

**The high altitudes of Colorado & their climates : an address delivered to the Royal Meteorological Society, January 18th, 1893 / by C. Theodore Williams.**

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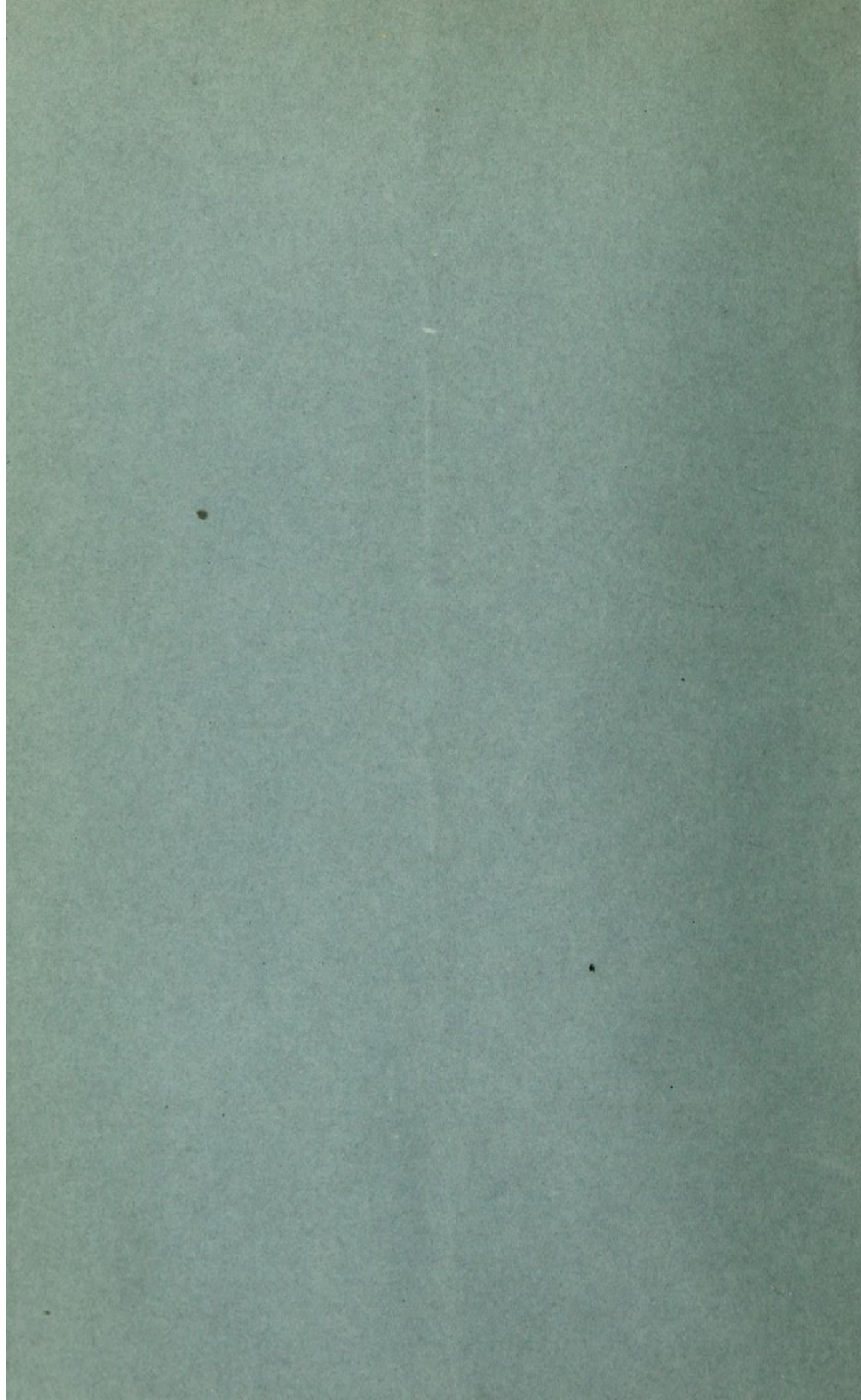
# THE HIGH ALTITUDES OF COLORADO & THEIR CLIMATES.

An Address delivered to the Royal Meteorological Society,  
January 18th, 1893.

By C. THEODORE WILLIAMS, M.A., M.D., F.R.C.P.

PRESIDENT.





With the author's kind reg

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I HAVE chosen as the subject of my Address to-night, the high altitudes of Colorado and their climates, because the climates of high altitudes have not been prominently brought before the notice of this Society, but it is a subject which is exciting great and increasing interest in the medical profession and among the public, and the influence for good or for evil of these climates on human beings is undoubted. The topic has been partially discussed by Dr. Tucker Wise and myself in this Society, and by others in the Medical Societies, in reference to the Swiss Alps, but, as far as I can remember, no other mountain group has been treated of here, though the works of



Archibald Smith, Denison, and Kellet have given some valuable contributions elsewhere with regard to certain mountain ranges.

It has fallen to my lot to study the effects of elevated regions on hundreds of pulmonary invalids during the last 25 years, and such study has resulted in the formation of very decided conclusions, which now guide my practice; but these, being medical, are quite outside the province of this Society, and therefore I do not propose to discuss them, but to deal with the special meteorological features of these elevated regions, which exercise so remarkable an influence on human life.

Mountain climates, though classed together, vary in temperature, moisture, and wind prevalence, according to latitude, relation to land and water, and relation to other mountain ranges; but they have one common feature—to wit—diminished barometrical pressure, varying with the altitude, and itself giving rise to another peculiarity of mountain climates, diathermancy, which greatly influences animal and vegetable life; of this more will be said presently.

Naturally, too, we should expect that the atmosphere of mountains should be cooler than that of plains, and being cooler, it is incapable of holding in suspension as much moisture, and is therefore drier. Here again the position of the range comes in, for if, as in Assam, the mountain lies in the track of a wind laden with moisture, such as the South-west monsoon, the mountain causing the current to ascend, serves as a condenser, by lowering the temperature, and we get an annual rainfall, like that of Cherapunji, of 493 ins. If, on the other hand, it lies like the American Rockies to the lee of other ranges, such as the Sierra Nevada and Wahsatch mountains, the rainfall is moderate, and the climate dry.

There is another class of phenomena which is very remarkable in mountain climates, viz. the electrical, for from their position mountains are the natural conductors of terrestrial and atmospheric electricity, and it is no wonder that they are the scene of marvellous displays, as we shall hear when we allude to Pike's Peak.

The climate of Colorado is my text to-day, first, because I have lately returned from an interesting visit there, undertaken for the purpose of investigating the leading characteristics of the Rocky Mountains, and secondly because the situation of this chain in the heart of a great continent, far away from the sea or any large body of water, renders it especially fitted to serve as a type of a mountain climate. The annexed chart (Plate VI.) founded on a relief map of the United States, supplied to me free of cost by the Geological Survey at Washington, with that liberality which distinguishes the U. S. Government in all its scientific relations, will show that west of the Mississippi Valley a gradual rise takes place, which is still more marked when we reach longitude  $99^{\circ}$  W; the line of elevation extending from north to south of the United States; and here a height of from 2,000 to 5,000 ft. is reached. This comprises the vast prairie lands of North and South Dakota, Nebraska, Kansas, and part of Texas, a great portion of which are now cultivated farms. West of this we observe a further elevation, limited chiefly to the States of



Wyoming, Colorado, and New Mexico, of from 5,000 to 8,000, 11,000, and even over 14,000 ft. in the Rockies themselves. It is in these three States that we find the localities which are utilised, or likely to be utilised, as health resorts. The Rocky Mountains run nearly north and south, through British North America and the United States, and consist of a more or less distinct central chain and spurs running in various directions.

In the United States the range appears to bear different names in different States. In Montana it is called the Rocky Mountains, in North Wyoming the Bighorn Mountains, in South Wyoming the Black Hills, the spur running transversely from the main chain into the territory of Utah is called the Wahsatch Mountains, a portion of which is known as the Uintah Mountains and forms, with the last mentioned, a feature in the beautiful view from Salt Lake City. The range extends over a large portion of the State of Colorado, is penetrated by various valleys and streams, including the famous Rio Grande, and here rises to its greatest elevations; most of the grand peaks, Sierra Blanca, Mount Lincoln, Long's and Pike's and Gray's Peaks being situated within the confines of this State. The main range ends in the beautiful Spanish Peaks, but a portion, passing to the west, extends into Arizona, a large proportion of which State is elevated ground.

In the State of Colorado are various chains of the Rockies, two of which, running north and south, are called Front and Park ranges. These enclose between them the great natural parks—North, Middle, South, and San Luis Parks—which are wide valleys of pasture land at a high altitude, sheltered from winds, and surrounded by beautiful scenery. North Park stands at an elevation of 8,000 ft., and contains 2,500 square miles. Middle Park, which has a warmer climate, is 65 miles from north to south by 45 miles from east to west, and embraces about 3,000 square miles, 7,500 ft. above sea level. Communicating with it are Estes Park, Antelope and Manitou Parks, to which we shall refer presently.

Middle Park is enclosed by grand mountains; Long's and Gray's Peaks and Mount Lincoln; it contains beautiful meadow land and some celebrated sulphur springs. South Park is 60 miles long and 30 miles wide, including 2,200 square miles of, for the most part, pasture land, at an elevation of 9,000 ft., and it has a milder climate than the other two great parks. South of these is the San Luis Park, larger than all of them combined, and containing 18,000 square miles with an elevation not exceeding 7,000 ft., and its more southerly latitude, combined with a very abundant water supply, causes it to be more thickly wooded than the others.

All these parks enjoy fine climates; the wilder parts abound in elk, deer, mountain sheep, antelopes, bears, wolves, lynx, mountain lions, coyotes and beavers, and the streams supply plenty of trout. Cattle pasture all the year round without shelter or covering, and thrive on the abundant grass. It is supposed by Dr. Denison<sup>1</sup> that these parks were once beds of immense bodies of water, lakes in fact, which breaking through their rocky barriers cut deep

<sup>1</sup> *Rocky Mountains Health Resorts.*



rugged gorges or cañons, over which the rivers have flowed for centuries, depositing their *débris* in the foot hills and plains.

The deep gorges, or cañons, are a remarkable feature of the Rockies, as they may be found penetrating the chain in many directions. They are clearly the result of water action, and the various layers of strata cut through and exposed are well shown in the neighbourhood of Denver, where we have a good example in Clear Creek Cañon, where the river, starting from the base of Gray's Peak, has forced its way through a labyrinthine channel eastwards to the plain at Golden.

A grander cañon is that of the Arkansas, which is the line taken by the Denver and Rio Grande Railway in penetrating the Rockies. In parts, owing to the narrowness of the gorge and the great height and precipitous character of the giant granite cliffs and mountains through which the Arkansas threads its way, the scenery is magnificent. The forms of the rocks are specially fine, a specimen of which is seen, for instance, in the Currecanti needle, a fine pyramid of granite, and the mountain of the Holy Cross, which owes its name to the form of the Cross being delineated by snow accumulating in crevices in its rocky sides. The grandest piece of scenery on this route is the Royal Gorge, where the chasm is so narrow that there is only space for the river to flow through, and the railroad is therefore suspended by an ingenious bridge above it for some distance, the cliffs on either side reaching the height of 2,600 ft. Another striking mass of rocks is the Castle Gate, the fine portal by which the railway escapes from the gorges into the more open valleys on the western side of the Rockies.

This cañon of the Arkansas is surpassed in grandeur and wild magnificence by the great cañon of the Colorado, situate in Arizona, where that river boils and surges at the bottom of the greatest cañon in the world, one mile in depth, with nearly precipitous and beetling cliffs on either side, but this is outside of the State of Colorado.

The railways encircle, and in many cases penetrate into the region of the parks. The Denver and Rio Grande sends branches up several of the smaller cañons opening into them, while Middle Park is traversed by both the Denver and Rio Grande and by the Midland of Colorado, so that the district is rendered fairly accessible. Moreover the numerous towns, for the most part mining centres, like Leadville, scattered throughout the Rockies, or situated like Denver on the adjacent plains, amply supply the wants and necessities of residents and of camping out visitors.

The peaks of the Rocky Mountains vary in altitude from 13,500 ft. to 14,500 ft., the highest being the Sierra Blanca, which terminates the Sangre de Cristo chains; there being more than 100 peaks exceeding 13,500 ft. in height, and Gray's and Pike's and Long's Peak all exceed 14,000 ft., the general average being higher than in the Swiss Alps.

In appearance, however, they are not nearly so imposing as the Alps; they rise from a higher plateau varying from 5,000 to 6,000 ft. in height, their outlines are more rounded, the lower slopes, probably on account of the great dryness of the atmosphere, are less wooded, and for the same reason and also



because of the lower latitude the summits have less snow massed on them and no glaciers furrow their sides. The absence of cloud and mist causes their outlines to be very clearly defined even at great distances, and they form a fine feature at the ends of the tree-lined avenues of both Denver and Colorado Springs.

The geology and mineralogy of the Rocky Mountains are too complicated subjects for me to deal with, (especially as, according to the Denver and Rio Grande prospectuses, all known minerals are found there!) but the greater part consists of masses of granite rising beyond an outer stratum of red sandstone, which last forms the very weird and picturesque rock scenery of Monument Park and the Garden of the Gods among other instances. The colouring of both granite and sandstone is very vivid and rich in tone.

The Rockies, as will be seen by our maps, form the greater part of the State of Colorado, the eastern portion consisting of the Prairie, which extends far to the east and north, and in this State has an altitude of about 5,000 ft. Between Denver and Colorado Springs a spur of the range runs eastwards into the prairie called the Divide, in which lies Castle Rock, Perry Park and Palmer Lake, but south of this the great plain extends to the Gulf of Mexico, 800 miles.

We must therefore remember that in Colorado State there are four series of elevations, viz.:—

1. The snow clad peaks, 12,000 to 14,000 ft. and upwards in height, with a climate of their own.
2. The natural parks, varying from 7,000 to 10,000 ft. in altitude.
3. The foot hills and adjoining valleys, rising from 6,000 to 7,000 ft.
4. The prairie plains, varying from 5,000 to 6,000 ft.

The first class is of course useless for health station purposes, but the last three might be made available and offer an infinite variety of altitude and of climate.

Having described the general conformation of the country, we come to its meteorology as a whole, and the annexed map (p. 70) of the Weather Bureau of the United States will give some idea of the distribution of the rainfall.

In Colorado the rainfall varies from 8·71 ins. to 22·30 ins., at Denver it is 14·17 ins., at Colorado Springs 15·17 ins., and at Santa Fé, the capital of New Mexico, 14·17 ins. It does not appear to increase with altitude, for Gunnison, 7,680 ft. in the heart of the mountains, has only 10·02 ins., and Leadville, at 10,200 ft., only 12·80 ins. Georgetown has 14·39 ins.; Pike's Peak, with its great elevation and consequent liability to act as a condenser, has a larger rainfall, viz. 29·18 ins., but this is after all small in comparison with other high peaks. The western stations, such as Fort Lewis, seem to have larger rainfall than the eastern.

Throughout Colorado scarcely any rain falls from October to April, and the greater part is precipitated during the thunderstorms which are so frequent from May to September. Snow occasionally falls in autumn and winter, but except at the higher levels, does not lie.



Relative humidity returns from several portions of the State show a percentage varying from 46 to 58 per cent., contrasting with those of the Pacific Coast, such as at San Francisco 78, and at St. Louis, in the valley of the Mississippi, 78, or on the Atlantic, as exemplified by New York, 75 per cent.



Mean Annual Rainfall of the Western States.

The average amount of cloudiness in Colorado, as given in Dr. Denison's Charts, is also very small; whether the season be spring, summer, autumn or winter, it always shows a percentage far less than that of either coast line. The number of days on which rain falls is about 85, but on many of these the day is fine generally, with an evening storm.

The temperature shows great extremes, and, as might be expected in a mountainous region removed from all equalising influences, such as that of the sea, the nocturnal radiation is considerable. The mean annual temperature of Denver is  $50^{\circ}$ ; the maximum reading, occurring in July, being  $100^{\circ}$ , and the minimum,  $7^{\circ}$ , in February.



The monthly means are as follows :—

January	...	27·2	July	...	72·0
February	...	29·6	August	...	72·8
March	...	43·3	September	...	60·0
April	...	51·1	October	...	51·8
May	...	55·5	November	...	32·4
June	...	64·3	December	...	40·5

The summers are warm, tempered by showers, as most of the rain falls in summer and spring. The autumn is fine with, perhaps, some frosty nights, but very sunny and warm by day. There is practically no winter till January, and then but little snow, which the powerful sun usually soon melts, though nocturnal frosts are frequent and very severe, but the striking feature is the range of temperature, which amounts at Denver occasionally to 107°, and has been known in some stations of Colorado to reach 118°.

The minimum has been known to fall to -25°, this was in January 1876, and 101° is the highest maximum recorded. Wind is undoubtedly present, and may be almost said to be a feature of the climate, though some spots are completely protected. The wind prevailing is the South, and the average wind force for the year is 7. Only between 30 and 40 days are reported as absolutely calm, so the climate may be considered as by no means devoid of aerial movement.

The number of fine days is one of its strongest recommendations, and I see the Weather Bureau for 1889 records for Colorado Springs 171 cloudless days, 135 partly clouded ones, and 59 cloudy.

These figures all point to a very dry climate, with small rainfall and relative humidity and great absence of cloud and vapour; and a glance at the relief and rainfall maps will explain this peculiarity. The usual rain-bringing winds come from the Pacific coast, where it will be noted that the rainfall is comparatively large, but before they reach Colorado State, and more especially the parks and plains, they are driven upwards over the Sierras, which condense much of their moisture; next they have to cross 60 miles of the great American desert, which is not likely to add to their humidity; then they are deviated upwards again by the Wahsatch Mountains, and passing at an altitude of at least 13,000 and 14,000 ft. over the Rockies, they arrive at Colorado as dry, and for the most part warm, winds. The country to the east is a vast plain gradually descending to the Mississippi valley, and on the whole dry, the only source of moisture being the Gulf of Mexico, 800 miles off; the consequence is that Colorado and New Mexico enjoy remarkably dry and cloudless climates, and are also extremely sunny regions. The hours of sunshine far exceed in number those which can be counted at most European resorts. Dr. Solly gives a table of temperatures indicated by the solar radiation thermometer during the year 1886-7.

	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.
Highest temperature	137	155	152	135	124	110	112	123	114	121	124	129
Lowest temperature	110	138	133	118	104	94	97	95	101	108	98	101



We shall now consider our first class of climates, that of the snowy peaks of the Rockies, and the enterprise and energy of the American Government has supplied unequalled records in this respect, as for 14 years they maintained the meteorological observatory at the summit of Pike's Peak, 14,147 ft. above sea level, the highest observatory in the world, where regular and careful observations have been made by the officials of the Weather Bureau. The station has since been abandoned, but I understand it is to be reopened this year. Meteorological energy has been equalled by engineering, and a cogwheel railway, with a wonderfully adapted locomotive, conducts visitors to the summit during the summer, though the snow compels the closure of the line in winter.

Pike's Peak is of granite, and on the somewhat flat summit are strewn great blocks of this formation. Snow is always present in patches, but there are no glaciers. The barometer shows 17.54 ins. of pressure.

A remarkable feature of the Pike's Peak records is the resemblance between the recurring annual phases of atmospheric pressure and of the air temperature.

The curves of these are not only alike in having a single bend, but the maximum of both occurs in July, and the minimum of both in January.

The mean monthly pressure rises and falls .016 in. for every degree Fahrenheit of the monthly mean temperature. Similar phenomena have been noted on Mount Washington (6,279 ft.), another lofty observatory of the United States situated in New Hampshire, in the Eastern States. It has also been found that actual barometric pressure in the Rocky Mountains, generally at altitudes above 4,000 ft., attains its minimum in January, and its maximum in July or August, and that the barometric phases are of the same kind, in reference to the annual mean, as the temperature phases at such stations. This phenomenon of atmospheric pressure is the reverse of that in parts of the United States at low elevation, and results, according to General Greely,<sup>1</sup> from the lower average temperature of the winter months contracting the great body of air so that much of it is brought below the summit of the mountains, while in summer the reverse conditions obtain.

The highest temperature on Pike's Peak was 64°, noted on July 19th, 1879; the lowest —39°, noted December 21st, 1887; the mean temperature being 19°.3. This has ranged during the 14 years from 17°.9 to 21°.9.

It may be interesting to note that Mount Washington during the same 14 years had a maximum of 74° and a minimum of —50°, showing at a considerably lower temperature greater extremes.

The maximum daily range of temperature on Pike's Peak takes place in July and August, being 14°.3 and 14°.2 for each month respectively. The minimum range is in December (11°.6). Thus the mean daily range on Pike's Peak is about half that noted on the prairie plains, on which Denver and Colorado Springs are situated.

The rainfall on Pike's Peak has been stated to be 29 ins., of which the minimum (1.39 in.) is in February, and the maximum (4.46 ins.) in July.

<sup>1</sup> *American Weather*.



33 per cent. falls in spring, 35 per cent. in summer, the remaining 32 per cent. being distributed equally between autumn and winter, these seasons exhibiting the same dryness as at Denver and Colorado Springs.

The winds are chiefly Westerly, 31 per cent are from South-west, 20 per cent. from West, 21 per cent. from North-west, 10 per cent. from the North, 8 per cent. from the North-east, 5 per cent. from the South, and the rest are distributed among the East and South-east and calms.

This contrasts with Colorado Springs, nearly at the foot of Pike's Peak, where the most prevalent winds are the North (27 per cent.) and the South-east (22 per cent.); showing the effects of local currents.

The velocity of the wind varies from a mean of 26.6 miles in January to one of 12.3 miles in August. The highest mean monthly velocity occurs with the lowest mean monthly temperature, and the least mean velocity with the highest mean temperature. Severe and prolonged wind storms are rare at the summit of Pike's Peak, and the days are few when the mean hourly velocity equals or exceeds 50 miles. In two storms in 14 years it ranged 70 and 71 miles an hour, and once, on May 11th, 1881, it reached 112 miles.

Mount Washington, on the other hand, has stronger winds and they prevail longer; velocities of 116 miles have been recorded, and on one occasion the great rate of 186 miles.

The most interesting part of the meteorological diary on Pike's Peak is the record of the electrical phenomena, and as an abridgment would spoil the pure American style in which the narrative is written, I give some extracts.

*February 24, 1874.*—Summit continued enveloped in snow clouds till 2 p.m. As a curious illustration of the rapidity with which water boils at this elevation, the observer notes that this evening a dish pan full of loose snow was set on the hot stove to melt, and in a very short time the water in the bottom of the pan began to boil, while the snow on the top of it was yet 3 or 4 inches deep. On examination it was found that a solid crust had formed above the boiling water, and even this was not sufficient to condense all the steam, which escaped with loud hisses from its icy confines.

*May 29, 1874.*—At noon the summit became densely enveloped, and sleet fell in short showers till evening, while the rumbling of distant thunder was occasionally heard to the south. At 6 p.m. a storm began which will long be remembered by the present occupants of the station. A violent thunderstorm, accompanied by heavy sleet, passed over the peak from south-south-east to north-north-west. It came up so suddenly that there was barely time to cut out the telegraphic instruments before blinding flashes of fire came into both rooms from the lightning arrester and stoves; loud reports followed in rapid succession, while outside the noise of thunderclaps was almost drowned by the rattling of the indescribably heavy showers of sleet which followed each discharge. The storm appeared to surround the peak in all directions. At 7 p.m. a bolt struck close to the north window, and at the same time a heavy discharge took place through the lightning arrester, which made it appear that the building had been struck and was on fire. A cloud of smoke filled the embrasure of the north window, which was afterwards found to have resulted from the melting of rubber insulation on the office wires.

After this discharge the storm passed slowly to the west. The observers were beginning to breathe more freely when the wind veered to the South-west, and brought back the storm in all its fury. The rattling of torrents of sleet, mingled with the incessant rolls of thunder, the blinding flashes and loud reports in the rooms, were enough to make the stoutest heart quail.

It has been noticed, by closely watching the beginnings of storms which were so frequent during the latter part of May and not uncommon during June, that



the great majority of them originated over the extensive parks west, south-west and north-west of this peak, and dividing it from the main range. The lower strata of air become powerfully heated, and are probably at this season of the year, when the surrounding mountains discharge their melting snows into the parks, heavily charged with moisture. The cold, heavy West winds descending the eastern slope of the main range, and wedging under the heated, moist, lower strata, might explain the frequency of local storms on the peak during the hottest part of the day.

*February 14, 1881.*—Fog in morning and afternoon. Four mock moons appeared on different sides of the moon at night, at equal distances from that body and from one another. These increased in intensity of colours until they were brighter than the moon itself, which appeared as if hidden behind a veil. By-and-by bows as brilliant as those of the sun appeared over each, which increased in size until they almost joined, and formed a perfect circle of the most brilliant colours. These gave way for double halos, the second being nearer to the first than that was to the moon. Both were of a beautiful violet tint. When the moon had risen about two-thirds of the distance between the horizon and zenith, these rings disappeared and a new one appeared much further removed from the body, the refraction of whose light produced these fantastic shapes. The new halo was much paler than those it had succeeded; it was the precursor of one of the most magnificent refractions of light that any human being ever witnessed. Near the moon appeared two mock moons, shining like balls of fire, and in the horizon opposite these were reproduced, but in a milder colour. A halo of a mild pink colour passed through the plane of these four mock moons and intersected the main halo. To complete the display a bow appeared at the zenith, and this was as brilliant as a rainbow, and comprised all the colours of that bow of promise.

*June 7, 1882.*—During a violent thunderstorm, while sleet was falling a "singing" or "sizzling" noise on the wire was distinctly heard. At 8.45 p.m. on opening the door, the line on the summit was distinctly outlined in brilliant light, which was thrown out from the wire in beautiful scintillations. On near approach to the wire these little jets of flame could be plainly observed. They presented the appearance of little electrified brushes or inverted cones of light, or more properly, little funnels of light with their points to the line, from which they issued in little streams about the size of a pencil lead, and of the brightest violet colour, while the cone of rays was of a brilliant rose white colour. These little cones of light pointed from the line in all directions, and were constantly jumping from point to point. There was no heat to the light, though it was impossible to touch one of these little flames, for as soon as they were approached by the finger they would instantly vanish, or jump to another point of the line. Passing along the line with finger extended, these little jets of flame were successively puffed out, to be instantly relighted in the rear. It was a curious and wonderful sight. No sensation was experienced on applying the tongue to the line. Not only was the wire outlined in this manner, but every exposed metallic point or surface was similarly tipped or covered. The cups of the anemometer, which were revolving rapidly, appeared as one solid ring of fire, from which issued a loud rushing and hissing sound. The anemoscope represented a flaming arrow, and a small round wooden stake stuck up in the snow to show the position of the gauge was similarly tipped, as well as an angle of our stone chimney. Observer, on placing his hands close over the revolving cups of the anemometer, where the electrical excitement was abundant, did not discover the slightest sensation of heat, but his hands became instantly aflame. On raising them and spreading his fingers, each of them became tipped with one or more cones of light, nearly 3 ins. in length. The flames issued from his fingers with a rushing noise, similar to that produced by blowing briskly against the end of the finger when placed lightly against the lips, accompanied by a crackling sound.

There was a feeling as of a current of vapour escaping, with a slight tingling sensation. The wristband of his woollen shirt, as soon as it became damp, formed a fiery ring around his arm, while his moustache was electrified so as to make a veritable lantern of his face. The phenomenon was preceded by lightning and thunder, and was accompanied by a dense driving snow, and disappeared suddenly at 8.55 p.m., with the cessation of snow.



*June 9.*—Repetition and previously defined sensations, and the observer's hair stood erect, crackled, and the pricking sensation to the scalp (bareheaded) was extremely painful. The peculiar electrical odour was strongly recognised. To protect his head, he put on his black felt hat and returned to the roof. But a few seconds elapsed before he was fairly lifted off his feet by the electrical fluid piercing through the top of his hat, giving him such a sudden and fiery thrust that he nearly fell from the roof in the excitement. Instantly snatching the hat from his head, he observed a beam of light, as thick as a lead pencil, which seemed to pass through the hat, projecting to about an inch on either side, and which remained visible for several seconds. The top of his hat was at least 2 ins. from his head when this fiery lance pierced him. When the fluid began to thrust its fiery tongues into other parts of his body, he was spurred to a hasty, but "brilliant" retreat. He experienced a peculiar burning or stinging sensation of the scalp for several hours afterwards. The phenomenon lasted 15 minutes. Lightning and thunder were continuous during the evening; the sharpest flashes drew from the metallic roof loud snapping sounds.

*November 17, 1882.*—Aurora this morning at 4.30 a.m. The arc was about  $12^{\circ}$  high in the centre. The one end extended nearly to the eastern horizon, the western one being hidden by the mountains. Along the eastern part luminous beams shot up from  $15^{\circ}$  to  $20^{\circ}$ . For a time it looked like a veil or sheet of pale light, but before fading it became very bright. A wide band of light from the sun extended nearly to the zenith, although nearly two hours before the sunrise. Ended 6 a.m. About 4.45 a.m. the "singing" or humming noise began on the telegraph wires, and became very loud. Aurora began to-night at 6.15 p.m. It appeared in the form of an irregular greenish-white cloud along the northern horizon, and under it was a very dark space. Above and apparently issuing from the green light, in different places, was an intensely red light, almost of a blood colour. These red spaces were probably  $15^{\circ}$  wide and from  $15^{\circ}$  to  $18^{\circ}$  high. Near these beams of white light extended to the zenith. The red would alternately fade and re-appear, until finally it remained stationary at the west end of the clouds, fading and appearing in rapid succession until 8.30 p.m., at which time the white cloud appeared to break up into beams or groups of beams, which were probably from  $15^{\circ}$  to  $20^{\circ}$  in height. At this time the red light at the western part was intensely bright, and all gradually faded, the white colours settling down into a regular arch of about  $15^{\circ}$  high in the centre, and remained so. Aurora steadily disappeared at 11 p.m.

We next come to the climate of the natural parks, varying in altitude from 7,000 to 10,000 ft. Unfortunately I have only imperfect meteorological records, as there has hitherto been no station of the Weather Bureau in North or Middle Park. One has been recently established in South Park near Como, but I do not know its altitude, and the information from there, except as to rainfall, is incomplete. These parks extend from  $37^{\circ}$  to  $41^{\circ}$  N. latitude and are of different elevations, so that considerable choice of climate may be found in them. In many places the vegetation shows an excellent soil, a good supply of water, shelter from winds, and freedom from the great cold of the higher peaks.

The Weather Bureau gives, among reports by voluntary observers, a year's observations made at San Luis, a small town situated at an elevation of 7,946 ft. in San Luis Park at the extreme south of Colorado State, and these I have analysed with the following results:—

The annual mean temperature is  $41^{\circ}\cdot7$ , the mean maximum  $70^{\circ}$ , the temperature rising in June and July to above  $90^{\circ}$ , and falling in December and January to  $-25^{\circ}$ ; the mean minimum being  $8^{\circ}\cdot28$ . The annual rainfall is  $13\frac{1}{2}$  ins., occurring principally in September, December (when  $2\frac{1}{2}$  in. falls), March, and April.



At Como (Middle Park) the rainfall is less, being 11.64 ins., but it occurs chiefly in summer, as on the plains.

I explored Estes and Manitou Parks, and perhaps an account of my visit to one of them, may enable you to picture them to yourselves better than a minute description. Let us take Estes Park, which is close to Long's Peak, and the greater part of which belongs to an English company, of which Lord Dunraven and Captain Whyte are the principal directors.

We left Denver one fine October morning, and after three hours by rail, journeying northwards, we reached Lyons, a small timber built town in the foot hills, the present terminus of the railway, which it is contemplated to continue up to Estes Park itself. Quitting the rail we ascended an excellent road in a winding valley, through which the Little Thompson River flows out from Estes Park. We first passed some grand masses of red sandstone, which, as is common in the Rockies, rise precipitously, ending in pinnacles, resembling castles and ramparts of fortresses and the like, and soon we reached the rocks of granite formation.

The sinuous valley was well wooded with scrub oak, in October of bronze to scarlet hue, with golden-tinted cotton trees, a species of poplar very common in the States, with what they call cedars, a sort of cypress; and strewn about were huge boulders, brilliant with ferns and mosses, and wreathed with clematis, which had fallen from the beetling cliffs on either side. As we drove upwards the cotton trees and cedars gave place to pines of various kinds, some of great size, and here we made the acquaintance of some of the natives, the grey squirrel, the chipmunk, a lively little animal about half the size of our squirrel, with a long bushy tail striped in two shades of greyish brown. They were skipping about the larch fences in which they delight. The beautiful American jay, with its brilliant blue plumage, flew from tree to tree. We passed the entrance to Antelope Park, another fine pasture land, and came into more open country with numerous ranches; before each farm house was a pile of stag horns shed by the deer in the adjacent mountains, and collected by the farmers.

After four hours' ascent through beautiful scenery we reached the portals of Estes Park, and found ourselves descending into a magnificent basin of park-like country, interspersed with several species of pines, and backed by grand mountains.

The park is an irregular shaped depression with various recesses, and measures 10 miles in its greatest diameter and 4 miles in its smallest. It is undulating and carpeted with excellent grass, but some fine wooded eminences rise in parts. Surrounding it is a remarkable circle of rocks, behind lie the grand mountains; to the south Long's Peak (14,271 ft.), to the west Mount Upsilon, then Mount Kenry, named after the Earl of Dunraven, and the Mummy Mount, and on the north, Mount Signal, and to the east the granite form of Mount Olympus.

The Thompson River, a moderate sized trout stream, flows through Estes Park, and there are several small lakes. On the south side rises a fine wooded hill called Prospect Hill, up which we saw a coyote stealing (a coyote being an animal something between a wolf and a fox).



The park itself stands at an elevation of 7,500 ft., and contains an hotel and Captain Whyte's house, where we were most hospitably entertained, as well as several ranches, and in summer a large number of visitors camp out for shooting and fishing purposes. There is plenty of fish and game. Deer had been down in the park the day we arrived, and, what was more rare, a herd of mountain sheep had appeared on one of the crags above Captain Whyte's house. Beavers, of which we saw the traces, abounded, and had built their dams so effectually as to cause some trouble by diverting part of the stream destined for irrigation. Coyotes skulk about but do not seem to do much harm, though the wire meat safes must always be placed at a height beyond their reach. We drove across the beautiful park in several directions, generally over the grass, then burnt up after the long summer, and we selected the site for a proposed new hotel, and saw Captain Whyte's fine herd of 400 red Herefordshire cattle, all in excellent condition. He told me that they fatten on the good herbage, and lie out all the winter without shed or stable. The cattle apparently were very healthy, and had become thoroughly acclimatised. That night we had a sharp frost, which covered the ranche's pond with  $\frac{3}{4}$  in. of ice, but hardly whitened the trees, and before sunrise next morning I witnessed a splendid Alpine glow on the surrounding peaks, and then the sun rose gloriously in a clear sky, flooding the whole park with the golden beams, and imparting plenty of warmth to us all. From the information I could gather from the residents, the climate is never excessively cold, as appears in the San Luis Park observations, and there is but little wind, the mountains, which do not overshadow, effectually sheltering the park. The rainfall is small, and snow does not lie on the ground for any time.

A great advantage are the endless excursions, not only in the park itself, but into the beautiful valleys which open into it, the Black Cañon and the Horse Shoe Valley for instance;—excursions replete with interest for the artist, the sportsman, and the man of science.

At present these parks are used chiefly in summer, when the dwellers in cities, like Denver, flock to them and camp out during the two hottest months, but it is contemplated to utilise them during a longer part of the year, as being well suited for more active and less delicate invalids. There is at present accommodation in Estes Park, but more is forthcoming in the shape of a new well-appointed hotel to be kept open all the year round. The present hotel has 50 beds and several ranches with cottages attached, Ferguson's, Macgregor's and James's (late Elkhorn), also lodge invalids with tolerable comfort and at a moderate cost. There is a post daily bringing letters and parcels.

Manitou Park lies 8,000 ft. high, 26 miles from Colorado Springs, and rather nearer to Manitou, up the Ute Pass, with a fine view of Pike's Peak. It is about 10 miles in length and 4 in breadth, and is one of the approaches to Middle Park.

The scenery much resembles that of Estes Park, and the neighbourhood abounds in large game, such as elk and deer. There is an excellent hotel



and a number of wooden cottages, which are used by visitors in summer, when the place is a great camping centre.

A picturesque line of rail, the Colorado Midland, connects Woodland Park Station with Colorado Springs, and then a 9 mile drive, partly through lovely fir woods, leads to Manitou Park, which is much recommended by the medical men of Colorado Springs.

Our third class of elevations, the Foot-hills, an expressive term, may be considered in conjunction with the fourth, the prairie plains, the difference being that the climate of the former is rather cooler.

The third and fourth class comprise all the Colorado plains of an elevation of 5,000 ft. and upwards, and the towns situated on them, such as Denver, Longmont, Boulder, Golden, Colorado Springs, Manitou, and the various settlements on the foot-hills.

The climates of Denver and of Colorado Springs, as set forth in the admirable meteorological reports of the Weather Bureau, have been well examined by Drs. Denison and Solly, and may be considered as typical of the true Colorado climate, the principal features of which have been already given.

The prairie in which these towns lie is as remarkable for its vastness as for its colouring. When standing on any elevated spot, one sees it is not a flat surface, but presents here and there undulations, though stretching away, as it does, for hundreds of miles north, east, and south, these are sometimes hardly visible, and the general impression is of some great billowy moving sea which has suddenly become petrified.

The sun rising in the east floods the vast plain with its rays and turns it a brilliant golden colour beautiful to behold, and gradually as the shadows extend, tints of red, purple, and brown appear and advance in great lines across the plain, while with the setting sun the colouring becomes first orange, then red, then purple, changing at last from delicate pearly tints to cold grey. The sky also undergoes the most brilliant changes, passing from the usual sunset phases to an exquisite violet which suffuses successive portions of the sky long after the sun has set. The vault of heaven appears of boundless height, and the air is so transparent that objects 20 miles off appear close at hand, and Pike's Peak, 75 miles distant from Denver, is quite distinct, indeed some of the fine peaks seen from that city are calculated to be more than 120 miles off.

Another feature of this vast plain is the absence of life. You may travel for miles and miles and see nothing but an occasional prairie dog village, with its little fat denizens sitting up on the tops of their mounds, with their paws hanging in front, looking like posts, so unmoved are they, even when the locomotive rushes past; after awhile a few cattle are to be discerned, then a mounted cowboy, looking larger than human from his solitariness—but the general feature of the prairie is its intense solitude.

The vegetation consists of buffalo grass, several varieties of cactus, a small kind of yucca, and what is called the prairie flower, besides lilies and other summer blooming flowers.



Driving in a light buggy with a pair of fast cobs is very pleasant, provided you hold on tight, as it is not uncommon to descend into a prairie dog's hole, or worse still into a dry creek or water bed, where the jolting is considerable, for the horses delight in the grassy trail, and fly through the air at a tremendous pace.

As I have said before, the prairie is undergoing cultivation; by means of sinking artesian wells and bringing water from the mountains, the plains are gradually being supplied with irrigation water, and are made to produce a better grass as well as wheat and Indian corn; a little less cactus, a little more alfalfa everywhere, this last being the usual western food for cattle, but it will be long before the prairie is transformed into great farms.

Denver is situated in the prairie on the small river of South Platte, and though only about 30 years old, is a city of 150,000 inhabitants with fine buildings, capital schools, excellent clubs, theatres, monster hotels, cable and electric cars, electric lighting, and all the advantages of American civilisation. The streets are well planned and many are paved with asphalt, the avenues are wide and many are lined with trees and command fine views of the Rocky Mountains. The city extends over at least 5 miles, and though parts of it are smoky, owing to the ore smelting and other works, the suburbs, which are remarkably open and only bounded by the prairie, are charming and suitable for invalids' residence. The medical profession is well represented, while a completely equipped faculty of medicine exists in the University of Denver, and all accorded a warm welcome to your President. I may add that many of these doctors are instances of consumption cured by the climate.

There are also a number of boarding houses in the small towns and ranches in the Foot Hills and up the cañons, where Denver medical men place their patients with advantage, such as the following:—Stewart's ranch in Bear Cañon (7,000 ft.) about 20 miles from Denver, Longmont (5,000 ft.), a small town with good water and lighting, and near it an excellent moderate pension called Hygiea. Boulder (5,409 ft.), at the mouth of the romantic Boulder Cañon, is a small town with a university 29 miles from Denver, and has suitable accommodation with charming excursions up the adjoining valley. Greeley and Fort Collins, at a little lower elevation and some 50 to 60 miles to the north of Denver, have been well spoken of for invalids.

Idaho Springs (7,800 ft.) in the Clear Creek Cañon is strongly recommended by Dr. Denison, and stands on a plateau well sheltered by mountains, having remarkable saline and ferruginous springs, used for baths and drinking, and, like most of the preceding, is connected with Denver by rail. There is a very good hotel at Perry Park (6,000 ft.), situated on a spur of the Rockies called the Divide, which separates the basins of the South Platte and the Arkansas rivers, about 40 miles south of Denver, and there are many others, one of the great advantages being the extensive rail communication in all directions with Denver.

Colorado Springs is situated on the prairie, at an altitude of 6,022 ft., 75 miles south of Denver, 5 miles from the foot-hills of the Rockies, and 6



miles from the base of Pike's Peak, which forms so fine a feature in the view from the town. It has a population of 13,000, and no manufactories, and consequently no smoke. The town is laid out picturesquely in avenues from 60 to 120 ft. in breadth, lined with a double row of trees which run north, south, east, and west, thus intersecting each other, the main roads being traversed by electric cars. The buildings are handsome, and especially the private houses are artistic, many of red sandstone and surrounded by gardens. Cascade Avenue is a fine street composed of houses mostly built by consumptives, who have selected this as their residence. There is a top soil of 2 ft. and gravel and sand to an average depth of 60 ft. below, and consequently all moisture drains away rapidly. The main drainage—and the plumbing, as our American cousins call it—is good, and the water supply is excellent, the water being brought from the mountains in iron pipes.

To the north of the town lies the Divide, which gives some protection from Northerly winds, to the south the open prairie, to the east the prairie on which rises a low range of hills called Austin's Bluffs, and to the west and south-west the great masses of Pike's Peak, Mount Rosa, named after Miss Kingsley, and the beautiful Cheyenne Mountain, with the foot-hills in front of them.

Intervening between these grand mountains and the town are Colorado City, and rather to the north of it the celebrated Garden of the Gods, Monument Park and Glen Eyrie, with the fantastically shaped red sandstone rocks, while nestling under the very mountains, surrounded by more timber than is usual in Colorado, lies Manitou Springs, about 1,000 ft. higher than Colorado Springs, where the mineral springs really do exist and of delicious quality, whereas there are none at Colorado Springs, the title of which is a misnomer.

The mean temperature of Colorado Springs is  $46^{\circ}\cdot4$ , but it is composed of considerable extremes. The maximum rises to  $101^{\circ}$ , the minimum falls to  $-25^{\circ}$ , but curiously the extremes do not appear to be much felt, perhaps owing to the dryness. The mean rainfall for 10 years is 15·87 ins., and of this about 12 ins. falls in spring and summer, generally in thunderstorms; only 4 ins. are noted between September and March. Snow, as a rule, disappears by evaporation in the sunshine. The number of clear days is 194, of fair days 128, and of cloudy 43. The sun shines during 330 days of the year, and for 165 days out of the 182 from October 1st to April 1st, so that on an average an invalid is deprived of sunshine for less than half-a-day a week in winter. The power of the sun is great, and during the entire winter ladies need parasols and invalids sit in the open piazzas, which are a feature of the houses, without extra wraps. The wind is the most troublesome item of the climate, and generally rises in the afternoon. The annual mean velocity is 8·58 miles per hour.

Dr. Solly<sup>1</sup> gives an admirable account of an invalid's day in midwinter, *i.e.* from 9 a.m. to 4 p.m., which I venture to quote.

“After a night in which there has been a hard frost and a clear sky, with a light breeze from the North, and during which the invalid has usually slept

<sup>1</sup> *Facts, Medical and General, about Colorado Springs.*



soundly under several blankets, with his window partly open, he wakes up to find the sun shining at his eastern window. And this is a feature which, whatever the weather may be later in the day, is rarely absent. After breakfast our invalid steps into the street, being then in an atmosphere in which the heat in the sun is  $92^{\circ}$ , and in the shade  $30^{\circ}$ . A gentle air is stirring from the North-east at the rate of 8 miles an hour. The mean dew point is  $18^{\circ}$ .

"As the day proceeds the temperature rises to its highest point, between 3 and 4 p.m. being  $100^{\circ}$  in the sun, and  $40^{\circ}$  in the shade, while the wind, which has veered rapidly from the North to the South, blows with its highest daily velocity of 13 miles an hour. After 2 p.m. the wind works back again towards the East, being at sundown North-east, and continuing as darkness falls to shift back to the Northern quarter, whence it blows from 8 p.m. to 9 a.m., its velocity dropping to between 7 and 8 miles an hour; the temperature of the air at the same time falling from  $3^{\circ}$  to  $4^{\circ}$ .

The ground is usually bare of snow; no rain falls from mid-September to mid-April, and the sun shines unobstructed by clouds. During the three winter months the cloudy days do not average more than three a month."

Accommodation is excellent and plentiful, and there are several able and experienced medical men, including Dr. Solly, to whom Colorado Springs owes so much. The excursions to be made are endless and charming. The cañons of the Cheyenne Mountain present lovely scenery of trees, granite needles, and waterfalls, the Ute Pass is grand, but the finest of all is Pike's Peak itself with its neighbouring valleys, which is daily ascended by rail in summer. Riding and driving are the chief exercise used, and the Broadmoor Casino with its boating on the lake, its music, and its races, furnishes amusement, while for the vigorous, the mountains and parks within easy distance offer plenty of shooting and fishing.

Manitou Springs is somewhat better protected by the mountains from wind, though it enjoys sunshine for a shorter period of the day than Colorado Springs. The annual mean temperature is  $47^{\circ}\cdot3$ , the maximum,  $96^{\circ}$ , occurring in July, and the minimum,  $23^{\circ}$ , in January. The relative humidity is 54 per cent. The rainfall, of which I was unable to procure statistics, is probably low.

It is a pretty little place, with some most valuable mineral waters and excellent hotels. It is also the starting point for several suitable summer stations on the Ute Pass, such as Cascade Cañon, Ute Park, Green Mountain Falls, and Woodland Park, all of which have good hotels placed at various elevations above Manitou.

The above description will, I hope, give a sample of the climate of Colorado and afford some explanation of its probable factors.

The chief elements appear to be—

1. Diminished barometric pressure, owing to altitude, which throughout the greater part of the State does not fall below 5,000 ft.
2. Great atmospheric dryness, especially in winter and autumn, as shown by the small rainfall and the low percentage of relative humidity.
3. Clearness of atmosphere and absence of fog or cloud.
4. Abundant sunshine all the year round, but especially in winter and autumn.
5. Marked diathermancy of the atmosphere, or, as Dr. Denison expresses it, "the increased facility by which the solar rays are transmitted



through an attenuated air," producing an increase in the difference of sun and shade temperatures varying with the elevation in the proportion of  $1^{\circ}$  for every rise of 235 ft.

6. Considerable air movement, even in the middle of summer, which promotes evaporation and tempers the solar heat.

7. The presence of a large amount of atmospheric electricity.

Thus the climate of Colorado is dry and sunny, with bracing and energising qualities, permitting outdoor exercise every day all the year round, the favourable results of which may be seen in the large number of former consumptives whom it has rescued from the life of invalidism and converted into healthy active workers. Its stimulating and exhilarating influence may also be traced in the wonderful enterprise and unceasing labour which the Colorado people have shown in developing the riches, agricultural and mineral, of their country. Let us take the latter alone: In 1890 30 millions of dollars, or £6,000,000 sterling, worth of precious metals, was mined in the State of Colorado, which is larger than the United Kingdom and Ireland and at present numbers only 500,000 population. Thirty years ago Denver may be said not to have existed. Now it is a well built, well organised city of 150,000 inhabitants.

Surely we may claim some of these results as the effect of this magnificent climate on the Anglo-Saxon race, while the Colorado people are as kindly and generous as they are energetic and enterprising, and a warm welcome awaits all visitors and settlers from the old country, who may certainly hope to procure health, and possibly also wealth, in this rising State. Well may we here, as in other cases, render homage to the Empire of Climate.



RELIEF MAP OF THE UNITED STATES.

