THE CROONIAN LECTURES. CONTRIBUTION TO THE HISTORY OF THE RESPIRATION OF MAN.

Delivered before the Royal College of Physicians of London.

By W. MARCET, M.D., F.R.S.

LECTURE IV.

MR. PRESIDENT AND GENTLEMEN,—So far we have dealt with the phenomena of respiration as carried on in the ordinary course of life. I now wish to draw your attention to breathing under circumstances which are not of daily occurrence; the first of these being under the influence of diminished atmospheric pressure as met with on ascending into high altitudes. This subject is important not only physiologically, but also with reference to the modern treatment of phthisis.

It must be clearly understood that the carbonic acid expired is unconnected with the consumption of the oxygen taken in the previous inspiration, as the oxygen derived from the air is carried into the circulation by the hæmoglobin, and there serves the purpose of heat production and metabolism; the carbonic acid produced in the tissues passes out into the blood, and is ejected with the expired air. Thus it is impossible to tell when a certain volume of oxygen taken into the blood may reappear as CO₂. This point I wish to establish clearly, as I believe an objection to my work has been made on that score.

If experiments on the respiration of man could be continued for a length of time—say the whole day—then the volume of air breathed would certainly compare with the weight (or volume) of CO₂ produced; but it is not possible to do this, and the only alternative is to repeat the experiment as often as possible throughout the day, and take the means of the volume of air breathed and CO₂ produced—a method invariably adopted in my experiments. I do not claim a relationship between the oxygen inspired and the carbonic acid expired immediately afterwards, but I claim a relationship between the mean volume of air breathed and the mean weight of CO₂ expired in the course of one day.

On ascending a mountain the air pressure diminishes and the pulmonary ventilation increases, in order to aerate the blood to its full extent. Now, although the volume of air breathed increases on rising above the sea level, still the weight of that air falls; in other words, its volume reduced to dryness, freezing point, and seaside pressure diminishes. Hence it may be said that as one ascends, a less weight or volume (reduced to dryness and standard temperature and pressure) of air is breathed for the production of a given amount of carbonic acid. For instance, if at the seaside a person inspires a mean of 4.5 litres of air and expires 0.375 g. of carbonic acid per minute, or, what is the same thing, inspires 12 litres of air corresponding to the emission of 1 g. of carbonic acid, on rising to such a height that the atmospheric pressure falls by one-fourth its amount at the sea level, the volume of air breathed corresponding to 1 g. of carbonic acid, will not exceed the original 12 litres by one-fourth, and thus become 15 litres, but will be less than 15 litres.

It must be understood that the volumes of air breathed (reduced) decrease at increasing altitudes, a fact first published by a Swiss gentleman, Dr. Mermod, in 1875, and which I confirmed a few months later by observations made at much greater altitudes, his experiments being unknown to me at the time.

A number of experiments made on the Peak of Teneriffe have also shown me conclusively that in perfect health the amount of carbonic acid expired remains unaltered with increasing altitudes, at any rate, up to about 12,000 feet. According to Mermod, on the other hand, it becomes greater on rising above the sea level. On this point we therefore disagree.

Discarding for a moment the idea of the influence of altitudes, it is well known that when the temperature of the atmosphere falls, a greater volume of air is breathed and more carbonic acid expired, but the volume of air breathed

for the emission of a certain weight or volume of carbonic acid is proportionately less, hence it appears that a fall of the atmospheric temperature gives rise to the same kind of effect on respiration as increasing altitudes without change of temperature. My earliest experiments made on the Alps were all attended with a fall of temperature at increasing altitudes, this circumstance necessarily producing an increased combustion in the body in order to overcome the action of the cold; it was therefore impossible by this means to determine the exclusive influence of atmospheric pressure on respiration, hence the necessity of selecting for these experiments a mountain of sufficient height near the tropics where one might expect to find the temperatures fairly equal at different altitudes. With this object in view I spent three weeks on the Peak of Teneriffe in the summer of 1878, selecting for this inquiry four stations varying in altitude. The temperatures differed but very slightly at the four stations, though somewhat higher at the lowest, but there was no cause for any marked influence of temperature on the formation of carbonic acid.

The air was expired into an india-rubber bag of known capacity, and a sample of the air was shaken with baryta water in a glass cylinder. The fluid, having absorbed all the carbonic acid, was afterwards collected in bottles, one for each analysis, and carefully stoppered, the final analysis being made at a subsequent period.

In the following results every figure is the mean of the number of experiments entered in parentheses, the table showing the number of litres of air expired (reduced to dryness, freezing point, and seaside pressure) for 1 g. of carbonic acid expired:

	Litres.	Temp.	
Seaside	12.0	75.7°	(20)
Guajara (7,090 feet)	11.6	69.6°	(21)
Alta Vista (10,700 feet)	10.4	64.0°	(20)
Foot of terminal cone (11,740 feet)... ..	10.3	64.0°	(5)

The difference is not great, still for 10,700 feet it amounts to 1.6 litre, hence one eighth less air was required at the two higher stations to produce through the respiration the same amount of carbonic acid as at the seaside. In other experiments made on the Col du Géant the reduction for an increased altitude of 9,800 feet amounted to about one-fifth in my own case, and rather more than one-twelfth for a young companion. On other occasions at various altitudes, from 8,115 ft. to 13,680 ft., the mean height, 11,256 ft., gave a mean reduction of 2.03 litres of air breathed for 1 g. of carbonic acid produced. These experiments show clearly that the aëration of the blood takes place more readily under diminished pressures than at the seaside, which is not easily accounted for. Paul Bert observed that the blood of various animals forwarded to Paris from the town of Mexico situated at an elevation of 7,480 feet had the power of absorbing considerably more oxygen than the blood of similar animals kept in Paris, and he concluded that the Mexican blood contained more hæmoglobin. This may be correct, but such a character could only be acquired after a number of years, perhaps of generations, while in my experiments the effect was produced, if not immediately, certainly after a few hours, when no change in the constitution of the blood could possibly have taken place.

Frankland found that candles burn more brightly in air partially exhausted by an air pump than in the surrounding atmosphere, and concluded from this experiment that the molecules of oxygen have a greater mobility in the rarefied air. The more ready passage of oxygen into the blood at the lungs on reaching a high altitude may be due to a similar cause, but I cannot think that it is in any way connected with an increase of hæmoglobin.

As regards the medical aspect of the question, with reference to the treatment of phthisis in high winter stations, as Davos and St. Moritz, people residing there must live under circumstances facilitating the aëration of their blood, and I have no

doubt that this is a primary and important cause of the beneficial effects produced. The extreme cold experienced must also be beneficial, since cold reduces the volume of air that has to be inspired for the production of a given amount of carbonic acid, so that both altitude and cold join in facilitating the respiratory phenomena.

There is another experiment of Dr. Frankland which throws light on the circumstance that cold is so little felt on high winter stations. He found that if a platinum wire carried through an air pump receiver was made red hot by an electric current, it rose to white heat when the air pressure was reduced in the receiver, although the source of heat remained unchanged, from which he concluded that rarefied air removed less heat by conduction than the same air under atmospheric pressure. In accordance with this observation Frankland accounts for the fact that cold is felt less than might have been expected in the still air of Davos, from the circumstance that the lightness of the air checks the removal of heat from the body by atmospheric conduction.

This view gains support from the statement of Paul Bert, in his book on barometric pressures, that compressed air has a tendency to produce a sensation of cold, although the temperature of the compressed air chamber may be higher than that of the external air, and with persons subject to the impression of cold this effect of increased air pressure is observed to become greater the longer the exposure and the higher the pressure. I, therefore, cannot help believing with Frankland that increased lightness of the air, acting inversely to increased pressures, assists in accounting for the remarkable fact that patients at Davos are so little troubled by the intense cold.

An easy respiration at great altitudes is in a great measure the result of training; thus while practised climbers easily ascend Mont Blanc, tiros, after about 10,000 feet are attained, have to stop frequently for a few seconds to take breath, and often give way to fatigue or to a sleepy sensation or mountain sickness. Perhaps the most remarkable illustration of the influence of training is shown in the case of Mr. Whympers, who, having fought his way slowly and patiently to the summit of Chimborazo in spite of the suffocating effect of the low atmospheric pressure, experienced no difficulty whatever in repeating the same ascent six months later, having been engaged meanwhile in explorations at great altitudes in the Andes.

It may be remembered that in my last lecture I traced a connection between "volition" and respiration; it will now be interesting to observe the effect of low atmospheric pressure on volition. Paul Bert submitted himself to low pressures in a closed chamber. At a pressure of 17.5 inches of mercury, having attempted to whistle, he found it impossible to do so: at 17 inches he suffered from dizziness, which recurred at 16.6 inches; and at 16.4 inches he felt rather unwell, and, having counted 28 pulsations at the wrist in 20 seconds, found great difficulty in multiplying that figure by 3. These statements show that Bert experienced in a marked degree what we might call want of power to respond to volition under that low pressure. When the pressure had risen to 22.2 inches he began to recover his ability to whistle. Is not this an illustration of the action of oxygen towards promoting the power of the will?

A more remarkable illustration of the effect of a deficient supply of oxygen towards the suspension of the action of volition is found in the account given by Glaisher of his balloon ascent with Coxwell on September 5th, 1862, when, at an elevation of 29,000 feet, the balloon still rising rapidly, he lost consciousness. Allow me to extract verbatim from Glaisher's book, *Travels in the Air*:

"At 1 o'clock and 51 minutes the barometer read 10.8 inches. After this I could not see the column of mercury in the wet-bulb thermometer, nor the hands of a watch, nor the fine divisions on any instrument. I asked Mr. Coxwell to help me to read the instruments. In consequence, however, of the rotatory motion of the balloon, which had continued without ceasing since leaving the earth, the valve line had become entangled, and he had to leave the car and mount into the ring to readjust it. I then looked at the barometer, and found the reading $9\frac{3}{4}$ inches, still decreasing fast, implying a height exceeding 29,000 feet. Shortly after I laid my arm upon the table possessed of its full vigour, but on

being desirous of using it, I found it powerless; it must have lost its power momentarily. On trying to move the other arm I found it powerless also. Then I tried to shake myself and succeeded, but I seemed to have no limbs. In looking at the barometer my head fell over my left shoulder. I struggled and shook my body again, but could not use my arms. Setting my head upright for an instant only, it fell on my right shoulder; then I fell backwards, my back resting against the side of the car, and my head on its edge.....As in the case of the arms, so all muscular power was lost in an instant from my back and neck.....In an instant intense darkness overcame me, so that the optic nerve lost power suddenly, but I was still conscious, with as active a brain as at the present moment while writing this.....While powerless I heard the words 'temperature' and 'observation,' and I knew Mr. Coxwell was in the car speaking to and endeavouring to rouse me before consciousness and hearing had returned. I then heard him speak more emphatically, but could not see, speak, or move.....Then the instruments became dimly visible, then Mr. Coxwell, then shortly I saw clearly, next I rose from my seat and looked around as though waking from sleep.....I then drew up my legs, which had been extended, and took a pencil in my hands and began observations.....It is probable that three or four minutes passed from my hearing the words 'temperature' and 'observation' till I began to observe."

The case of Mr. Glaisher is very remarkable if taken in conjunction with the fact, which I look upon as proved experimentally, at all events as far as an experiment can go for the present, that the exercise of volition requires the direct action of oxygen on the brain centre concerned. In the present instance the conception of volition was not in abeyance, as Mr. Glaisher could direct his will as he pleased, but there was no response; he wished to move his limbs and could not. Hence as far as can be concluded from the experiment of Bert and the narrative of Glaisher the conception of volition does not require oxygen, but the manifestation or response of volition cannot be carried out without it.

Another effect of rarefied air when accompanied by intense cold is that it appears to check the mental faculties, producing the sensation of drowsiness so often experienced on high mountains.

Thus far the effects of diminished pressure have been considered; those produced by increase of pressure have been the subject of many inquiries. Paul Bert assimilates the effect of an increased atmospheric pressure to the respiration of a proportional addition of oxygen at ordinary pressure; this view, however, does not take into account the cooling influence of compressed air.

From Dalton's law the solubility of gases increases proportionately with the pressures, hence under increased atmospheric pressure a little more oxygen should be absorbed by the blood, and this is found experimentally to be actually the case. There is also a slight increase of carbonic acid expired, which, according to Bert, may be observed up to about 5 atmospheres, the maximum increase occurring at about 3 atmospheres. At pressures above 5 atmospheres oxidation falls below the normal, the excess of oxygen arresting rather than exciting combustion. Quoting from Bert's book, this cessation of the oxidation of tissues from excess of oxygen takes place in all living tissues; even seeds no longer germinate when maintained under pressure. Dr. G. von Liebig, from experiments made in 1875, found that at pressures of about 40.5 inches of mercury the carbonic acid expired was increased by less than 1 per cent. These experiments correspond with others I had occasion to make, when atmospheric air was inhaled in which one-third was replaced by oxygen gas. According to the views advocated by Bert, this artificial air, containing 43 per cent. of oxygen instead of 20.9 per cent., would be equal to a pressure of about 2 atmospheres. In every experiment there was a large increase of oxygen absorbed by the blood, an increase which very clearly exceeded the absorbing power of the blood corpuscles, but the carbonic acid expired was but slightly, and in some cases not at all, in excess of the normal, thus illustrating very forcibly the remark made in my first lecture, that it is not the oxygen which by offering itself to the blood and tissues promotes the tissue changes. The slight excess of carbonic acid expired when the body is subjected to

increased atmospheric pressure is probably due to the greater conducting power of compressed air, which withdraws heat from the body.

Dr. C. T. Williams, in his book on *Aërotherapeutics*, states that in certain cases of asthma decided relief was obtained by the use of the compressed air bath. I account for this favourable action of compressed air in asthma by regarding the bath as a method of training the respiration. Dr. Williams observed that a larger volume of air was breathed after the use of the bath than before. This increased pulmonary ventilation will obviously assist in aerating the blood and ridding it of its carbonic acid, the percentage of which in the expired air would, I doubt not, be found lower than normal, thus assimilating the phenomenon to one of unconscious forced breathing.

To pass on to another subject: Allow me to draw your attention to the effects of the inhalation of carbonic acid, and first of all to the phenomena observed on rebreathing one's own expired air. I made experiments by rebreathing for five minutes 35 litres of air contained in a bell jar suspended over salt water. The air was inspired through nasal cannulae connected with the roof of the receiver, and expired by the mouth into the bell jar in the usual way. At each inspiration the bell jar fell slightly, and rose at the following expiration. Little or no distress was felt during the first three or four minutes, though in the last minute a slight feeling of want of air was occasionally experienced, but this varied with different people.

Tracings of this kind of respiration show that as rebreathing continues the respiration becomes deeper and more rapid, while the direction of the tracing is not quite horizontal, but has invariably a tendency to fall; this is due to the absorption of oxygen and carbonic acid in the blood and the consequent diminution of the volume of air in the receiver. The history of the phenomenon is very simple. Oxygen is consumed from the air and partly converted into carbonic acid, while the remainder is used up in other ways. Under ordinary circumstances the carbonic acid produced is exhaled; but in this case it accumulates in the bell jar, and, being inhaled, prevents the free diffusion of the gas from the blood into the lung cavity, and therefore carbonic acid becomes retained in the blood in gradually increasing quantity. Moreover, the amount of oxygen in the air inspired falls rapidly, and this air therefore becomes less and less fit to maintain life. In my inquiries 5 persons submitted to a total of 42 experiments, each of which consisted of 4 stages. In the preliminary stage the carbonic acid was determined in normal respiration. In the second stage 35 litres of atmospheric air were rebreathed for five minutes and subsequently analysed. Immediately after rebreathing, the air expired was diverted into another bell jar, till about 35 litres had been expired, after which the air given out from the lungs was collected separately for a further period of four or five minutes, both quantities being analysed for carbonic acid.

The broad results obtained from this inquiry were as follows:

1. On rebreathing air in a closed vessel, less carbonic acid is expired in a given time than in ordinary breathing, a certain proportion remaining absorbed in the blood.
2. When fresh air is taken into the lungs immediately after rebreathing, the volumes of air breathed and carbonic acid expired are greater than in ordinary breathing.
3. When after the rebreathing stage fresh air has been inspired for five or six minutes the blood has recovered its normal state of aëration, and given out the whole of the carbonic acid which had been absorbed in the rebreathing stage.

Paul Bert has shown that animals, when left to die in closed vessels, are not asphyxiated from carbonic acid, but die solely from want of air, the phenomenon being the same as if they were submitted to diminished pressures corresponding to the proportion of oxygen left in the receiver in which they were confined.

In five of the above rebreathing experiments the mean percentage of the original oxygen which had disappeared was 19.2; the pressure corresponding to this reduction of oxygen would be 24.23 inches, equal to an altitude of about 7,480 feet; such a low altitude explains the absence of any

difficulty or distress in the breathing. On one occasion rebreathing was continued till the air in the bell jar contained 13.64 per cent. of carbonic acid and only 5.40 per cent. of oxygen, this percentage of oxygen corresponding to a pressure of 7.74 inches of mercury. The person under experiment felt very giddy, and the vision was obscured by a dark mist.

It is difficult to state the limit of altitude to which man can attain, because as he rises higher he needs less and less air; the secret of attaining to very great heights is training and time. Whymper reached an altitude of 20,517 feet on the Chimborazo, and Conway to 22,600 feet on the summit of the Pioneer Peak in the Himalayas.

Returning to the consideration of the influence of carbonic acid on respiration, it is often asked to what extent this gas can be breathed with impunity in the atmosphere. The subject has been investigated, amongst others, by Professor Emmerich and Dr. von Pettenkofer, who, in company with others, shut themselves up in a small vault of the Institute of Hygiene at Munich with bottles of liquid carbonic acid. Light was emitted from candles.

The gas was allowed to escape from the bottles, and when the lights went out most of the visitors left the chamber. Emmerich and Pettenkofer remained inside, and when seized with headache and discomfort took several samples of air, and then left the vault none the worse for the experiment. The analysis of the samples gave a mean of 8 per cent. of carbonic acid, which proportion can therefore be breathed for a short time without producing any serious effects. Rabbits have, according to Professors Friedländer and Härter, withstood for more than an hour 34 per cent. of carbonic acid; and even 60 per cent. was breathed for three-quarters of an hour, after which cramp and coma set in; after being exposed for a quarter of an hour in this 60 per cent. mixture, the rabbit quickly recovered in the open air.

ASTHMA.

Having said so much on respiration, allow me to offer a few remarks on a disease which is peculiarly one of the respiratory function, that is, asthma; and first of all, as an introduction to the subject, let us analyse the phenomenon of coughing. In coughing, a long breath is taken, which is exactly like a deep or forced inspiration, in which, as I have shown, a certain amount of carbonic acid is produced for work done, the oxygen being derived from that pre-existing in the contracting muscles, while a larger volume is displaced from the blood by a purely physical process; but though forced breathing is attended with but comparatively little work, in coughing the respiration is laboured, the muscles having to strain against the closure of the pharynx and forcibly expel the air from the lungs. This results in the production of an excess of carbonic acid, hence at the end of the expiration there is an increased amount of carbonic acid in the circulation.

After the forced expiration of coughing a deep breath is taken to supply the blood with a fresh quantity of oxygen and rid it of the excess of carbonic acid produced, and this process goes on till the fit of coughing comes to an end, then deep inspirations and expirations follow till the blood is again perfectly aired and the carbonic acid in excess completely eliminated. It therefore appears that in coughing there is a tendency to a want of oxygen and a distinct excess of carbonic acid in the blood, which are conditions met with, though in a much intensified form, in asphyxia. Now asphyxia is occasionally productive of spasms of the glottis, as seen in some cases of recovery from drowning, and might not the momentary want of air produced by a bad fit of coughing be the cause of asthma in people who are subject to it? The following observation was made by a physician who at times had severe attacks of asthma, though usually in the enjoyment of good health. On February 13th last, after taking a cup of tea at 2.30 A.M., loud wheezing and tightness of the chest came on, when a succession of forced inspirations had the immediate effect of arresting both the wheezing and tightness; a second attack the same night was averted in a similar manner. In this case the forced breathing returned to the blood the oxygen it was clearly in want of, while at the same time removing the carbonic acid.

I have shown in my third lecture that forced breathing is a means of supplying the centre of respiration with oxygen towards the respiratory phenomena; hence it appears to

follow that a deficient supply of oxygen to the respiratory centres has also something to do with asthma. In keeping with these remarks, it may be said that all circumstances productive of an excess of carbonic acid in the body and therefore of a deficiency of oxygen predispose to asthma. Cold and certain kinds of exercise do so pre-eminently, so does the ingestion of food, as happened in the case referred to above, where an attack of asthmatic cough came on pretty regularly two hours after dinner or at the time of the maximum production of carbonic acid from the meal.

A bad attack of asthma usually sets in with a sudden loud dry cough, coming on in the evening or at night; then follows a bronchial spasm during inspiration and the acute feeling of suffocation. After fighting for breath for ten, twenty, and in some cases thirty hours the respiratory muscles become very tired, and also volition towards the respiratory effort. Moreover, the impediment to breathing prevents oxygen reaching the centres of respiration to promote the exercise of volition for forced breathing; hence the power of the will becomes less and less.

It is difficult to reconcile the fact that some asthmatic persons find themselves better under lower atmospheric pressures, while others, on the contrary, suffer the moment they leave the sea level. This is apparently due to the circumstance that some persons take in oxygen more readily under low pressures, and others under high pressures. I cannot help comparing asthma in those who suffer under low pressures to a sort of mountain sickness—the higher they go the worse they are, and the moment they return into the lower plains the asthma passes off as by magic. If mountain sickness can be prevented by training for the exercise of climbing under low pressure, why should not asthma also yield to the training of the respiration, carried out by practising the respiratory movements wanted to carry the tidal air through the lungs to oxidise the blood and emit the carbonic acid, while imparting to the circulation a better tendency to work in perfect harmony with the respiratory requirements?

Of all means of training the respiration I think cycling is the best. When a person first takes to cycling he is troubled with shortness of breath, his heart beats uncomfortably, and his legs get tired, but after some training these discomforts all disappear. Why should not people liable to attacks of asthma also train their respiration by such a kind of exercise, of course on condition of the heart and lungs being in perfect health?

Cycling exercise first of all increases the depth of breathing, and that without fatigue, as the respiratory movements are automatic; at the same time it will accustom the rider instinctively to take in at each respiration the volume of air required to aerate the blood and to eliminate a fixed proportion of carbonic acid leaving in the circulation the precise amount compatible with health. In cycling, volition has also a good deal to do towards exercising the motor centres to take in the exact volume of oxygen required for that kind of work. Persons who do not care for cycling out of doors can take the same description of exercise at home by means of a dummy cycle.

My experience of the results of this treatment is unfortunately limited to one person; in which case it has proved eminently successful. This person took to bicycle riding three years ago for pleasure and afterwards on account of his health. He observed last summer that the attacks of asthma to which he was subject had become very much fewer, having only suffered two since last October, both of these being brought on by exposure to cold. The tightness and wheezing which occurred every night have nearly entirely disappeared, his sleep, which for years had been restless and broken, has very much improved, and all this he ascribes in a great measure to the use of the bicycle.

Allow me, gentlemen, to summarise shortly the Croonian lectures for the present year.

In the first lecture the oxygen of the atmosphere was shown to be the main agent of life, and Hermann's discovery that oxygen is an integral part of the tissues was appealed to with the object of explaining the remarkable tenacity of life of certain organisms—such as seeds. Next came an attempt to explain that it is not the oxygen of the air which, by offering itself to the tissues, produces the phenomena

of metabolism, but that the living tissues call upon the oxygen to effect the changes they undergo. The influence of tissues as the prime movers in the matter was shown by the action of cold, which, through the nervous system, first increases their vitality and consequently their demand for oxygen, though when the cold is excessive it exerts an influence the reverse in its character. Muscular exercise invariably tends to the production of carbonic acid in excess; and this led to some remarks on the temperature of the body while in the act of ascending. It was concluded that with some people there is a slight increase and with others a slight fall of temperature.

The second lecture was prefaced with a short allusion to past investigations on human respiration; then followed the history of the different forms of breathing, which were illustrated by tracings (reduced in size) taken directly from the person under experiment. Attention was also drawn to the interesting phenomena of the absorption of oxygen in the body independently of the formation of carbonic acid, and a number of analyses were quoted showing to what extent this absorption takes place.

The third lecture was given up entirely to the influence of volition on the respiration. It was shown that volition towards any kind of muscular exercise, including forced breathing, is attended with the absorption of oxygen in excess, and that this oxygen is necessary towards the performance of volition, and, if necessary to volition it must be taken up by the motor centres of volition. A remarkable effect on the development of muscular force by this charging of the motor centres with oxygen was shown to take place. Finally, an experiment was described in which, volition becoming tired out, the muscles refused to work; this experiment being in keeping with Mosso's discovery.

The fourth lecture was devoted first of all to an account of the influence of climbing on the respiratory changes, and on the state of the respiratory phenomena at high altitudes. Next rebreathing and air breathed under pressure were considered, and it was explained that the effect of rebreathed air was apparently due more to the want of oxygen than the absorption of carbonic acid. After a few remarks on the effects of breathing mixtures of carbonic acid and common air, the lecture was concluded with an allusion to asthma, and a method of treatment suggested by the considerations which may be looked upon as the substance of these four lectures.

CATS AND DIPHTHERIA.

By WILLIAM WILLIAMS, M.A., M.D., D.P.H. OXON.,
Medical Officer of Health to the Glamorgan County Council.

I have read with interest in the *BRITISH MEDICAL JOURNAL* of June 29th your remarks under the above heading, calling attention to the possible association of diphtheria in human beings and a suspicious illness amongst cats.

Some years ago, when acting as deputy and assistant to Dr. Thursfield, M.O.H., Shropshire, it was my lot to investigate a limited epidemic of diphtheria coincident with the deaths of three cats in one of the infected households.

In the month of December, 1889, a limited epidemic of diphtheria took place at and in the neighbourhood of an agricultural village in Shropshire.

Thirteen cases, one of which proved fatal, occurred amongst five families. The first case occurred on November 7th, at the house of Mrs. L. (in the village), in the form of a slight sore throat, but that it was of an infectious nature is clear from the fact that the children at this house, eight in number, all suffered more or less severely since that date, including a grown-up daughter who came home at the time, and was laid up with a sore throat a few days after.

The second case—taken ill November 26th—was that of a child of Mr. B., whose house was quite a mile distant from the village.

The third case was that of a servant girl of Mrs. R., next door to Mrs. L. (in the village), who suffered very severely from marked diphtheria, but ultimately recovered. The fourth and fifth houses to be attacked were in the same street.

At Mr. B.'s there were three cats kept. All these cats were