the difficulty in breathing. Owing to the gradual nature of our ascent this shortness of respiration was scarcely noticeable below 10,000 feet. It was definitely apparent above 14,000 feet, and above 19,000 feet the slightest exertion made breathing laboured and severe. When the body was at rest, even at extreme altitudes, the rate of breathing was apparently normal and as comfortable as at sea-level. But the very slightest exertion, such as the tying of a bootlace, the opening of a ration-box, the getting into a sleeping-bag, was associated with marked respiratory distress. The difficulties of the ascent were thus enormously increased. The breathing was quicker rather than deeper, but it was necessary to stop at frequent intervals and take a series of long deep breaths. This very quickly brought relief and made one ready for a further advance. Norton told me that, when he found himself dropping behind, his only chance of catching up the party was by taking a number of these deep long breaths. Somervell gives a record of his breathing at 27,000 feet. At that altitude he had to take seven, eight, or ten complete respirations for every single step forward. And even at that slow rate of progress he had to rest for a minute or two every 20 or 30 yards. At 28,000 feet Norton, in an hour's climb, ascended only about 80 feet. This was the highest point reached without the aid of oxygen. The strain at that altitude was certainly intense, but when we remember that the supply of oxygen is only about one-third of that available at sea-level, we are surprised that men can make these strenuous efforts, and still more that they can remain in comparative comfort when they sit down to rest.

The alteration in the rhythm of the breathing—commonly known as Cheyne-Stokes respiration—was frequently noticed during the expedition. I heard one member of the party breathing in this way as low as 12,000 feet. Though as a rule it seldom occurs when awake, yet at the base camp I was conscious of this type of breathing before passing off to sleep. Illness at high altitudes markedly increases it. It was most pronounced in one member when suffering from fever at 15,000 feet, and still more so in a Gurkha when dying of cerebral hæmorrhage at 18,000 feet. The rapid breathing of cold dry air produces some important secondary effects. It causes inflammation of the respiratory passages. Every member suffered from sore throat, from hoarseness, or from loss of voice. Most had irritating coughs, but with little expectoration. Some of the porters developed severe bronchitis: one had a profusely ulcerated throat, another persistently coughed up blood. Dr. Kellas was of opinion that the breathing was less laboured in a high wind. He thought that the wind might have the effect of packing the air into the lungs; also that it swept away the exhaled air and thus prevented it from being inhaled by the next breath. Our experiences did not agree with his.

Mount Everest is noted for its heavy winds. They caused considerable obstruction to the breathing. A moderate breeze had a freshening effect, but a strong wind impeded progress, and there was a feeling of suffocation when facing powerful gusts.

I made some experiments on the respiration. The power of holding the breath is a simple test to which pilots are submitted in the Royal Air Force. The following table shows the diminution in this power at successive altitudes in the ascent. The first column is the most complete. Where at sea-level the breath was held for 64 seconds, at 21,000 feet it was held for only 14 seconds.

Altitude in feet.	*Time breath held (in secs.).*									
	R.W.H.	E.O.S.	B.B.	G.B.	E.F.N.	G.L.M.	J.V.H.	A.C.I.	T.H.S.	N.E.O.
Sea-level ...	64	—	120	—	—	—	90	120	—	—
7000	40	40	60	40	40	50	42	80	60	55
14,300	39	32	35	32	37	40	—	47	48	—
16,500	20	23	35	20	31	—	23	30	41	28
21,000	14	17	—	20	—	—	17	—	—	—

Another test used amongst airmen is the measurement of the expiratory force. This consists in blowing a column of mercury up a graduated glass tube. The height reached by the mercury is read off, and this gives a measure of the expiratory force. If the expiratory force is much below the average it suggests that the airman will be incapable of sustained effort. The following table gives the results of our experiments. It suggests that with increasing altitude the expiratory force tends to improve. Look again at the first column. At sea-level the expiratory force was 110 mm. Hg; at 21,000 feet it was 150 mm. Hg. The third, fourth, fifth, sixth, seventh and eighth columns also show that an improvement has occurred.

Altitude in feet.	*Expiratory force in mm. of Hg.*									
	R.W.H.	E.O.S.	B.B.	G.B.	E.F.N.	G.L.M.	J.V.H.	A.C.I.	T.H.S.	N.E.O.
Sea-level ...	110	—	—	—	—	—	—	—	—	—
7000	110	120	140	160	110	110	130	160	120	110
14,300	110	90	160	190	120	120	—	160	120	—
16,500	140	130	210	200	170	—	120	170	120	100
21,000	150	120	—	210	—	—	150	—	—	—

I did not anticipate this improvement in the expiratory force. But the test has little to do with the function of respiration. It is more an indication of physical fitness and muscular strength. And this tends to improve during an ascent, when the progress is slow enough to be accompanied with acclimatization and before the wasting of high altitudes becomes marked. The march across Tibet made us tougher and harder. Hence the expiratory force improved. Mosso came to a similar conclusion in the Alps. He made his men perform exercises with dumb-bells, and was surprised to find that they did much more work at a height of 4560 metres than when they performed the same exercises at Turin.

Circulation.—I pass to the changes in the circulation. Blueness of the face and lips, lividity of the nails, coldness of the extremities, were the indications noticed of the impaired circulation at altitudes above 19,000 feet. Three of the members experienced giddiness. One noticed that it was immediately relieved by taking a deep breath. Once the extremities become cold at these high altitudes there is a great difficulty in regaining warmth even in the interior of a sleeping-bag. The pulse is not markedly accelerated while at rest, but increases rapidly on the slightest exertion. Norton's normal pulse is 40, and it was only 60 when he was resting at 27,600 feet. An intermittent pulse may develop at high altitudes. In one instance, after crossing a pass of only 14,000 feet the pulse missed four beats every minute without causing any particular symptoms or distress. This irregularity of the pulse seems to be a common feature. Mosso states that, when on Monte Rosa, he noticed that nearly all the members of his party showed some signs of irregularity of the heart. Hæmorrhages at high altitudes have often been described, from the gums, the lips, the conjunctivæ, the nose. Nothing of the kind occurred amongst the members of our expedition.

The following table shows the changes in the pulse of one individual at successive altitudes above sea-level. The first column gives the pulse-rate when the person is at rest. There is no change except at the highest altitude, 21,000 feet. The second column shows the change that occurs when the person is made to stand up. There is an increase in the pulse-rate somewhat in proportion to the altitude of the experiment. Column 3 shows the change after regulated exercise. The exercise consisted in standing alternately on a chair and on the ground five times in 15 seconds. Again there is a marked increase in the pulse-rate, and this increase is greater the greater the altitude. The last column gives the time in seconds that the pulse takes to return to normal.

Pulse rate of one individual.

Altitude in feet.	*Pulse rate per minute sitting.*	*Pulse rate per minute standing.*	*Pulse rate per minute after regulated exercise.*	*Time in secs. of return of pulse to normal.*
Sea-level	72	72	84	20
7000	72	84	96	15
14,300	72	84	108	40
16,500	72	96	120	20
21,000	108	120	144	20

The blood pressure was taken with a sphygmomanometer in the manner adopted by the Royal Air Force. The following is a table of results. There seems to be no change in the blood pressure definitely associated with increase in height.

Blood pressure at successive altitudes.

Altitude in feet.	R.W.H.		E.O S.		B.B.		G.B.		E.F.N.		J.V.H.		G.L.M.		A.C.I.		T.H.S.		N.E.O.	
	Sys.	Dias.	Sys.	Dias.	Sys.	Dias.	Sys.	Dias.	Sys.	Dias.	Sys.	Dias.	Sys.	Dias.	Sys.	Dias.	Sys.	Dias.	Sys.	Dias.
Sea-level...	120	80	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
7000 ...	130	90	125	90	150	110	130	90	140	80	120	100	120	85	130	100	110	85	100	80
14,300 ...	135	95	115	80	145	85	130	90	135	90	—	—	120	90	130	100	130	90	—	—
16,500 ...	146	104	128	90	140	102	128	93	136	96	126	94	122	78	140	110	120	82	125	95
21,000 ...	138	118	100	80	—	—	110	90	—	—	100	80	—	—	—	—	—	—	—	—

A well-known change that takes place during an ascent to high altitudes is the increase in the number of red corpuscles per unit volume of blood. The conditions on Everest were too rough for these delicate determinations But further west, on the Pamir plateau, I had previously made a series of blood counts up to 18,203 feet. The following table shows the results :—

Date.	*Altitude.*	*Corpuscles per cu. mm.*
April 10	700 feet	4,480,000
May 12 ...	... 4,390 ,,	5,240,000
May 21 ...	... 8,000 ,,	6,040,000
May 28 ...	... 10,000 ,,	6,624,000
May 30 ...	... 11,960 ,,	6,760,000
June 1 ...	... 12,400 ,,	6,800,000
June 21 ...	... 13,300 ,,	7,525,000
June 23 ...	... 15,600 ,,	7,840,000
June 26 ...	... 16,900 ,,	7,640,000
July 27 ...	... 18,200 ,,	8,320,000

There has been an increase in the number of red corpuscles from 4,480,000 at 700 feet to 8,320,000 at 18,200 feet. Another point of interest is that the people who live on the Central Asian plateau have a higher blood count than those at sea-level. The average blood count of the Sarikoli is 7,596,000, of the Kirghiz 7,920,000. The blood count of the European is about 5,000,000, but, on making an ascent to the Tibetan plateau, the corpuscles in his blood rapidly increase until they reach the number normal to the people who live permanently at those heights.

Muscular Power.—Airmen describe great muscular weakness when flying at considerable altitudes. Even working a camera-shutter calls for enormous effort. We did not notice such pronounced effects, probably because our ascent was slow. But if inhalation is inadequate the legs soon become tired. It is not the tiredness of a prolonged walk, but more a heaviness and a lassitude which quickly disappears with a short rest.

The endurance test employed by the Royal Air Force is said to indicate the stability of the medullary centres and the capacity of the individual to resist fatigue. The test consists in blowing a column of mercury to a height of 40 mm. and noting how long the person is able to sustain it at that height. The pulse is counted in periods of five seconds during the performance of the test. The following table gives the result of this test. Every column shows a diminution in the powers of endurance at each successive height. Take, for example, the first column. At sea-level the subject could sustain the mercury for 45 seconds ; at 21,000 feet for only 15 seconds.

Endurance test.

Time in secs. Hg maintained at 40 mm.

Altitude in feet.	R.W.H.	E.O.S.	B.B.	G.B.	E.F.N.	G.L.M.	J.V.H.	A.C.I.	T.H.S.	N.E.O.
Sea-level ...	45	—	—	—	—	—	—	—	—	—
7000	35	30	60	50	20	60	35	45	50	50
14,300	30	30	25	40	25	35	—	45	25	—
16,500	23	23	23	15	23	—	17	25	22	20
21,000	15	15	—	15	—	—	10	—	—	—

The pulse-rate was taken during the above test. Some of the results are given below. The first figure in each series shows the normal rate of the pulse during the five seconds before the test begins. This figure is separated from the following figures by a stroke. These following figures give the pulse-rate during each successive period of five seconds throughout the performance of the test. Take, for example, the first line of figures in the first column—6/7.8.9.9.8.7. The 6 is the pulse-rate during the five seconds immediately before the test. The 7 is the pulse-rate during the first five seconds of the test. The remaining figures, 8.9.9.8.7, are the pulse-rates during the successive periods of five seconds until the test ends. In this way we obtain the character of the pulse while the person is undergoing continuous strain.

Pulse-rate in secs. during Endurance test.

Altitude in feet.	E.O.S.	B.B	G.B.	A.C.I.
7000 ...	6/7.8.9.9.8.7	6/6.7.9.9.9.7.6.6.6.5	5/6.6.8.6.5.4.5.5.5	8/9.11.10.8.7.6.6.6.6
14,300 ...	6/6.7.7.7.7.7	6/7.8.8.6.5	5/7.7.7.6.8.6.5.5	8/9.9.11.10.9.9.9.9.8
16,500 ...	6/7.7.8.7	6/9.9.9.3	6/7.8.9	8/11.10.9.7.6
21,000 ...	8/10.8.6	—	9/10.10.6	—

The chief points of interest in this experiment is the marked slowing of the pulse that takes place when the capacity of endurance is beginning to tell. At the commencement of the test the pulse first increases, but after a lapse of 15 to 20 seconds it begins definitely to slow up. This slowing of the pulse is more marked at the higher altitudes. There is an extreme case in the lowest line of figures of column two. The 6/9.9.9.3 indicates that on the commencement of the experiment the pulse immediately rushed up from 6 to 9 beats in the first 5 seconds, and after a lapse of 15 seconds suddenly fell back from 9 to 3. This occurred at 16,500 feet.

Nevertheless, in spite of these vagaries of the pulse, it is remarkable how well the strength is maintained at altitudes over 20,000 feet. This specially strikes us when we observe how animals can move so freely at such great heights. Ravens and crows used to come to our camp at 21,000 feet. We saw lammergeyers circling round the mountain at 23,000 feet, and choughs followed the climbers to their highest bivouac at 27,000 feet. They moved through the air with perfect ease, though it must have required much greater effort to sustain them than when flying in the denser atmosphere of the plains.

Special Senses.—Changes in the function of the special senses have occasionally been noticed by mountaineers. They describe an impairment of vision, a diminution in hearing, alterations in the taste and smell. Most of our party noticed nothing in this respect, but two members were particularly emphatic in their loss of the sense of taste. One said that "taste was distinctly affected," that "things seemed to have less taste, though there was no change in the character of the flavour." He was unable to taste onions at 19,000 feet. Another found food "distinctly tasteless." At 19,000 feet he could eat a slab of peppermint without strongly appreciating the flavour. Their sense of taste returned on descending to the base camp at 16,500 feet.

Pain.—The only kind of pain which we could attribute to high altitude was the occasional occurrence of a slight headache. Most of the members never experienced it, but some of us noticed it on first reaching the plateau, though, after a few days' acclimatization, it completely disappeared. It usually commenced at the back of the neck, spread into a general mild headache, and disappeared after an hour's rest. Exercise, and particularly stooping, increased it. Lying down quickly brought relief. Our porters also suffered from headache. Many of them asked for headache tablets the first time we passed over into Tibet. Even the inhabitants of the plateau are not immune. It is common to see patches of plaster on their temples and black pigment smeared on their cheeks. These are remedies which they use to alleviate the headache caused by the altitude and wind.

Gastro-intestinal Symptoms.—Loss of appetite is a serious consequence of residence at great heights. Probably it is the cause of much of the wasting that occurs. There is much individual variation in this respect. Some of the climbers maintained that there was no loss of appetite. I found some dislike for food even at the base camp, though this disappeared on acclimatization. Bruce thought that his appetite was unimpaired up to 21,000 feet. At 23,000 feet he found a disinclination for meat, though he still had an appetite for cereals and sweets. At 25,000 feet he lost all appetite for solid food, but could still take coffee and to a less degree soup. Somervell at 27,000 feet found an absolute distaste for solids, though he enjoyed liquids and sweets and fruit. The general opinion seemed to be that sweet things were the most palatable and meat the least palatable above 19,000 feet. There was no suggestion of nausea or vomiting even at the highest altitudes reached.

Diarrhœa is not uncommon. It is usually of a transient nature, and may be associated with much bile. Occasionally it may be more persistent, and refuse to yield to any treatment until a descent is made to moderate heights. Thirst is a far more important factor. It may be excessive at the end of a hard day, and, owing to the practical difficulties in obtaining water, may cause exhaustion of the climbers and failure of the climb. How best to relieve thirst at the high camps is a most important practical point. The craving for drink is not the result of perspiration, but of the loss of moisture in the respiratory passages from the excessive inhalation of cold dry air. This desiccation of the body at extreme altitudes may result in a great scantiness of urine. One of the climbers at 21,000 feet did not micturate for 16 to 18 hours ; another on his descent from 28,000 feet did not do so for 24 hours.

Mental Effects.—High altitudes affect the operations of the mind. One member was confident of a dulling of the will power, a diminution in the strength of purpose, with less and less desire to reach the summit the further he made the ascent. Somervell describes a lack of observance at and above 25,000 feet. Bruce records an enfeeblement of memory. He found an effort in recalling previous events. Above 23,000 feet his ideas became increasingly inaccurate. It was necessary for him to record them immediately, as otherwise they would become forgotten or distorted. I think every one experienced some mental lassitude. Though the mind was clear, yet there was a disinclination for effort. It was far more pleasant to sit about than to do a job of work that required thought. We did not notice any peevishness or petulance, though I suspect that high altitudes would cause unsociability in a party less perfectly harmonious than ours. Though mental work is a burden at high altitudes, yet with an effort it can be done. One physiologist has said that sustained mental work is out of the question at anything over 10,000 feet. We certainly could not agree with this. Those who have read Norton's despatches to the *Times*, especially one dictated at Camp III., when he was burdened with anxiety and partially blind, will admit that this effort from 21,000 feet was not a bad intellectual performance. The main effect of altitude is a mental laziness which determination can overcome.

I made some mental tests on the members of the party. These tests were very simple. The first was a multiplication test. It consisted in multiplying the figures 123456789 by 7. The second was a division test, and consisted in dividing the same series of figures by 9. A record was made at successive altitudes of the time taken to do these sums. Probably these tests were far too simple. By an effort of concentration they could be easily done, and thus the effect of altitude was not properly shown. I give the results for what they are worth. They show no definite deterioration of mental activity. It will not please the members of the next expedition to hear that more complicated and worrying tests are required.

Multiplication test, showing time in secs. for completion of sum.

Altitude in feet.	R.W.H.	B.B.	E.F.N.	G.L.M.	T.H.S.	E.O.S.	G.B.	J.V.H.	A.C.I.	N.E.O.
0	20	—	—	—	—	—	—	—	—	—
7000	25	25	27	13	40	43	40	35	25	80
14,300	25	24	19	15	28	43	25	—	28	—
16,500	18	23	28	17	40	35	35	55	35	30
21,000	17	—	—	—	—	35	27	40	—	—

Division test. Showing time in secs. for completion of sum.

Altitude in feet	R.W.H.	B.B.	E.F.N.	G.L.M.	T.H.S.	E.O.S.	G.B.	J.V.H.	A.C.I.	N.E.O.
0	30		—	—	—	—	—	—	—	—
7000	20	20	30	10	25	55	15	35	15	45
14,300	28	20	13	23	20	45	17	—	17	—
16,500	13	27	23	17	40	38	23	43	20	50
21,000	15	—	—	—	—	40	13	59	—	—

The knee-jerks were examined at successive altitudes. In no case did they seem in any way affected by the height. Three of the party developed mild tremors : one a tremor of the eyelids at 14,000 feet, two a fine tremor of the fingers at 21,000 feet. This was an indication of nervous strain. It was a common sign of exhaustion and anxiety amongst those serving in the great war.

Sleep.—To my mind insomnia was an unpleasant feature. But there were others who suffered from no lack of sleep except when they happened to be cold. Bruce on two nights slept for more than ten hours at 21,000 feet. He had a fair, but somewhat broken, night at 23,000 feet. He had about two hours' sleep at the beginning of the night, then a long period of sleeplessness, then a few more hours' sleep in the morning, when at 25,000 feet. He always slept with his head raised, having learned the trick on the previous expedition. Somervell slept well at 25,000 feet, and had two good spells of sleep at 27,000 feet. Norton, however, takes the record. He slept well and had an excellent night at 27,000 feet. A point about high altitude sleeplessness is the fact that it is not associated with restlessness, nor does it cause weariness the next day. One lies awake, but does not toss about; nor is the sleep accompanied with irritable dreams.

Glacier Lassitude.—A distinct feature in the Mount Everest region is the very pronounced glacier lassitude which develops over tracts of ice. This was most marked on the Rongbuk glacier, especially when passing through a trough in the ice at an altitude of about 20,000 feet. The trough was a remarkable feature, being girt on either side with walls of ice in many places hewn into fantastic pinnacles and ornamented with pyramidal spires. In this trough there was a peculiar sapping of energy, a weakness of the legs, and a disinclination to move. It was not a breathlessness due to exertion, but a loss of muscular power. There was a feeling of prostration. One seemed to drag oneself along, instead of going with the usual strength. A profuse sweating was not uncommon. It was something like the oppression experienced when marching through a hot moist jungle in the rains. The lassitude appeared immediately after stepping on to the glacier ; it was as quickly relieved on again reaching rock or moraine. It was most noticeable in the absence of wind and in the middle of the day when the sun was strong. It was absent late at evening and in the early morning, and was less marked on cloudy days.

The cause of this lassitude is easily explained. The conditions for its development are a sheet of ice, a hot sun, and a still air. The sun melts the superficial layer of the ice. The lowest stratum of the atmosphere becomes saturated with moisture but does not rise owing to its being chilled by contact with the ice. Thus, when on the glacier, one is in a saturated atmosphere, and this, in conjunction with the high altitude, is sufficient to cause the unpleasant effects.

We did not notice that other atmospheric conditions had any special influence on these high altitude symptoms. This was different from my experiences in the western Himalaya. There, on two occasions, our party climbed the same peak to a height of 18,203 feet. During the first ascent the sky was clear, the air was free from moisture, and our disability was slight. On the second occasion the conditions were different. The sky was dark, stormy weather was imminent, and the atmosphere felt heavy and damp. Our distress on this second occasion was acute. Every few paces found us gasping for breath, and we had repeatedly to make short halts. The same explanation applies to this as in the case of the glacier lassitude. On the second ascent the atmosphere was laden with moisture. The free evaporation of perspiration was checked, and, as a consequence, the high altitude symptoms were increased.

Individual Variation.—The experiences of the party, as already detailed, indicate considerable individual variation with respect to oxygen want. It was obvious that some of us breathed more laboriously than others. One suffered from headache, another did not ; one lost the sense of taste, another observed no such change ; one was sleepless at comparatively low altitudes, another slept well at the highest camps. One member seemed particularly resistant to the lassitude that occurs over snow and ice. All were agreed that the Sherpa porters suffered, on an average, less than Europeans. Their power of carrying loads was extraordinary. They went with loads as fast as did the climbers without loads. It was not that they were muscularly more powerful than we. Probably their actual strength was less. It was their capacity to carry that was so much greater. This must be due to their permanent habitations being at altitudes of 12,000 to 14,000 feet, and to the fact that they habitually carry loads over passes of 16,000 and 18,000 feet.

Oxygen.—To what extent does the breathing of oxygen alleviate the symptoms already described ? Theoretically we should expect an enormous benefit. We know of its great value in balloon ascents, which could not be made to extreme altitudes unless oxygen was breathed. But our evidence on the subject is most unsatisfactory. The two climbers who could have told us most about it have perished on the mountain. Bruce used oxygen on his ascent to the North Col—that is, between 21,000 and 23,000 feet. He noticed scarcely any benefit. Odell used it at the same altitude and considered that it gave no relief. Later he used it between 25,000 and 27,000 feet. There the oxygen seemed to relieve the breathing and diminish the tiredness of the legs. He thinks it may have helped to keep up the temperature. Its use produced an uncomfortable drying of the throat which necessitated frequent swallowing and expectoration. He abandoned the oxygen at 27,000 feet and descended easily without it. It is remarkable how little benefit was obtained from the oxygen compared with the experiences of the previous expedition.

Acclimatization.—I pass to the problem of acclimatization. When we compare a rapid with a gradual ascent we see how powerful is this factor of adaptation to increasing heights. Haldane describes the condition of visitors after a rapid ascent of Pike's Peak to a height of only 14,100 feet. " Many persons walked or rode up during the night to see the sun rise, especially on Sunday morning, and the scene in the restaurant and on the platform outside can only be likened to that on the deck or in the cabin of a cross-channel steamer during rough weather." Now the altitude at which this scene took place was about the same as that of the Tibetan plateau. But our ascent to the plateau was gradual, and therefore accompanied by acclimatization. As a consequence we felt scarcely any distress. We were quite comfortable at a height where, if our ascent had been rapidly made, we should have been like the nauseated visitors on Pike's Peak.

But the contrast is more marked if we compare our progress with an air ascent. In the year 1875 Tissandier and his two companions made their famous ascent in a balloon from Paris. They were provided with oxygen but were unable to make use of it. Tissandier fainted at 26,500 feet, and when he recovered consciousness the balloon was descending and his companions were dead. The balloon had reached an altitude of 27,950 feet. This was a rapid ascent with no acclimatization. The result was death between 26,000 and 28,000 feet even when sitting quietly in a balloon. Compare this with a gradual attack on Mount Everest. Climbers without oxygen have ascended the mountain to 28,000 feet, somewhere about the same height where death occurred in the balloon. Yet at that altitude they were capable of strenuous effort ; they showed no indication of fainting ; they could sleep well at a slightly lower elevation, and were comparatively comfortable so long as they were at rest. The difference in the two ascents is due to acclimatization, without which any attempt to reach the summit of Mount Everest would be altogether out of the question. The fact is that balloon ascents and experiments in air-chambers are not at all comparable to the conditions of a prolonged climb.

A special point which the expedition of this year taught us is that persons who have once experienced high altitudes will acclimatize very much more rapidly than those entering them for the first time. Those of our party who had been on two expeditions were unanimous in the view that they suffered less on the second than on the first occasion. One said that his mind was much more active than it was in 1922, another that he reached Camp III. with much less difficulty, another that he had not to breathe deeply at night as he had found necessary on the previous expedition. Also it was obvious that the new members of the party were distinctly more affected than the old. This is a point of practical importance. It means that, other things being equal, old hands will acclimatize more rapidly and be in a fitter state to climb the mountain than will be a party of fresh recruits. Even aviators have noticed the same thing. Although their ascents are so quick and short, yet they say that they get accustomed to the height. The body seems, as it were, to become trained by one experience, and therefore to make the necessary adjustments more easily on reaching high altitudes a second time.

To what height can acclimatization continue? There seems to be no doubt of a steady improvement at 19,000 feet. Shebbeare spent over a month at that altitude in Camp II. At first he found the ascent to Camp III. very laborious, but at the end of a month could do it with ease, and on the last day did it in the record time of 1 hour 55 minutes. Odell remained for ten days at 23,000 feet, and said that he certainly felt better as a result of this. Somervell believed that acclimatization took place at 24,000 feet. But we must remember that while acclimatization is in progress there may be physical deterioration at the same time. Though the body is becoming more accustomed to the altitude, yet simultaneously it is losing both in weight and strength. Dr. Kellas puts the important question: "Is it possible to become sufficiently acclimatized to altitudes of 24,000 feet to 26,000 feet to enable one to climb to over 29,000 feet?" I think that most of our party would reply in the affirmative. Two of them have already reached 28,000 feet aided by no other power beyond their own natural capacities for acclimatization.

After-Effects.—A note as to the after-effects consequent on residence at the high camps. The climbers were examined before we left the mountain. All of them showed signs of dilatation of the heart; in two it was decidedly marked. All were debilitated. All had wasted considerably—probably as much as $1\frac{1}{2}$ to 2 stone. The porters too had lost much weight. Barcroft observed the same effect on his expedition to Peru. Loss of weight occurred in all the members of his party, the most marked being a decline from 155 to 131 lbs. in twenty-seven days.

Those of the expedition who had been badly frostbitten required treatment for weeks after we had left the mountain. Frostbite showed itself in two varieties: the moist form with large blisters full of fluid and the dry gangrenous type. Snow-blindness also may need after-treatment.

A point of interest was that Norton developed a severe attack of blindness when at high altitudes though in the absence of snow. At 28,000 feet he was on bare rock. He thought it unnecessary to use his snow-glasses, and on the next day he was completely blind. The sun's rays in this thin air can cause a most acute attack of conjunctivitis even when reflected from bare dark rock.

Thus life on the mountain causes physical deterioration. Improvement followed on our return to the base camp, with increase in appetite and better sleep. Finally we descended into the Rongshar valley, where, at the pleasant altitude of 10,000 feet, all were quickly restored to health.

Conclusion.—A last word on the possibility of reaching the summit. In the year 1916, at an afternoon meeting of this society, Dr. Kellas showed an interesting dissociation curve of Oxy-Hæmoglobin in blood. On this curve he plotted the heights of some well-known mountains. From it he drew the following deductions. "The curve," he said, "is very suggestive. It shows that the strain on the climber is nearly negligible up to 10,000 feet, and at about 15,000 feet becomes appreciable; but one must pass above 20,000 feet before the steepening of the curve indicates that the mountaineer will have to adapt himself carefully to his aerial environment. At 23,000 feet the curve is getting much steeper, and the climber will obviously be put on his mettle above 25,000 feet, for the curve then attains its steepest. Every 1000 feet still higher must mean considerably increased difficulty, and the climber near the summit of Mount Everest will probably be on his last reserves in the way of acclimatization and strength." This deduction was made before the first assault on Everest, and I think that we can now safely say that our practical experiences bear it out.

I think that climbers will reach the summit of Mount Everest even without the help of oxygen. Though the physiological difficulties are undoubtedly severe, yet they can be overcome. But the condition of the weather must be more favourable than this year. The climbers must be in perfect health and in first-rate training; they must be men of exceptional powers of endurance, and their capacity for acclimatization must be complete.

Before the paper the PRESIDENT said: We open our session of afternoon papers with a statement by Major Hingston showing the effects which high altitudes have upon human physiology. These results, of course, are interesting, because the Mount Everest Expedition has reached greater altitudes than any expeditions which have preceded it, and any general conclusions which may be drawn from such results consequently must have an important bearing upon the whole question. I will now ask Major Hingston if he will give us his paper.

Major Hingston then read the paper printed above, and a discussion followed.

Air-Commodore MUNRO (Director, Medical Service, R.A.F.): I am pleased to have had the opportunity of hearing the paper; all the more so as in some ways I had a hand in Major Hingston joining the Expedition, in that I was partly instrumental in getting the Government of India to allow him to leave 'Iraq, where he was serving with the Royal Air Force. The paper is of particular interest to us in the Medical Service of the Royal Air Force, of which I am the Director. Our problem, of course, is very different in that airmen go to great altitudes in very short spaces of time; in other words, we have not to deal with the problem of acclimatization mentioned by Major Hingston. But we do need in the Royal Air Force the same standards of physical fitness; men need to be in perfect physical condition. It is, therefore, of great interest to us to see the results of our own tests employed at these high altitudes, and I should like, on behalf of the Medical Service, to thank Major Hingston very much for so kindly undertaking to do these tests for us. I congratulate him very heartily upon the paper he has just read.

Professor J. B. HALDANE, F.R.S. (Oxford University): I think this paper is one of extraordinary interest to physiologists, and I beg to congratulate Major Hingston on its clearness and simplicity. He avoids—I have no doubt purposely—certain physiological points which are just now the subject of acute contention.

I should like to make one or two comments on the points raised. First, in regard to breathing at high altitudes. What is the cause of the enormous increase in breathing during work? Proportional increase is present during rest too, no doubt, but is not so noticeable. Is the cause of increased breathing when at work want of oxygen immediately? It is certainly want of oxygen in the long run; but there is no evidence that it is immediate want which causes it chiefly. Excessive panting is, I have no doubt, due to accumulation of carbon dioxide with the blood in the condition in which it is in an acclimatized person at high altitudes. During the process of acclimatization, as Kellas, Kennaway, and I showed, the blood loses alkali, so that in an acclimatized person the amount of carbon dioxide in it must be kept much lower in order to preserve the normal alkalinity. To keep the carbon dioxide low there must be greatly increased breathing, which during work causes much distress. It is possible to reproduce that condition artificially at sea-level by means which my son discovered three or four years ago, namely, by producing acidosis by the administration of ammonium chloride, and I shall not easily forget the experiment. When he was sitting at rest he was breathing deeply without discomfort; but when he went in the street for a stroll, walking about 3 miles an hour, he was panting as if he were running. He had to keep down the carbon dioxide. I was familiar with this effect in connection with the effects of carbon dioxide in the air of submarines, mines, and helmets of divers. The capacity for any considerable work is destroyed by excessive panting, as would exist on Mount Everest. If the person is unacclimatized oxygen has an enormous beneficial effect, which I can testify to from experiments in steel chambers. If he is acclimatized he will breathe not quite as much as before, but nearly as much, because it is not mainly want of oxygen which is worrying immediately, but excess of carbon dioxide. Hence the somewhat disappointing effects of oxygen on well-acclimatized persons.

The experiments on holding the breath are also very interesting, especially the time during which breath can be held. There is, I think, no doubt from physiological evidence that it is mainly want of oxygen that limits the holding of the breath at high altitudes. There is very little oxygen in the lungs, and it runs down very rapidly if the breath is held.

Mr. J. BARCROFT, F.R.S. (Cambridge University): I should like, first, to add my congratulations and, still more, my thanks to Major Hingston for having given us the data which he has put before us this afternoon. It is really a great matter that on an Expedition of this sort reliable scientific data should be accumulated, and it is a great advantage to have had on the Expedition a person who has with such care and such evident exactitude brought us home definite information. I feel somewhat diffident in saying anything at all, because, of course, a little knowledge is a dangerous thing, and the little knowledge that I have on this subject has been gained for the most part at altitudes of about 15,000 feet or thereabouts, and therefore at altitudes which in Major Hingston's mind, if I could see right into it, are really quite low and possibly altitudes which I should not discuss at all. My only excuse is that I imagine some lower altitudes affect lesser men in the way the higher ones affect those best suited to compete with them.

There are one or two general matters most interesting to physiologists, and first, why in practice does oxygen not seem to be of more use? As Major Hingston said, in theory one would have thought—perhaps wrongly—that oxygen should have solved their difficulties. If one considers why it has not done so, a number of reasons come into the mind. Firstly, that their difficulties were not altogether in regard to oxygen, but were associated with cold and other such things. I take it that those difficulties have all been eliminated. And then there is another possibility about which I have no knowledge, namely, the extent to which the party were drilled in the use of oxygen beforehand. Of course, with all forms of respiratory apparatus of that kind drill is essential, because when you use it under difficult circumstances you will almost invariably come to grief if you have only used it under easy circumstances beforehand. One would like a little information as to how much oxygen the climbers got; whether their tubes froze up, and so on; and whether they were getting the adequate or calculated amount. Let me pass over that and assume they were; there comes the question, Why is it, if they were getting oxygen, it did not help them? That is very interesting and significant from the point of view of the physiologist, from the point of view of the doctor, and from the point of view of the next Mount Everest Expedition.

I think that probably we will all agree that the fundamental trouble at this altitude on Mount Everest is one of oxygen, but whether the cumulative effects of want of oxygen over days and weeks can be abolished by the immediate breathing of oxygen is, I think, really the kernel of the matter and is a question on which we have but little data. The information brought by Major Hingston appears to be extremely to the point and should be sifted very carefully.

There is another point of rather general interest, I think, in connection with the pulse, namely, that in the last column of a table of Major Hingston's tabulated observations there were some very irregular figures, showing that the pulse came back to its normal period rather rapidly at high altitudes, when one might have expected it to come back rather slowly. Those figures were to me of extreme interest, because the irregularities began to show about 7000 feet, and at about the same altitude I got the same results in the Andes. I am glad that I am not alone in getting those results. Also during the war, Dr. Hunt, Dr. Price-Jones, and Miss Dufton (now Mrs. Wilson) were working on gassed cases in this connection and doing exercises, and they got the quick return of the pulse to the normal figure and even below it, and then going up and down again, and so on, where one would have expected a slow and gradual return. That evidently was what we physiologists call a *vagal* *affaire*, and rather significant, because the return of the pulse is used as a test for insurance data, and so on, and this seems to be a sort of anomalous condition in which that test is invalid.

Lastly, I wish to comment upon something which Major Hingston said. He found that there was very little difference in the power to do arithmetic at great heights as compared with low altitudes. He kept a record of the time taken to do multiplication tests, and it was shown that by an effort of concentration they could easily be done. That, indeed, is so, but he also said, "It will not please the members of the next expedition to hear that more complicated and worrying tests are required." I think Major Hingston will agree with me that that is just the point. Down here it would not "displease" us to know we had to do tests rather more complicated than simple division, but up there that sort of thing is most worrying.

Professor LEONARD HILL, F.R.S. (University of London): I would like to add my word of admiration of this paper. I think Major Hingston has put forward with extraordinary simplicity and clearness conclusions which have the greatest interest and value to us physiologists. One point which has come out is a confirmation of the value of the Air Force tests which were introduced by Group-Captain Martin Flack. I quite agree with Major Hingston as to his interpretation of the results of the expiratory force test; these are due to extraordinary development of the breathing muscles through training and going up to these great altitudes. The Air Force men who fail in the test through fatigue or after crashing are in a condition of nervous debility, and have not got that power which is developed by long training in climbing to high altitudes. That is why there is a discrepancy in this test. The other tests come out exactly as one would expect, showing diminished efficiency at great altitudes.

Another point that struck me as being of great interest was the immense increase in the number of red corpuscles coupled with the great increase in breathing power. By these two means compensation seems to be set up by which climbing can be done at great altitudes. Dr. Haldane, who is a great authority on all these matters, has suggested that the lung has the power of secreting oxygen into the blood. I do not know—he has not told us to-day—what he feels about the results in regard to that matter; whether he thinks it upholds his views or not. My own opinion is that by acclimatization, by the increase of red corpuscles, by the great power of increasing breathing through training, and possibly by loss of weight, which is so pronounced, the loss of weight lightening the body and making the load less—that by all these means the power to climb these altitudes is reached, and we need not bring in the supposed secretory power of the pulmonary epithelium.

Then another point which interested me very much was the loss of efficiency in that glacial trough where the members of the party were exposed to strong sun and a windless wet atmosphere which produced sweating. That is exactly what I expected. I have often read of such places in Alpine climbs where mountain sickness has been increased, and it has always been my view, and I am pleased to hear it confirmed, that this was due to the very conditions described by Major Hingston. The blood under such conditions is determined in much greater volume to the skin. One of the great points which enables people to climb to these immense heights is the great cold which constricts the blood-vessels, drives the blood into the internal viscera and muscles, and keeps it out of the skin. The skin as a radiator comes less into play; the heat-loss is taking place largely by evaporation from the lung, as Major Hingston showed, and cooling of the body is brought about by convection, due to cold wind, without sweating coming into play and with the least quantity of blood in the skin. All that is very favourable to meeting the conditions. We have found, when working in hot places, that what fails is the heart. The pulse-rate goes up, and if it goes up much above 140 our man begins to fail and cannot go on with the ergometer test. In exposed places on Mount Everest we have the heart saved from having to send blood in large quantity to the skin in order to keep the body cool because the cooling is brought about without that means. But directly you get into the hot troughs described, with sun pouring down and the air saturated, then the sweating comes into play and more blood is sent to the skin, and the heart has to do the work of pumping it to the skin in order to cool the body as well as pump to the muscles in order to keep up muscular energy. That is why the failure takes place. If we could get pulse records made in those troughs I think they would be of great interest.

There is another point—the breathing of very dry cold air may make it easier for oxygen to diffuse through the breathing membrane into the blood, while the breathing of warm saturated air by making the film of moisture thicker on the breathing membrane may lessen the rate of diffusion. We know that the breathing of war gas poisons by increasing the exudation of fluid opposes the passage of oxygen through the breathing membrane.

Professor BOYCOTT, F.R.S. (University College Hospital): I am glad to have the opportunity of thanking Major Hingston very much indeed for this interesting and concise account of the symptoms produced by high altitudes. I will not detain the meeting by making comments on the various points, but I would like to make one suggestion that may possibly be practicable. The body evidently does a great variety of different things in trying to compensate for the strain entailed in reaching high altitudes. Among the compensatory processes is the increase of the red corpuscles in the blood, which has been shown by Professors Haldane and Douglas in the Pike's Peak Expedition to be due to the making of fresh red corpuscles in the body. That is a process that in man takes some little time to occur; it may take many days or perhaps several weeks before you get the result, and I take it it might be an advantage if you could accelerate that process so that it took place in a few days. As a matter of fact, if you give the body practice in reproducing red corpuscles you can increase the capacity to do so. If you take an animal and take away one-third of the red corpuscles it will replace them in about twenty days; if you do it again on the same animal it will grow the same number of red corpuscles at the end of six, seven, or eight days; and again you can still further accelerate the process. I take it that one may obviously produce exactly the same thing in man, and that he need not have practice by going to high altitudes because it can be done by bleeding a person in the ordinary way. That is to say, you might very much improve the capacity for going to these high altitudes by simply having an old-fashioned course of bleeding before you begin.

Dr. T. G. LONGSTAFF: Major Hingston has omitted all reference to the most remarkable of his achievements as medical officer to the Expedition of 1924. So soon as he heard that Colonel Norton was snow-blind on the North Col after his great climb, he just walked straight up to over 23,000 feet and fetched him down—blind. Now Major Hingston does not admit to being a mountaineer: but all mountaineers took off their hats to him when they heard of this exploit. They all realized the problem involved in taking a blind man down such a place as the North Col was this year: it was a proposition that the sturdiest climber might well have recoiled from. I do not think the lecturer brings out the magnitude of the demands that must be made on will-power in order to overcome the mental and moral laziness from which we all suffer at high altitudes. This attack on our mentality is the complement of the attack on our vitality which is shown by reduced resistance to cold and fatigue. I feel that very few people at all realize the extraordinary degree of resolution and determination which is required to attain success. The man who at great altitudes succeeds in taking photographs, or collecting specimens, or in observing and noting physiological effects, possesses the supreme attribute of the successful mountaineer. You may safely back such an one as a winner.

Dr. MALCOLM L. HEPBURN: I should like, first of all, to thank you for the compliment you have paid me in asking me to join in this discussion. I feel it is a compliment which I do not altogether deserve, and any work I may have done on the subject was carried out between the years 1894 and 1902. I have not done any since, and thus I feel that I am in a somewhat false position. However, to justify myself in your eyes I should like to say one or two things which have come to my mind from studying work that has been carried on since 1902. In a paper in the *Alpine Journal* for that year I analyzed all the numberless symptoms complained of on the mountains, and came to the conclusion that many of them arose from ordinary fatigue due to either pathological or physiological causes, often aggravated by want of training, imperfect respiratory mechanism, inadequate or improper food, thus leading to gastric disorders. The cold, privations, anxieties, and exposure found in ordinary mountain climbing lower the resistance, as Dr. Longstaff has told you, and contribute to the onset of fatigue. I think few people realize how enormously they are accentuated in the attempt to conquer the highest mountain in the world. The amount of work measured in foot-pounds is probably greater than in any other form of muscular exercise, and cannot be undertaken by anyone unless physically sound and after an amount of training which far exceeds what is necessary for the most strenuous work at sea-level, and not the least important of which is the ingestion of a proper and suitable form of diet.

I also analyzed in the same paper the symptoms complained of by sufferers from other forms of diminished atmospheric pressure. In addition to mountaineers there are three other classes of people who suffer, or may be made to suffer, in this way; they are workers in caissons, aeronauts, and those working in the laboratory at sea-level. I agree with Major Hingston that these are of very little value for the purpose for which we are gathered here, which is to inquire into the physiological effects of high altitudes. I think this subject should be treated alone.

A further conclusion I came to after a study of the work of other scientific observers was, that after eliminating the question of direct or indirect fatigue it was possible to isolate a set of symptoms which were definitely and constantly associated with climbing in the higher ranges. These are well known, but I will say briefly that they are: While at rest, a feeling of lassitude and disinclination for exertion, associated with excessive breathlessness and its accompanying discomforts on the slightest manifestation of muscular effort.

I have also pointed out the similarity between these symptoms and those complained of by patients suffering fron anæmia at sea-level. In the latter case we have poorness of hæmoglobin in the presence of a full supply of oxygen, as opposed to richness of hæmoglobin in the presence of a poor supply of oxygen in mountain climbing.

I would like to remind you, in further justification of my position here, that in a paper in the St. Bartholomew's Hospital Reports in 1895 I said that provided (1) proper organization could be carried through, and (2) the weather would allow of sufficient time for the establishment of the necessary number of camps on the mountain; (3) the mountain to be ascended were relatively easy; and (4) the carrying of oxygen were rendered feasible, the physiological effects of high altitude would not prevent the highest point on the Earth's surface from being ascended by man. This opinion was gravely challenged at the time, and I still have private letters in my possession from high climbers—Mr. Edward Whymper, Sir Martin Conway, and Mr. Douglas Freshfield—sternly rebuking me for my youthful optimism.

As regards the means to be employed for overcoming the difficulties in the future: The men to be chosen must be physically sound and show definite signs of being able to take the fullest advantage of the opportunity for acclimatization so as to eliminate as far as possible the symptoms due to fatigue; but this can only be tested on the mountains at heights of 16,000 feet and over. Their individual power of increasing the number of red cells in the blood should be investigated; their capacity for accomplishing excessive muscular effort, entailed in climbing and carrying, in the most economical way should be encouraged. Special idiosyncrasies, such as sleeplessness, varying powers of ingestion and assimilation of food, variation in pulse-rate from the normal, should be noted, and all this with a view to making the symptoms of fatigue as remote as possible. The food most necessary for muscular exercise has been proved long ago to be of a carbohydrate nature and especially sugar. This again has been emphasized by Major Hingston. During the war it was found that large doses of acid sodium phosphate were especially valuable in increasing the capacity for muscular work. I do not know whether climbers have tried that.

Finally, we come to the efficacy or otherwise of the inhalation of oxygen on the mountains. No doubt, if it can be utilized effectively the benefit to be derived from it would be incalculable. There is no question that it is of value in attaining high altitudes, and in a position of rest a height of 40,000 feet has been safely reached by this method. It has also been definitely proved by Dr. Leonard Hill, Commander Martin Flack, and Mr. Just (in 1908) that it is of special value in the performance of muscular work, and particularly in postponing the onset of fatigue. At the same time, it is possible that the increase in the number of red blood-cells may so increase the oxygen-carrying power of the blood that it enables the blood to carry an indefinite amount of oxygen, though each individual corpuscle may not be saturated. In this case inhalation should be useful, since very little oxygen goes into solution. But against this, it is possible that the benefit in the performance of muscular work may be exactly counterbalanced by the increased effort entailed in transport. Thus we see, once more, the differences in individuality which enable some climbers to attain great heights without oxygen and others with its aid; but if it can be proved that it makes the ascent easier it ought to be used.

I consider I am justified in the optimism I felt thirty years ago, since Himalayan explorers, physically sound, properly trained and equipped have reached higher and higher altitudes, eventually attaining a record of over 28,000 feet, some with and some without oxygen.

Dr. PRICE-JONES (University College Hospital, Med. School): I have nothing special to say in a meeting such as this, but I am interested because I have received from Dr. Hingston some blood films which were taken at different altitudes. I am examining them, and I hope they will show some interesting results. What I think is the chief feature is the fact that Major

Hingston should have had the will-power and energy to have taken these specimens at the altitudes at which they were taken.

A FELLOW: Might I venture to add a word? In the Andean range there is a railway on which the trains leave Lima at 7 o'clock in the morning and ascend to Cerro de Pasco and other districts in that mountainous region. The train staff are to the last degree unaffected by any differences of altitude, but the passengers leave very palpable evidence alongside the line from hæmorrhage, and the more so when the train emerges from a tunnel which is above the snow-line. The suffocation in that summit tunnel is beyond conception, so that both passengers and staff have a very severe trial indeed. That bears out what Dr. Leonard Hill has said, that it is largely a matter of accustoming one's physiological condition. But the fact remains that this train leaves every morning at 7 o'clock, ascends to Cerro de Pasco, arrives there before 4 p.m., so that there is abundant experience of a very practical character. Very much the same is noticeable in Colorado, where on Pike's Peak the altitude of the tunnel is 14,442 feet, whilst the altitude of the tunnel on the Lima line is 15,212 feet above sea. At the former, however, there are evidences along the railway to a greater degree than on the Cerro de Pasco line.

The PRESIDENT: It only remains for me to express the gratitude of the Society to Major Hingston and to the other eminent speakers who have taken part in this afternoon's discussion. I was particularly interested in what was said by Professor Leonard Hill, because his remarks bear out to a great extent my own experience in these matters, namely, that the extent of the altitude is by no means the only factor in bringing about physiological changes in the system and consequent bodily discomfort. I have not climbed to any very great altitudes, but I have reached 19,000 feet in the west of Tibet without any discomfort of any kind. It is true that on that occasion I had undergone a pretty prolonged period of acclimatization, for I had been living at altitudes varying from 10,000 to 14,000 or 15,000 feet for a considerable time, and it may be that that accounts for the fact that I experienced no discomfort on climbing to 19,000 feet. On the other hand, in other parts of the Himalayan Mountains where there is a greater degree of humidity in the atmosphere, I have experienced considerable discomfort at very much lower altitudes; not only that, but I have found great variation in different places not very widely separated from one another. I think probably Sir Francis Younghusband may recall a certain spot in the north-east of Sikkim which has a particularly bad name for producing bodily discomfort in spite of the fact that its altitude is not very great, probably only about 13,000 feet, whereas the surrounding country runs up to a much greater altitude—16,000 to 18,000 feet—and does appear to affect one in the same way. It seems to me that these somewhat curious results are explained, to a great extent, by what Professor Leonard Hill said in the course of the discussion.

Let me, on behalf of the audience, in the first place express our gratitude to Major Hingston for the care which he has taken in compiling these results of his recent experience. I fully agree with those who congratulate him upon the will-power which enabled him at these great altitudes to sit down methodically and carry out these investigations, and I feel sure that the result of his labours will not only be of academic interest to physiologists, but will probably prove of great practical value to any subsequent expedition which may attempt to reach the summit of Mount Everest.