sumption is said not to be uncommon in Palma. It is the same in all the large close towns of the Mediterranean, no doubt principally from defective ventilation. Night air is feared all over the Mediterranean, and windows are shut at sunset only to be opened next day. Intermittent fever, as I have stated, is very common in summer and in autumn in every region of these islands—in Minorca, which is a mere rock, without a rivulet or a marsh, as in Majorca—quite irrespective of marshes of any description. This fact explains the climate of Cyprus, and its assumed unhealthiness. Both islands, Cyprus and Majorca, have the same kind of climate: what may be called the Mediterranean climate. A large body of troops disembarked in midsummer in Majorca, and located on the healthiest and driest plains, and then treated as if they were at Aldershot, would have the same fate that our troops had in Cyprus. I never could understand how or why our army medical men, knowing, as they must do, from their experience of Malta and Corfu, the natural history of the Mediterranean climate, could have allowed such a foolish irrational step to be taken, without at least making a formal protest.

The conclusions at which I arrived, after a careful survey of the two principal islands of the Balearic group, are, that they cannot be recommended to invalids as winter residences. The climate is mild and moist in winter, it is true, which would agree with some forms of chronic disease. It is as mild and moist, apparently, as that of Algiers; but the winds are too constant and too vehement, and the storms and rains, when they occur, are too violent in the winter seasons. The mountain range on the north-west is not sufficiently high or wide to exhaust these storms coming from the north, and to protect the island from their influence. Indeed, there appears to me to be no condition that makes

these islands preferable to the mainland of Malaga, Muria, Elche, Alicante, Valentia (see my work on the Mediterranean, chapter ix, Spain). I must add that there is no accommodation whatever for invalids. The inns at Palma are simply vile, and there is no other refuge for them in this large city. Invalids appear to be neither wanted nor cared for. The Spanish invalids must be taken in by friends and relations, for I failed to discover any place to which they could go. Out of Palma, in the numerous villages, there is simply no good accommodation to be found. Port Mahon, it is true, does contain a decent *posada* or inn. It was so long in the possession of the English that, like Corfu, it still shows many of the evidences of our civilisation. But there is nothing in Minorca to attract the stranger, except the mildness of its climate, the facilities its long beautiful port gives for boating, and a fine old cathedral.

The Balearic Islands, in conclusion, seem to me merely suited for a spring tour in April or May, such as I made. Then they are truly delightful, and the tour, allowing for bad accommodation, was to me a most enjoyable and fascinating one. For further information respecting these islands, I would refer to the appendix of the third edition of my work on the *Treatment of Consumption*, to the work I have quoted by Fernando Weyler, *Topographie Physico Medicale des Iles Balears, Palma, 1854*—if it can be obtained, which I failed to do—and to M. George Sand's *Un Hiver à Palma*. Although merely a literary production, the latter work gives a most graphic, and no doubt a true, description of the winter climate of Palma, and of the island in general, as also of the difficulties of social and material life.

ON THE INFLUENCE OF ALTITUDE WITH REFERENCE TO THE TREATMENT OF PULMONARY DISEASE.*

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

THE following communication may be divided under three heads.

1. The effects usually produced on a person in good health on ascending high mountains.
2. The influence of altitude in disease, with especial reference to pulmonary affections.
3. The influence of altitude upon respiration as accounting, in a great measure, for the beneficial effects of high stations in some cases of phthisis.

When, from a low altitude, approaching that of the sea-level, a walk is taken over high cliffs or a neighbouring hill, a sensation of easy breathing is experienced, the body appears to feel lighter, and a state of general vigour and comfort ensues. If a mountain a few thousand feet high be ascended, the sensations experienced on low hills are intensified, the breathing becomes fuller, and a pleasurable excitement from the pure state of the atmosphere, united to Alpine scenery, well repays the fatigue of the climb. Seven or eight thousand feet in the Alps appear to be the limit which those accustomed to mountaineering usually attain with perfect comfort; above that height, the respiration, in the sitting posture, begins to indicate infrequency, although in an unconscious way; the breathing also becomes deeper, and an unpleasant nervous discomfort is often induced, productive of fatigue, and interfering with sleep at night. At ten or eleven thousand feet, the cold from the low temperature of the atmosphere, and increased evaporation from the skin and lungs, begins to be seriously felt, mostly at night, when no amount of blankets can keep the body warm. After a chilly restless night, an attack of mountain sickness is not unlikely to set in at three or four o'clock in the morning; and, although attended with considerable distress, resembling very much that of sea-sickness, the attack may have passed off altogether in time for a fairly early start for some higher altitude. I need not add that those who are in good training for mountain excursions can rise to a very great height without inconvenience, or any degree of ill-health.

A sojourn of eight days in succession, in 1875, on the well known pass of St. Theodule (10,899 feet), another of three days, this last summer, at 11,050 feet (Col Sen Géant), and excursions to much greater heights, have afforded me many excellent opportunities of observing the influence of altitude on health. It is singular that the power of digesting food should often fail at a considerable elevation above the sea; as a rule, tourists eat little; their guides have a large share of their provisions to fall back upon, and to that they usually do not fail to do justice. It is not that the appetite is at fault, but, after partaking of very little food, there is no desire for more; and the food taken is often

* Read in the Section of Medicine at the Annual Meeting of the British Medical Association in Cambridge, August 1880.

digested but slowly and with difficulty. I conclude, from my own experience, that milk, coffee, tea, bread and cheese, chocolate, and dried fruit, are about the best articles of food at great altitudes, and a great deal of physical work can be done upon them; it is remarkable that such a diet is precisely that which Dr. Edward Smith has found experimentally, to yield most carbonic acid in the body. After living some days on such a short allowance of food, and returning into the plains or valleys, where good hotels are to be found, it is wonderful how keen an appetite is felt, and how much can be eaten and digested with the greatest ease. A stay of a few days at an altitude of about 11,000 feet in the Alps, is productive of fatigue and debility, with an undefinable state of discomfort; there is a peculiar harshness of the air breathed, and a great desire to return into lower altitudes. This I fully experienced at St. Theodule, and I believe my guide, although more accustomed than I was to such a kind of life, was not sorry when the time came to move downwards. The feeling of comfort after descending only a thousand feet was most marked, and the relief to the respiration very positive. A similar grateful sensation was experienced after a stay of three weeks on the Peak of Teneriffe; but it was due in this case not only to the increased density of the air as we progressed downwards, but also to the greater atmospheric humidity. After living under a nearly tropical sun, we entered the zone of trade-wind clouds which surrounds the peak up to between five and six thousand feet, and has a thickness of about 2,300 feet; the sensation on losing sight of the sun, and breathing the damp fog in a denser atmosphere, was exceedingly refreshing.

On rising above the sea, less and less oxygen is held in a given bulk of air, although remaining the same relatively to the nitrogen; and the atmosphere becomes, as a rule, colder and drier, the dryness being, of course, especially conspicuous in fine weather. The air also contains a smaller proportion of carbonic acid, and is freer from organic germs productive of fermentation and putrefaction. On the other hand, the sun becomes more and more powerful, as it passes through a smaller thickness of the atmosphere before reaching the earth, and a thinner layer of atmospheric moisture, the latter absorbing the sun's heat very readily.

The amount of carbonic acid in the atmosphere at increasing altitudes is an important circumstance to notice. Not long ago, it was thought that there was rather more carbonic acid in the atmosphere at an altitude of six or seven thousand feet than at the sea-level; recent experiments, however, by M. Truchot, have shown that such is not the case, and that the carbonic acid in the air undergoes a somewhat rapid reduction at increasing altitudes; thus, at an altitude of 1,296 feet, he found 3.13 parts of carbonic acid in 10,000 of air; and, at 2,056 feet, its proportion had fallen to 1.72 in 10,000. I have myself been surprised on various occasions on noticing to what a comparatively small extent air precipitates a solution of hydrate of barium at ten or eleven thousand feet high. While I was engaged experimenting on the Col St. Theodule (10,899 feet), a pool of glacier-water freely exposed to the atmosphere was found to be absolutely free from carbonic acid, but perhaps the temperature of the water may have had something to do with the circumstance. The presence of a comparatively small proportion of carbonic acid in the air breathed on high mountains must be beneficial to health in cases of diseased lungs. The air breathed is certainly the more pure on that account, although, with healthy people living at the sea-level, and in the midst of a luxuriant vegetation, the amount of that gas which they inhale is perfectly consistent with health. If an excess of carbonic acid in the atmosphere, beyond its normal proportion, is known to be injurious where a disposition exist to consumption, it is but natural to conclude that, the smaller the amount of that gas in the air breathed, the more likely will it be to agree with such patients. The fact that the entire vegetation at Davos is concealed under a thick coating of snow throughout the winter, must assist in keeping the proportion of carbonic acid in the air breathed very low indeed.

As to the organic germs in the atmosphere, from Dr. Tyndall's experiments, they may be considered absent, or nearly so, in the atmosphere of such a place as Davos, except, of course, inside or in the immediate proximity of a dwelling.

The heat of the solar rays, as previously stated, is much greater on the mountains than at the sea-level; thus the sun may act with great power through an atmosphere which is nearly freezing. The air itself absorbs but little heat; and at Davos, as soon as the direct rays of the sun are hidden, either by a passing cloud or the shade of some other object, an immediate transition from great heat to a piercing cold is often experienced. On the Peak of Teneriffe, under the twenty-eighth degree of north latitude, Mr. Piazza Smyth, the well known astronomer, has reckoned that the temperature of the direct sun-rays at 9,000 feet amounts to no less than 212° , or the boiling point of water at the sea-side. I have seen, on that very mountain, water left in a plate on the

hot sand in the evening, to be frozen next morning into a solid mass of ice.

The intensity of the sun's light on stations situated at about 5,000 feet above the sea is a circumstance also well worth taking into account. The brightness of the sun's light is certainly one of the great attractions of the Riviera, and no doubt but this is an important feature of a climate for consumptive invalids. There are direct experiments bearing on this subject. Moleschott, in 1855, observed that light had a distinct influence on the production of carbonic acid in animals, and he concludes from his inquiry: 1. That frogs of similar weights, and in equal periods of time, exhale from one-twelfth to one-quarter more carbonic acid when breathing under the influence of light than while in the dark, so long as the temperature remains the same or varies but slightly; 2. That the production of carbonic acid is greater and greater in a direct ratio with the increase of the light to which the animals are submitted; 3. That the influence of light towards an increase of the amount of carbonic acid expired acts partly through the eyes, partly through the skin. The excess, however, of heat and light at great altitudes, especially when the earth is covered with snow, may be productive of ill-health; and people wintering on mountain stations should be warned against the glare of the sun, lest their eyes should become affected from this cause. Snow-blindness in the high Alps is not uncommon, and I had an opportunity of seeing a severe case of this painful affection at Chamounix not long ago.

The Influence of Altitude on Health.—It is well known that a moderate altitude exerts a bracing or tonic influence on health; and this applies, not only to the air of mountains, but to that of places raised but a few hundred feet above a patient's dwelling. I have had many opportunities of testing the beneficial influence of the hills skirting the Mediterranean coast, and have obtained excellent results by sending cases of phthisis with acute symptoms from the sea-level either to the hills at the back of Nicé, or to the picturesque slopes rising near Cannes. These stations, if on the top of a hill or a raised plateau, are rather colder than the seaside, but they are somewhat warmer if situated on a slope facing the south. It is quite remarkable what benefit intractable cases of hæmoptysis, for instance, often derive from such a change. The continued influence throughout a whole winter of a high station, such as Davos, must be considered to some extent as different from that resulting from a stay of a few days only in such a place. Experience certainly shows that any prolonged strain of the functions of the body must prove objectionable. Those who are born in the mountains, and have never left them, are in their normal condition under light mountain air, and it will be a strain on their functions to take up a residence near the sea-level. A long-continued stay on high mountains is well known to be productive, for the inhabitants of the plains, of exhaustion, debility, loss of energy, and want of reaction against external influences. Dr. Lombard, Dr. Jourdamiet, and M. Paul Bert, who are well qualified to express an opinion on the influence of mountain climate, bear out this view. I have been told by the monks of the Great St. Bernard (8,115 feet) that, although they are all young, strong, and healthy, and indeed men selected for the work, most of them are obliged to leave, after a residence of one or two years, from ill-health and exhaustion, and most, if not all, of them lose their energy more or less.

The Influence of Altitude on Disease, with especial reference to Pulmonary Affections.—There is abundant evidence to show that phthisis is nearly unknown amongst the inhabitants of altitudes of 5,000 or 6,000 feet, and higher—a fact, the explanation of which will be found, I think, in the last portion of the present communication. They are subject, however, to other diseases, and can hardly be considered, I should say, as living so long and healthy an existence as the inhabitants of the plains, who, moreover, enjoy more comforts, and have, as a rule, better food.

Inflammatory diseases are more frequent amongst the inhabitants of the mountains than those of the plains; and Lombard remarks that, in the highest towns in Europe, nobody can be found who has not suffered repeatedly from what Dr. Albert of Briançon calls "inflammatory fever without any local affection" (*sans localisation*), ending with perspiration, loaded urine, and a slight eruption at the lips. Bronchitis, asthma, emphysema, pneumonia, pleuropneumonia, and pleurisy are amongst the most frequent diseases met with in mountain towns and villages, such as those situated on the high plateau of the Engadine in Switzerland. At Chamounix, about one-fifth of the death-rate is said to be owing to pneumonia.

Rheumatic affections are very common amongst mountaineers in northern latitudes, although nearly unknown, according to Dr. Tschudi, on the high plateaus of Peru. Dr. Lombard considers rheumatism as mostly prevalent under a climate free from extremes of cold or heat. My own experience is quite in accordance with this observation; and I

well recollect, when engaged with the out-patients of the Westminster Hospital, that, in the spring of the year, cases of pulmonary affections, frequent in winter, fell off rapidly, and were replaced by rheumatic affections.

The stomach is not unlikely to suffer after a prolonged stay above six or seven thousand feet: the St. Bernard monks complained much to me of gastric symptoms. Under the tropics, diarrhoea and dysentery prevail in mountainous regions; and, according to Lombard, they form, together with affections of the liver, about one-sixth of the total number of deaths.

Hæmoptysis certainly appears checked by removal from the plains into the mountains. It is remarkable that inflammations of the lungs and air-passages should be so prevalent in high regions, although the reverse be the case with phthisis; a circumstance appearing to show that there is a greater difference between tubercular disease and inflammation of the lungs than is usually supposed. Are we also to conclude that, above 5,000 feet, pneumonia, although common, does not run the same course as it often does in the plains, and yields no caseous deposit likely to soften down and give rise to a cavern?

If pulmonary inflammation be common in mountainous districts, it is not so on the Riviera and Mediterranean coast; people live there under the full atmospheric pressure, and winter in a comparatively warm genial climate; breathing is carried on quietly and regularly, and every precaution is taken to avoid the cold air, which is usually limited to the early morning and after sunset. Hence there is no excitement of the pulmonary circulation, and no increase of cold in the pulmonary organs, from evaporation of moisture from the air-passages. The consequence is, that those who suffer from bronchitis in England, when the cold weather and fogs begin in autumn, experience great relief on the Riviera and Mediterranean coast. So far, the difference between the influence of mountain air and the Mediterranean climate is most clearly defined. We now come to the main point of the present communication, namely:

The Influence of Altitude upon Respiration as accounting in a great measure for the Beneficial Effects of High Stations in some Cases of Phthisis.—On first undertaking, in 1875, an experimental inquiry on the influence of altitude upon respiration, I little anticipated obtaining a result which was likely to throw much light on the influence of high winter stations on the progress of phthisis. My first paper on the subject was published in the *Proceedings of the Royal Society* for 1878, and a second in 1879. My experimental stations were situated, at the following altitudes, in Switzerland: Yvoire (near Geneva), 1,230 feet; the Great St. Bernard, 8,115 feet; the Reffel (Zermatt), 8,428 feet; the St. Theodule Pass, 10,899 feet; the summit of the Breithorn, 13,685 feet; and in the Island of Teneriffe, 7,090 feet; on the Peak of Teneriffe, 10,720 feet. My present object is to limit myself to those results which bear on the subject of the present communication.

The first point is the increased bulk of air breathed, under low barometrical pressure, in order to supply the necessary amount of oxygen to the lungs. The following were the results obtained.

Air Expired per Minute.

Air actually Expired per Minute.		Air Expired per Minute reduced to Freezing-point and Seaside Pressure.	
ALPS.			
Altitudes.	Litres.	Litres.	Temp.
1,230 feet	5.66	5.14	57.3
8,115 "	6.05	4.42	43.7
8,428 "	6.50	4.64	52.4
10,899 "	5.03	4.67	39.2
13,685 "	7.94	4.85	34.9
TENERIFFE.			
Seaside	6.44	5.34	—
7,090 feet	7.62	5.47	—
10,700 "	8.07	5.14	—
11,745 "	8.04	4.99	—

It is seen, therefore, that the volume of air breathed does not increase exactly in the same ratio as the atmospheric pressure falls, although there is an approximation to such a change; but the amount or weight of air or oxygen inhaled shows a decided tendency to diminish as altitude increases. This is seen in the Teneriffe experiments more distinctly than in those undertaken in the Alps; but, in the latter series, the mean of the experiments at the high stations yields 4.65 litres (reduced) of air expired per minute; while 5.14 litres are expired at the lowest station, the difference amounting to 9.5 per cent. In the case of the Teneriffe experiments, a similar calculation gives, oddly enough, exactly the same reduction. Now, 9.5 per cent., or nearly one-tenth, less oxygen taken into the lungs constitutes a very great change in the function of respiration. It would appear, at first sight, that a fall in

the amount of carbonic acid expired at increasing altitudes might be expected, as less oxygen is taken in. I have shown, however, that, far from this being the case, there is critically an increased amount of carbonic acid expired by a person as he rises above the sea in the Alps, the extreme extent in my case amounting to 15 per cent., at an altitude of 13,685 feet. My experiments on the island of Teneriffe show that near the tropics, and probably also between them, the amount of carbonic acid expired cannot be considered as increasing as the atmospheric pressure falls; the difference between my results, under the two latitudes, being obviously due to the temperature of the air, which is high and nearly uniform on the Island and Peak of Teneriffe, while it falls considerably at high altitudes in the Alps. It may therefore be concluded that, as a tourist rises on the Alps (by tourist is meant an inhabitant of the plains who finds himself under new physiological conditions in the mountains), and while in the sitting posture and remaining perfectly quiet, he will take in a smaller weight of air than he usually does, and give out more carbonic acid. If such be the case, the same weight of carbonic acid will require the inhalation of less oxygen high up in the Alps than at the sea-level. On the island of Teneriffe, although there is no particularly marked increase of carbonic acid expired high up on the Peak, still, as the air breathed undergoes a positive reduction, the same remark will hold good—namely, that on the higher stations the carbonic acid expired will require, comparatively, the inhalation of a smaller quantity of oxygen. The following is a table showing the proportions of air expired corresponding to the expiration of one *gramme* of carbonic acid, both in the Alps and at Teneriffe.

Altitude.	Temperature of the Air.	Carbonic Acid Expired.	Litres of Air Expired Reduced.
THE ALPS.			
1,230 feet	57.8 deg. Fahr.	1 <i>gramme</i>	1.36
8,115 "	43.7 " "	1 " "	1.04
8,428 "	52.4 " "	1 " "	1.14
10,899 "	39.2 " "	1 " "	1.16
13,685 "	34.9 " "	1 " "	1.08
TENERIFFE.			
Seaside	75 " "	1 " "	1.24
7,090 feet	69.6 " "	1 " "	1.19
10,700 "	64.2 " "	1 " "	1.18
11,745 "	64.0 " "	1 " "	1.06

Nothing can be clearer than the result I have obtained. In the Alps, the experiments made, at altitudes varying from 8,111 feet to 13,685 feet, show that the mean amount of air expired at such altitudes corresponding to one *gramme* of carbonic acid amounts to 1.105 litres; while at 1,230 feet, in the neighbourhood of the Alps, the volume of air expired for one *gramme* of carbonic acid amounts to 1.36 litres, the difference being, therefore, 19 per cent. It may therefore be said that 19 per cent. less air (in weight) was required to make one *gramme* of carbonic acid in the body at these altitudes than at 1,230 feet.

On the Peak of Teneriffe, the expiration of 1.143 litres of air (reduced), at altitudes varying from 7,090 to 11,745 feet, corresponds to one *gramme* of carbonic acid; while, at the seaside, the volume of air expired, for the same weight of carbonic acid, is 1.24 litres, giving 8.8 per cent. less air for one *gramme* of carbonic acid at the high stations than at the seaside.

These results, obtained from a great number of experiments, at altitudes varying considerably, and under different latitudes, certainly show that the inhalation of a smaller weight of air is required for a similar degree of animal combustion on the mountains than near the sea-level; or, in other words—

The air breathed finds its way more readily through the pulmonary tissue into the blood at a certain altitude than nearer to the sea-level; and this law applies equally to various latitudes, although less marked in the South.—This phenomenon must be intimately connected with the influence of mountain stations on consumption; the increased readiness with which the oxygen of the air finds its way through the pulmonary tissue into the blood being clearly opposed to the progress of tubercular disease. It is also apparently this same circumstance which makes consumption so rare amongst the inhabitants of places situated at certain altitudes above the sea.

BEQUESTS, ETC., TO MEDICAL CHARITIES.—Mr. Peregrine Hogg Purvis, of Winchmore Hill, bequeathed £100 each to the Earlswood Asylum for Idiots, the British Home for Incurables, the Metropolitan Free Hospital, the Royal Free Hospital, the City of London Hospital for Diseases of the Chest, and Dr. Laserson's Deaconesses' Institution and Training Hospital at Tottenham.