

*Comparative, hypsometrical and physical Tableau of High Asia, the Andes, and the Alps.*—By ROBERT DE SCHLAGINTWEIT, Professor at the University of Giessen.

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*Remarks.*—1. Drawings of many of the objects (plateaus, peaks, towns, &c.) mentioned in this Tableau, as well as panoramic profiles and maps, are contained in the Atlas to the “Results of a scientific mission to India and High Asia,” by Hermann, Adolphe, and Robert de Schlagintweit.

2. The heights, given in English feet, are absolute, referring to mean sea-level.

*Transcription.*—Vowels and diphthongs sound as in Italian and German: ä = u in “but;” â = an in the French “gant;” ü = ü in German.—Consonants as in English. The sign ' marks the syllable to be accentuated.

The materials, upon which this comparative tableau is based, are :

For *High Asia*, viz.—The Himálaya, Western Tibet, the Karakorúm and Künlün, our own travels and observations, combined with the valuable data of the Great Trigonometrical Survey of India, and with those of our predecessors.

For the *Andes*.—The celebrated “*Voyages aux régions équinoctiales*,” by Alexander de Humboldt, which possess to this day the highest value and importance; in his recent publications,\* the newest contributions of science have been added with a master’s hand.

\* *Kosmos.*—*Ansichten der Natur*, 3rd edition.—*Kleinere Schriften*.—I always quote the original, German edition.

For the *Alps*.—The two volumes “*Untersuchungen über die physikalische Geographie und die Geologie der Alpen*,” published by my brothers Adolphe and Hermann.

## I. GEOGRAPHICAL CONFIGURATIONS.

### 1. Plateaux.

Plateaux, in consequence of their being more or less intersected by deep and broad valleys, or from being covered with ridges, are so variable in their form, that the use of the name, in many instances, appears to be somewhat arbitrary. I prefer not to extend the meaning of the name too far, and in so doing diverge from the practice of earlier travellers, who commonly applied the term to every mountainous region of great *general* elevations—as the natives of the *Himálaya* have a tendency to do—irrespective of its form.

In the *Himálaya*, which is composed in almost every direction of lofty and irregular ridges, and intersected by numerous valleys of inconsiderable width, no plateau of any extent has been discovered as yet, nor is it at all probable that one exists.

*Western Tibet* was for a long time supposed to be little else than a country of plateaux—an erroneous impression emanating from the first observers, though Humboldt had early pointed out the error of this belief,\* as well as later travellers (the Stracheys, Cunningham, and Thomson). Plateaux certainly do occur in Tibet; they are, however, much less numerous and considerably smaller than I had been led to expect. In *Bálti*, the plateau *Deosái* is 14,200 ft. high.

Between the *Karakorám* and *Künlün*, especially near the western crest of the former, several well-defined plateaux of extraordinary height occur. Some of the highest are called: *Dápsang* (17,500 ft.), *Búllu* (16,883 ft.), *Aksáe Chin* (16,620 ft.), and *Voháb* (16,419 ft.) In summer, no snow covers these plateaux, but also no vegetation: in the far distance there are some isolated, lofty, snowy peaks, besides which the eye discerns nothing but barren rocks, and extensive sterile plains, all well watered by streams, to which the glaciers covering the flanks of the peaks afford an ample and lasting supply. If water was wanting to these plateaux, they would be a complete desert, as uninhabitable to man as to any animal.

\* *Ansichten der Natur*. Vol. I., p. 104.

In the *Andes* are to be found, if not the highest, at least the most extensive plateaux of our globe, which generally lie along the very ridge of the mountains, and on which large towns are situated, as Cerro de Pasco (14,098 ft.), Potosi (13,665 ft.), and Cuzco (11,380 ft.). There is also a large plateau surrounding the elevated lake Titicaca (12,843 ft.).

In the *Alps*, plateaux occur only at their base; the Swiss plateau having a mean height of 1,460 ft., the Suevo-Bavarian plateau of 1,420 ft.

## 2. *Passes.*

The mean of a sufficient number of such passes, which lead over the *principal crests*, is particularly to be taken into consideration, it being approximatively proportional, or, to express it more clearly, equal to the general mean height of these *crests*. The passes situate in the lateral ramifications of the principal crests—though they are numerous—cannot be included in these general means, being geographically of subordinate importance.

The mean height of passes in the three principal mountain-chains of *High Asia* is as follows :

A. *For the Himálaya* (mean of 19 passes,)..... 17,800 ft.

From Sikkim to Kishtvar : Bhután and Kashmír being excluded : the former for want of materials, and Kashmir on account of the Himálaya there losing the character of one well-defined and predominant chain.

B. *For the Karakorúm* (mean of 3 passes,)...18,700 ft.

From long. E. Gr.  $76^{\circ}$  to  $79\frac{1}{2}^{\circ}$ , the heights in the eastern continuation being quite unknown.

C. *For the Künlün* (mean of 2 passes,) ..... 17,000 ft.

As the two passes are situated in parts not differing in any particular from the general mean of this chain, they may be looked upon as representatives of the other.

From these numbers it appears, that the Karakorúm has by far the greatest mean height of passes; but the one pass which we must still consider the highest, is situated in the Himálaya. This is the *Ibi Gámin pass* (20,459 ft.) leading from Gárhvál to Gnári Khórsum, which my brother Adolphe and I myself crossed as the first, and as yet as the only Europeans, Aug. 22, 1855. The pass next in height

is the Mustágh pass in the Karakorúm chain (19,019 ft.), the third the Changchénmo, or Yéngi Daván (about 18,800 ft.), in the same chain. None of these passes are generally used as commercial roads. The highest pass as yet known to be regularly crossed with horses and sheep, for the purposes of commerce, is the Párang pass (18,500 ft.; Mr. Theobald, Jr. makes it 19,132 ft., which seems too high—); and between this height and 18,000 ft. are situated several of the most important and frequented passes, as the Mána (18,406 ft.) the Karakorúm (18,345 ft.) and the Kióbrang (18,313 ft.). The lowest passes in the Himálaya chain are the Shínku La (16,684 ft.) and the Bára Lácha (16,186 ft.); the well known Níti pass reaches 16,814 ft.

In the *Andes*, the general mean elevation of the passes is, according to Berghaus :

For the Western Andes, .....	14,500 ft.
For the Eastern Andes,.....	13,500 ft.

The highest passes are: Alto de Toledo (15,590 ft.), Lagunillas (15,590 ft.), and Assuay 15,526 ft.). The latter pass attains, according to Schmarda, only 14,517 ft.

In the *Alps*, the mean of the passes is ..... 7,550 ft.

The highest pass, at least in former times not frequently used for commercial purposes, is the St. Théodule (11,001 ft.), upon which the brothers Platter have now erected a meteorological observatory.

### 3. Peaks.

In the beginning of this century, the Andes were supposed to contain the highest peaks on our globe, and Chimborazo to rise supreme above the rest. Though as early as 1816 this was proved by Captain Webb's measurements to be incorrect, yet some time elapsed, before the superiority of the *Himálaya* above the Andes was generally admitted. Now we know, from the valuable and accurate observations of the G. T. Survey of India, that Gaurisánkar, or Mount Everest (29,002 ft.) is the highest peak of the world. The memoir of Major J. T. Walker in the Journal of the Asiatic Society of Bengal, 1862, No. I., pp. 32—48, gives a detailed enumeration of the peaks hitherto measured in the Himálaya; this memoir, as well as the publications of Captain Montgomerie and private communications kindly received from the Surveyor General's Office, enable me to state, that 216 peaks are now accurately measured in the chain of the Himálaya. Among

these 216 peaks, 17 exceed the height of 25,000 ft., 40 the height of 23,000 ft., and 120 the height of 20,000 ft.

In the *Karakorúm*, peaks have lately been discovered, which are scarcely inferior in height to the loftiest in the *Himálaya*, though only its western part has as yet been explored. With regard to the heights of its eastern continuation, there is not enough known to allow even of an estimate being made.

The highest peaks of the *Karakorúm* are the *Dápsang* (Ko of the G. T. S. 28,278 ft.), the *Diámar* (26,629 ft.), and the *Masheribrúm* (25,625 ft.)

With reference to the *Künlün*, we can only mention the peaks that we saw and measured between the *Yurungkash* pass and the western termination of this chain; our idea about the general height is the more limited, as we have not even itinerary reports of former travellers to assist us. None of the peaks seen there by ourselves exceeds 22,000 ft.

In the *Andes*, important alterations have very recently been made with reference to the succession of the peaks, when arranged according to height, and, even now, the same amount of accuracy cannot be ascribed to the hypsometrical determination of its principal peaks as to the trigonometrical operations in the *Himálaya*. The highest peak in the *Andes* is the *Aconcagua* (23,004 ft.) in *Chili* (*Pissis* gives only 22,451 ft.): and there are as many as five peaks higher than the *Chinbarozo* (21,422 ft.). In *High Asia*, forty-five peaks are known, which exceed in height the dominating peak of the *Andes*, the *Aconcagua*.

In the *Alps*, *Mont Blanc* (15,784 ft.) and *Monte Rosa* (15,223 ft.) are well known to be the highest peaks. Other high peaks are; *Täschhorn*, or *Lagerhorn* (14,954 ft.), *Weisshorn* (14,813 ft.), *Mont Cervin* (14,787 ft.), and *Dent Blanche* (14,305 ft.).

## II. HYDROGRAPHY.

### 1. Lakes.

In the *Himálaya*, there are but very few lakes. That of *Nainital* (6,520 ft.), in *Kámáon*, the *Vállar lake* (5,126 ft.), and the *Chinär lake* near *Srinágar* in *Kashmír*, suffice to exhaust the category of those deserving mention.

Glacier lakes.—Accumulations of water formed by one glacier obstructing the outlet of a higher one—are of much more frequent occurrence. At times, the wall of ice breaks away before the pressure of the swollen waters, when the lower lands become suddenly inundated, and the torrent rushes on with uninterrupted violence for miles, exercising a marked influence even down to the lower parts of the river. Similar inundations, some of them of a most destructive character, have several times occurred. Two of the most elevated glacier-lakes are the Destál (17,745 ft.), in Gärhvál, and the Námto, or Yúnám (15,570 ft.) in Lahöl.

Western Tibet and Turkistán possess many lakes, all of which are situated in great heights; they are, however, gradually drying up, as becomes apparent by the unmistakable marks of larger surfaces remaining from former times. They contain a greater quantity of salt than lakes in general, and most of them to an amount which renders them more or less brackish.

The following are the names and the heights of the principal:—

*Lakes of Western Tibet and Turkistán.*

Aksáe Chin, ... ..	16,620	Níma Kar, ... ..	15,100
Tso Gyagár, ... ..	15,693	Háule, ... ..	14,600
Tso Kar, or Khauri Taláu,	15,684	Tso Gam, ... ..	14,580
Múre Tso, ... ..	15,517	Tso Bul, ... ..	14,400
Kiúk-Kiöl, ... ..	15,460	Tso Mitbál, ... ..	14,167
Mansaráur, or Tso Mapan,	15,250	Upper Tsomognalarí,	14,050
Rákus Tal, or Tso Lánag,	15,250	Lower Tsomognalarí,...	14,010
Tsomoríri, ... ..	*15,130		

In the *Andes*, the most remarkable lake is that of Titicaca (12,843 ft.)

The foot of the *Alps* is adorned with a great many lakes, all in low elevations of from 600 to 1,600 ft.

## 2. Springs.

Springs of an ordinary, mean temperature, commonly called cold springs, are of frequent occurrence in High Asia; the finest and most copious springs are to be found in *Kashmír*, as the spring Vérnag, Vétur Vúllar, Kókar Nag, Achibál, A'nat Nag and others. The spring Sóna Bréri, also in *Kashmír*, situate about five miles south-east of Shalahábál, is the only intermittent spring as yet known in High Asia.

\* According to Mr. Theobald, Jr. (see Journ. As. Soc., Bong, 1862, No. V., p. 513) only 14,272.

In *Western Tibet*, where rains in the higher parts are rare, and where the dryness in summer is so excessive that even the formation of dew is scarcely perceptible, cold springs are comparatively rare. In Turkistán, in Bálti, and Hasóra, we find a greater number of springs, a fact intimately connected with the general meteorological conditions of these provinces.

With reference to the limit, at which springs are to be found still in High Asia, I give the following data, derived from our own observations. The greatest height, at which we found a spring in the Himálaya, was 15,920 ft.; this spring was situated on the slopes of the Kyúngar pass. In Tibet, we discovered a real spring on the slopes of the Ibi Gámin peak still at a height of 17,650 ft.; this spring is probably the highest spring hitherto found.

As the highest spring in the Andes, Humboldt names the one called "Ladera de Cadlud," at a height of 15,526 ft. above the level of the sea; in the Alps, Adolphe and Hermann have found the highest cold spring at 10,440 ft.

Hot springs occur in High Asia in a surprisingly great number,\* from the sea-level up to heights of more than 16,000 ft. The highest hot springs of High Asia are at Murgái, (16,382 ft.), in Núbia, at Momái (about 16,000 ft.), in Sikkim, at Púga (15,264 ft.), in Ladák, near the lake Aiúkkió (15,010 ft.), in Turkistán, and at Chagrár (about 15,000 ft.), in Pangkóng. As a curious and remarkable fact I may add, that the highest hot spring in India, at Hazaribágh, in Bengal, is only 1,750 ft. above the level of the sea.

The hottest spring of High Asia is at Manikárn (temp. 202° Faht.) in Kúlu (this is the hottest spring as yet found all over Asia), at Jämnótri (temp. 193° Faht.) in Gárhvál, and at Chorkóna (temp. 190° Faht.) in Bálti. The hottest springs of the world (if we exclude those, which rise in the immediate neighbourhood of volcanoes) are to be found in the Andes. There "Aguas de Comangillas," near Chichemequillo and Quanaxuato, at a height of about 6,200 ft., in latitude north 21°, show a temperature of 205°.3 Faht.; † and the springs "Las Trincheras" between Porto Cabello and Valencias, in

\* See the "Enumeration of the hot springs of India and High Asia, given by me in *As. Soc. Journal*, 1864, No. I., p. 49.

† Humboldt's "*Essai pratique sur la Nouvelle Espagne*." 2nd Ed., Vol. III. (1827), p. 190.

Mexico, have increased, between the years 1806 and 1823, from 195° Faht. to 206°·6 Faht.,\* thus exceeding at present the temperature of the "Agua de Comangillas" by 1°·3 Faht.

The hottest known spring of Europe, unconnected with present volcanoes, is that of Chaudes Aigues in Auvergne (temp. 176° Faht.).†

### III. PHYSICAL PHENOMENA.

#### 1. Snow-fall.

The lowest height at which snow has fallen in the *Himálaya* during the winter, is about 2,500 ft., but such cases are extremely rare, having occurred in Kāmdon and Gārhwál only twice (in 1817 and 1847), since the British took possession of the country.‡ Snow has fallen in the memory of man only once in Nahán§ (3,207 ft.), in the province of Simla. The snow, which falls once within several years in the Kángra valley, down to heights of 3,000 and 2,700 ft., disappears almost immediately. At Haribágh the snow melts away on the day it falls, or at least within thirty-six hours. During my travels in Kúlu, I was informed by the natives, as well as by several gentlemen who knew this part of the country thoroughly, that the village of Mándi (2,480 ft.), is below the limit of snow-fall.

At an elevation of 5,000 ft. scarcely one year passes by without snow-fall; but, even at this height, the snow disappears after a few days, and sometimes even hours. "It snows, but one does not see it," the natives of Kathmándu (4,354 ft.) very significantly use to say, meaning, that the rare nightly snow-falls are melted away by the earliest rays of the sun. 6,000 ft. may be assigned as the limit in the *Himálaya*, where snow regularly falls in winter, with the probability of remaining some time upon the ground.

In *Western Tibet* and in the *Karakorúm*, the general elevation of the country is so great, even in its lowest regions, that no part lies below the limit of hibernal snow-fall. But the quantity of snow actually falling is inconsiderable, and this circumstance it is, which forms one of the chief causes that the passes of the *Karakorúm*, even

\* Humboldt's "Kosmos," Vol. IV., p. 246.

† Newbold, in "Philos. Transactions," 1845, p. 127.

‡ Colonel R. Strachey, in this Journal, Vol. XVIII., Part I., p. 309.

§ This Journal, Vol. III., p. 367.



the highest, remain open throughout the year. In some parts of Tibet the winter is the only season, when atmospheric precipitation at all takes place.

In the *Künlün*, even on its southern slopes, a greater amount of snow is precipitated than on the northern side of the *Karakorúm*, whilst its *Turkistani* (northern) slopes differ still more from the *Karakorúm* in this respect, they being visited by very heavy rains and great snow-falls. Even at *Káshgar* (about 3,500 ft), in *Turkistán*, there are said to be several snowy days every winter.

The data, which I was able to collect on snow-fall in the *Andes*, are so few and vague, that I could not draw any conclusion from them. Also for the *Alps*, I could not bring forward any new facts with reference to the snow-fall.

## 2. *Snow-line.*

The snow-line, or the average height where snow remains perpetually throughout the year, has offered unexpected difficulties in its determination for the *Himálaya*. When *Webb* and *Moorcroft* first pointed out the general heights reached by the snow-line, when they first discovered the remarkable fact, that, in spite of the influence arising from exposition, the snow-line of the *Himálaya* descends lower on its *southern* (Indian) than on its *northern* (Tibetan) slopes, the statements of these travellers, now proved to be correct in all material points, were discredited by men of science both in Europe and in India. *Humboldt*, however, was among the first who endeavoured to remove the distrust with which these discoveries were received; he also gave an explanation\* of the causes which were possibly sufficient to originate so remarkable a phenomenon as this of the unlooked-for differences existing between the snow-lines of the Tibetan and Indian slopes. He considers it "the results conjointly of the radiation of heat from the neighbouring elevated plains, the serenity of the sky, and the infrequent formation of snow in very cold and dry air." Of all these causes, however, the last is the most important. The direct insolation, being less interrupted on the Tibetan side, has also its share of influence; but the effect is comparatively small. As the best corroboration of the quantity of snow-fall being the principal cause of the depression on the southern (Indian) slope of the *Himálaya*, may

\* "Asio Centrale," pp. 284, 327; "Kosmos;" Vol. I. p. 358.

be adduced the fact, that we found the isothermal lines for the year and the summer, which coincided with the snow-line on the Indian side, decidedly warmer than those on a level with the Tibetan snow-line. The fact, moreover, of the *Karakorúm*—though on an average three degrees farther north—having the snow-line so excessively high on both its slopes, offers another instance of the influence of limited precipitation.

In the *Künlün*, the meteorological conditions also become apparent in the different limits of the snow-line on either side; but here the effect is the reverse of that perceived in the *Himálaya*, the greater precipitation on the “northern” slopes (towards the plains of *Turkistán*) lowering the snow-line on that side to a considerable extent.

Although, in the *Himálaya* at large, the snow-limit of the Tibetan side does not descend so low as that of the Indian, yet the influence of exposition at once becomes apparent in the ordinary sense, corresponding to these latitudes, if we examine the slopes of a crest or mountain, of which, by the nature of its position, both slopes belong either to the Indian side of the ridge in general, or to the Tibetan side. The many and vehement disputes upon the much-discussed subject of snow-limits have chiefly arisen from the entire neglect of this modification.\*

The values we obtain for the height of the snow-line on the three mountain chains of *High Asia* are :

			Feet.
A. <i>Himálaya</i> .	Southern (Indian slopes), ... ..	...	16,200
	Northern (Tibetan) slopes; ... ..	...	17,400
B. <i>Karakorúm</i> .	Southern (Tibetan) slopes, ... ..	...	19,400
	Northern (along the Turkistani plateaux),		18,600
C. <i>Künlün</i> .	Southern (facing mountainous ramifications),		15,800
	Northern (facing the Turkistáni plain),† ...		15,100

For the *Andes*, the snow-limits are, according to Humboldt and Pentland :

\* See Batten, in the “*Calcutta Journ. of Nat. Hist.*,” Vol. IV. p. 537; Vol. V. p. 383. Capt. T. Hutton, “in the same Journ.” Vol. IV. p. 275; Vol. V. p. 379; Vol. VI. p. 56; and Capt. A. Jack, “in the same Journ.” Vol. IV. p. 455.

† “*Asie Centrale*,” 1847, Vol. II. pp. 165 and 177.

	Feet.
Eastern Andes of Bolivia, ... ..	15,900
Western Andes of Bolivia, ... ..	18,500
Andes of Quito, ... ..	15,700
For the <i>Alps</i> , my brothers obtained :	
Southern slopes, ... ..	9,200
Northern slopes, ... ..	8,900
Extremes (near the Mont Blanc and Monte Rosa group), ... ..	9,800

### 3. *Glaciers.*

The existence of the glaciers of High Asia was first made known for *Western Tibet*, by Vigne, who alludes to them repeatedly in his "Travels in Kashmir," London, 1842. Colonel Richard Strachey was the first\* who (in 1847) proved their existence in the *Himálaya*. The recent date of this discovery will appear the more surprising, when the immense number of glaciers now positively ascertained to be in this region is taken into consideration. The great amount of ice to be met with, even in lower elevations of the *Himálaya*, could not of course escape the observation of previous travellers; these masses, however, they used to designate as "hard, frozen snow-beds," and to consider them as local phenomena, analogous to remains of avalanches.

On both sides of the *Karakorúm* and the *Künlün*, we also found glaciers, having forms identical with those of the *Alps*, and following the same laws of motion. Some of them are considerably larger than the glaciers in Europe. The *Aletsch* glacier in the *Alps* extends a little over fifteen miles in length, whilst some of the glaciers, surveyed by Captain Montgomerie and his party in *Bálti* (on the southern side of the *Karakorúm*)" boast of no less than thirty-six miles in length, with a breadth of from one to two and a half miles. The *Biáfo* glacier forms, with the glacier on the opposite slope towards *Miggáir*, a continuous river of ice of sixty-four miles running in an almost straight line, and without any break in its continuity beyond those of the ordinary crevasses of glaciers. The *Biáfo* glacier is supplied in a great measure from a vast dome of ice and snow, about one hundred and eighty square miles in area, in the whole of which only a few projecting points of wall are visible. The *Bálsoro* main glacier, thirty-

\* See this Journal, Vol. XVI., part II. p. 794; Vol. XVII. part II. p. 203.

six miles in length, and with fourteen large tributary glaciers of from three to ten miles in length, would form a study in itself, and give employment for several summers, before it could be properly examined."\*

In the *Himálaya*, the lowest glaciers go down to 11,000 ft. and even 10,500 ft.; the Pindari ending at 11,492 ft., the Timtimna at 11,430 ft., the Tsóji at 10,967 ft., and the Chàia at 10,520 ft.

In *Western Tibet*, they descend to about the same elevation; thus, the Mustágh 11,576 ft., the Tapto 11,508 ft., the Támi Chúet to 10,460 ft., the Bépho (Biáfo of Capt. Montgomerie?), near Askoli, even to 9,876 ft. The latter is worthy of notice as a remarkable case of low termination.

In the *Künlün*, the glaciers end probably at heights not much differing from those in Western Tibet; at least so we infer from the general appearance of the upper part of the glaciers we saw during our travels in these regions. The glaciers on both flanks of the Elchi pass presented, however, no instances of particularly deep descent.

In the *Andes*, no glaciers are as yet known to exist,† and they do not occur in tropical America, from the equator to 19° latitude north.

In the *Alps*, the lowest glacier is that of Lower Grindelwald, ending at 3,290 ft., but in general 5,000 ft. must be considered as a rather low end of a glacier.

#### IV. THE VARIETIES OF HABITATION.

##### 1. *Towns and Villages.*

The *Himálaya* rises, in general, so abruptly above the plains of India, and the latter, particularly in the western regions, are in themselves of such an elevation, that even in the lower parts of the valleys there are but few, if any points of less height than 1,000 ft. above the level of the sea. Two causes more especially have tended to displace the order of population in these districts, the lower parts being almost deserted in favour of the lands lying immediately above. In the first instance, the prevailing steepness of the country hercabouts, which is still considerably increased by the erosion of the rivers, precludes the successful cultivation of the soil; and, again, the fertile, well cultiva-

\* Montgomerie, in "Journ. As. Soc. Beng. 1862, No. II. p. 210.

† Humboldt, "Asie Centrale," Vol. II. p. 167.

ted plains of India are converted, wherever they touch the southern foot of the Himálaya, into swampy and marshy lands, called the Tarái, which in some parts form but a narrow strip or belt, whilst in others, as in Nepál, they attain a breadth of thirty to forty miles. The Tarái abounds with large and lofty forest trees. Owing to the swampy and malarious character of the Tarái, which skirts the extremities of the valleys, the neighbourhood is rendered as uninhabitable to the tribes of the Central Himálaya as to the highly susceptible and less seasoned visitor from European climes. Consequently (from all these reasons stated), in the inferior stratum of heights, ranging between 2,000 and 3,000 ft., the number of places inhabited by the natives is comparatively insignificant; while population reaches its maximum in the rich belt of life rising from 5,000 to 8,000 ft., the traces of man and his dwelling-place begin rapidly to disappear at 11,000 ft., and even before.

The *highest limits of habitation*, however, very often present themselves under a form which almost excludes the possibility of strictly comparing them as dependent upon climate. It is a remarkable fact, that in some provinces of the Himálaya, especially in Nepál, Kámáon, and Gárhvál, many villages are deserted in winter, though as far as regards their elevation and the solid construction of the houses, they might very well be inhabited throughout the year. The natives, however, prefer removing to villages less elevated, where they spend the colder months. In the Himálaya west of Gárhvál, such modifications do not occur; at least we are not aware of the existence of villages in Simla, Kúlu, Kishtvár &c., where the inhabitants follow regularly the nomadic example furnished in other parts of the hill country.

The Alps of Europe also present instances of this kind in Findelen (7,192 ft.), Bresily (6,594 ft.), and many other summer villages of greater or less elevation on the French side of the Alps.

*Western Tibet* is a country of such general elevation, that only in the province of Bálti villages are to be found below a height of 6,000 ft. Some of the chief towns are built at considerable elevations; Leh, the capital of Ladák, lies 11,527 ft. above the level of the sea. The *highest permanently inhabited places* are, however, Buddhist monasteries, the most elevated being probably that of Hánle, (15,117 ft.), in Ladák. I state it positively as my conviction, that nowhere in

the world there exists a permanently inhabited place at a height exceeding 15,600 ft. Paul de Carmoy's "Pueblo de Ocoruro," in the Sierra Nevada, 18,454 ft. high, will prove, on a closer examination, to be a temporarily inhabited place, similar to the *summer villages* of Tibet, of which I name Gártok (15,090 ft.), Nórbu (15,946 ft.), and Púga (15,264 ft.)

In the *Künlün*, even the foot of its southern (Tibetan) slopes is so elevated, that no villages exist at all. By combining our own observations a variety of reports received, I obtain for its northern slopes 9,400 ft. as the limit of permanently inhabited villages; summer villages reach about 10,200 ft.

In the *Andes*, large and important permanently inhabited places have been built at great heights (Cerro de Pasco, 14,098 ft., Potosi 13,665 ft.); they are generally situated on plateaux. Santa Barbara, a mine with solid houses, about three miles south of Huancavelica, is situated at a height of 14,508 ft.

For the *Alps*, I have already had occasion to mention their summer villages. The highest permanently inhabited villages are in the valley of Avers in Graubündten, where Juf lies at an elevation of 7,172 ft., and that of Cresta exceeds 6,700 ft. But the roads leading across the passes have rendered it necessary to construct houses near the top which are permanently inhabited; the highest of these at present being the well known monastery of St. Bernard (8,114 ft.) As long as the road over the Stelvio or Stilfser Joch was kept up, Santa Maria (8,146 ft.) was also inhabited throughout the year.

## 2. Pasture-grounds.

In the *Himálaya*, pasture-grounds "Kárik," for sheep and bovine cattle, are for the most part in low elevations, and at no great distance from the villages. The Kárik Biterguár, in Kámáon, must be mentioned as an exception to this general rule, it being situated at an elevation of 14,594 ft. Nowhere are there built on these pasture-grounds châlets (Alpenhütten), which are as little used in the Himálaya as tents in the Alps.

Dairies, which are dispersed all over the Alps, and which form the source of a profitable income under an able management, are quite unknown in the Himálaya, even in those parts, as Kashmír and Nepál,

where ample tracts exist extremely favourable for erecting such establishments even on a large scale.

The pasture-grounds of *Tibet*, to which the numerous herds of sheep are driven in summer, reach an elevation from 15,000 to 16,349 ft., beyond which the Tibetan shepherds, who sometimes remain upon the mountains from June to September, cannot be supposed to make any permanent residence. The most elevated pasture-grounds of Tibet are, *Lárstá* (16,349 ft.), *Zinchín* (16,222 ft.), *Kyángchu* (15,781 ft.), *Rúkehín* (15,064 ft.), *Ámlung* (15,300 ft.), and *Júgta* (15,058 ft.)

Though many cloudless days succeed each other in these lofty regions, thus leaving the power of direct insolation unimpaired, the climate always remains bleak; while the prevailing winds not only aggravate the effects of a low temperature, but also that of a low barometrical pressure, thus presenting a remarkable modification of climate, of which I shall hereafter give some detail in the considerations upon the influence of height in general. The shepherds with difficulty provide themselves with a sufficient supply of fuel for cooking purposes; sometimes they contrive with much labour and pains to erect rude stone walls, behind which they may take shelter during the night. These walls are usually circular in form, from four to five feet high, and without a roof.

In the *Künlün*, the slopes on its southern side are so elevated, that there exist no pasture-grounds at all; on its northern slopes, they do not occur above 13,000 ft.

For the *Andes* no data with reference to pasture-grounds are at my disposal.

The pasture-grounds in the *Alps*, which are generally in the neighbourhood of *Châlets*, may be met with at heights of 8,000 ft. and upwards: the *Fluhalpe* (8,468 ft.) on the *Findelen* glacier near the *Monte Rosa*, and the *Torrenthütte*, in the *Anniviers* valley, being instances of the greatest elevations.

## V. EXTREME HEIGHTS VISITED BY MAN.

### 1. *Mountain-ascents.*

Temporary habitations, frequented for some months, as we have seen from the discussion of the highest pasture-grounds, sometimes reach a height of nearly 16,300 ft. As far as my experience goes, I

may state, that for short periods of ten or twelve days, man may considerably exceed this height, not without suffering, but at least without positive injury to himself. During our explorations of the Ibi Gámin glaciers, August 13th to 23rd, 1855, we encamped and slept during these ten days in company with eight men at very unusual heights. During this period, our lowest camp was pitched at 19,326 ft.—the greatest height at which we ever passed a night: — another was at 19,094 ft. ; two camps exceeded 18,300 ft., and the remainder ranged between 18,000 and 17,000 ft. Apart from the extreme elevation and consequent cold, the bodily exertions imposed upon us during our stay, proved a great tax upon our powers. Once we crossed a pass of 20,439 ft., and three days earlier, August 19th, 1855, we had ascended the flanks of Ibi Gámin to a height of 22,239 ft. This, as far as we know, is the greatest height yet reached on any mountain, though considerably below that to which man has arisen in balloons.

On the Sássar peak we attained (August 3rd, 1856) an elevation of 20,120 ft. As early as 1818, however, the brothers Alexander and James G. Gerard ascended (October 18th) a peak in Spiti 19,411 ft. high, not far from the Porgyál, or Tazhigáng. Subsequently, August 31st, 1828, Dr. James G. Gerard reached 20,400 ft.

From Captain T. G. Montgomerie we learn, that a station of 19,979 ft. has been reached twice by Mr. W. H. Johnson, and another of 19,958 ft.\* in height by Mr. W. G. Beverley. Mr. Johnson took, besides, observations in Ladák at one station more than 20,600 ft. high, the greatest altitude yet attained as a station of the Trigonometrical Survey of India.† A trigonometrical mark has even been erected on a point 21,480 ft. above the level of the sea, “but unfortunately there was not sufficient space to put a theodolite on it.”

In the *Andes*, Humboldt ascended the flanks of Chimborazo (June 23rd, 1802) to a height of 19,286 ft. ; this being the extreme elevation attained at that period. Some years afterwards (December 16th, 1831), Boussingault reached, on the same peak, a height of 19,695 ft.‡

In the *Alps*, my brothers Adolphe and Hermann once remained in the Vincenthütte, on the slopes of Monte Rosa, fourteen days at a

\* See this Journal, 1861, No. II., pp. 99, 110.

† See this Journal, 1863, No. II., p. iii.

‡ Humboldt's “Kleinere Schriften,” p. 157.



height of 10,374 ft. The well known English Professors Tyndall and Frankland even passed the night of August 21st, 1859, on the top of the Mont Blanc (15,784 ft.)

## 2. *Balloon-ascents.*

In the free atmosphere the greatest height was reached by Mr. Glaisher in a balloon, which was directed by Mr. Coswell; he ascended, September 5th, 1862, the extraordinary height of at least 30,000 ft., but, as he was unable to make any observations above that height, being suddenly overtaken by sickness, it is supposed that the balloon rose as high as seven miles = 36,960 ft.

Not less remarkable than this ascent was the one performed by Gay-Lussac, as early as the beginning of this century (September 16th, 1804), when he rose to 23,020 ft. Between Gay-Lussac's and Mr. Glaisher's ascent, several attempts have been made to reach great heights in balloons, especially in England, during one of which the late Mr. Welsh reached (November 10th, 1852) 22,930 ft.\* The balloon-ascents made in England were all combined with experiments of a highly interesting nature, and instituted by a scientific committee, among whose members it is sufficient only to name Sabine and Sykes.

Previous to Mr. Welsh, Messrs. Bixio and Barral rose (July 27th, 1850) to a height of 23,009 ft.

As a balloon-ascent, remarkable not only on account of the height reached, but on account of the horizontal distance performed, I must mention the one made by Mr. Nadar, in company with eight persons, October 18th, 1863. Mr. Nadar rose from Paris and let himself down—or he rather fell down—near Rethem, a small town on the river Aller, in Hanover. The direct distance between these two towns is about 395 miles, and as it took 15 hours, 47 minutes to travel through this distance, the balloon flew 2,227 ft per minute, or 37 ft. per second. But, as the balloon was far from going in a straight line, it has been computed, that the greatest velocity attained by it amounted to 50 ft. per second.

## 3. *Effect of height.*

The effect of height is chiefly perceptible in the decrease of temperature and barometrical pressure. According to our observations,

\* "Philosophical Transactions," 1853, Part III., p. 320.

the atmospheric pressure is, at a height of about 18,600 or 18,800 ft., one-half of that at the level of the sea. At an elevation of 22,200 ft. (so trivial a height when compared with the extreme upper limit of the atmosphere), we observed a barometrical pressure of 13.364 inches, so that nearly three-fifths of the weight of the atmosphere lay below the point reached by us at the time.

It is evident that there must be a limit beyond which the degree of rarefaction is incompatible with the conditions of human existence; but it will ever remain extremely difficult to determine the line of demarcation, with any approach to scientific precision.

The influence\* which height exercises upon man, varies with the individual; a man in good health having the chance of less suffering. The difference of race has apparently no appreciable importance. Our Hindu servants suffered far more from the cold than our Tibetan companions, though not more from the diminished pressure. For the generality of people the influence of height begins at 16,500 ft., a height nearly coinciding with that of the highest pasture grounds visited by shepherds.

The complaints produced by diminished pressure are,—headache, difficulty of respiration, and affection of the lungs, the latter even proceeding so far as to occasion blood-spitting, want of appetite and even sickness, muscular weakness, and a general depression and lowness of spirits. Bleeding of the nose we experienced ourselves, though very rarely, the loss of blood on such occasions being insignificant; but bleeding of the ears and lips we neither experienced personally, nor observed in others during our travels in *High Asia*. Humboldt,† however, states, that on the Antisana, at a height of 18,141 ft., his companion, Don Carlos Montufar, bled heavily from the lips, and that during the ascent of the Chimborazo, every one suffered from bleeding of the lips and even the gums.

The effects here mentioned, which disappear in a healthy man almost simultaneously with his return to lower regions, are not sensibly increased by cold, but the wind has a most decided influence for

\* Notices and remarks on this subject are to be found in "Gleanings in Science," Vol. I., p. 330; Gerard's "Koonawur;" Hooker's "Himalayan Journals," Vol. II., p. 413; Thomson's "Western Himalaya and Tibet," p. 135 and p. 433.

† "Kleinere Schriften," Vol. I., p. 148.

the worse upon the feelings. As this was a phenomenon we had not hitherto found mentioned by former observers, we directed our particular attention to it, and remarked instances where fatigue had absolutely nothing to do with it. In the plateaux of the Karakorúm, it was a common occurrence, even for the sleepers in the tents, where they might be considered as somewhat protected, to be waked up in the night with a heavy feeling of oppression, the entire disturbance being traceable to a breeze, which had sprung up during the hours of rest.

The effects of diminished atmospheric pressure are considerably aggravated by fatigue. It is surprising to what a degree it is possible for exhaustion to supervene; even the act of speaking is felt to be a labour, and one gets as careless of comfort as of danger.

## VI. LIMITS OF VEGETATION AND ANIMAL LIFE.

### 1. *Vegetation.*

In *India*, the vegetation is not limited by climate in the elevations existing; the highest peaks, as the Dodabétta (8,640 ft.), in the Nilgiris, the most elevated plateaux are covered with trees, shrubs, and in fact a luxurious vegetation, not only along their slopes, but even on their top.

In the *Himálaya*, trees grow very generally up to heights of 11,800 ft., and in most parts there are extensive forests covering the sides of the mountains at but a little distance below this limit. Those forests are especially beautiful in the higher valleys of Kámáon and Gárhvát, in the Bhagiráthi valley.

In *Western Tibet*, though we did traverse it in various directions, none of us found anything at all corresponding to a forest. Apricot trees, willows, and poplars are frequently cultivated on a large scale; poplars, indeed, are found at Mángnang, in Gnári Khórsum, still at a height of 13,457 ft.; but they are the objects of the greatest care and attention to the Lamas.

In the *Künlün*, we found the trees on its northern side not to grow above 9,100 ft. On the northern side, we saw no trees at all; here the considerable height of the valleys we passed excluded them.

In the *Andes*, trees end at about 12,130 ft.; in the *Alps* on an average at 6,400 ft., isolated specimens occurring, however, above 7,000 ft.

The cultivation of grain coincides, in most cases, with the highest permanently inhabited villages : but the extremes of cultivated grain remain below the limit of permanent habitation. In the *Himálaya*, cultivation of grain does not exceed 11,800 ft., in *Tibet* 14,700 ft., and in the *Künlün* 9,700 ft. For the *Andes*, the limit is 11,800 ft. ; in the *Alps*, some of the extremes are found near Tindelen, at a height of 6,630 ft., but the mean is about 5,000 ft.

The upper mean limit of grass-vegetation is, in the *Himálaya*, at 15,400 ft., in *Western Tibet* at 16,500 ft. ; in the *Künlün*, grass is not found above 14,800 ft.

Shrubs grow, in the *Himálaya*, up to 15,200 ft., in *Western Tibet*, as high as 17,000 ft. On the plateaux to the north of the *Karakorúm*, shrubs are found at 16,900 ft., and, which is more remarkable, they occasionally grow there in considerable quantities on spots entirely destitute of grass. As an example, I mention the Voháb Chilgãne plateau (16,419 ft.) and Bashmalgún (14,207 ft.)

In the *Künlün*, the upper limit of shrubs does not exceed 12,700 ft. ; above this height grass is still plentiful ; and shrubs being here, as generally everywhere else, confined to a limit below the vegetation of grass, the range presents an essential contrast in this respect to the characteristic aspect of the *Karakorúm*.

In the *Andes*, shrubs grow up to 13,420 ft., in the *Alps*, their upper limit is at 8,000 ft.

The very extreme limit of phanerogamic plants appeared in *Tibet* at the north-eastern slopes of the Ibi Gãmin pass, at a height of 19,809 ft. ; next in order came those of the Gunshankãr peak, in Gnãri Khórsum, at 19,237 ft. In the *Himálaya*, the highest plants were found by us at 17,500 ft., on the slopes of the Jánte pass, in Kãmáon.

In the *Andes*, Colonel Hall found the highest phanerogamic plants on the slopes of Chimborazo, at 15,769 ft., consequently 4,040 ft. lower than the Ibi Gãmin plants in Tibet.

In the *Alps*, my brothers found an analogous extreme on the southern slopes of the Vincent pyramide at 12,540 ft. •

## 2. *Animal life.*

*Monkeys* appear to frequent, in the *Himálaya*, regions exceeding 11,000 ft. in height ; the *Semnopithecus schistaceus*, Hodg. ascending

higher than others. These monkeys, called "Langúrs" by the natives, have been frequently seen at 11,000 ft., while the fir-trees among which they sported were loaded with snow-wreaths. This species is not known in India, whilst the *Macacus Rhesus* is met with in India, as well as in the Himálaya.

In *Western Tibet*, and farther to the north, no monkeys have yet been found. *Tigers* ascend to 11,000 ft. in the Himálaya; they are not, however, seen in Western Tíbet or the Künlün.

*Leopards* may be met with, in the Himálaya and in Tibet, even at 13,000 and 14,000 ft. The *lion*, though intimately connected with the mythology of High Asia, has been forthcoming, in historical times, only in Kashmír. In India, the lion occurs at the present day only in Guzrát, and there only in very small numbers.

*Jackals* were found by us in the Karakorúm between 16,000 and 17,000 ft. *Wolves* are not known to frequent the Himálaya Proper, but they are found in Tibet, where we saw of traces of them in sand close to the Karakorúm pass (18,345 ft.)

Various species of beautiful *wild sheep* and *ibex*, together with the *Kyáng* and the *wild yak*, are met with in large herds on the highest plateaux between the Karakorúm and the Künlün.

The *cat* is common in Tibet; *dogs* are the companions of the Tibetan shepherds, whom they follow over passes exceeding 18,000 ft.

Some species of *bats* are seen in the Himálaya up to 9,000 ft.; and the Tibetan *hare* occurs even in heights exceeding 18,000 ft.

*Migratory birds* are not known to cross the Himálaya, as many birds of Europe cross the Alps. *Doves* were seen by us at very great heights in the Karakorúm and Künlün; this was the most surprising, as other birds were very rare.

The domestic *fowl* has recently been introduced with great success by Guláb Singh into Bálti, Ladák, and Núbra.

*Fishes* were found by us in some rivulets of Tibet exceeding 15,000 ft. In the *Alps* they cannot live beyond 7,000 ft.

Of *reptiles* we found snakes and saurians as high as 15,200 ft. In the *Alps* they go up to 6,000 ft., in the *Pyrenees* to 7,000 ft. In the *Andes*, snakes were found by Schmarda at about 11,500 ft.

For *butterflies* we found in the Himálaya 13,000 ft., in Tibet and Turkistán even 16,000 ft. as localities of permanent habitation. *Bee-*

*tes* probably follow the highest formation of grassy turf in the Himá-laya, as well as in the Andes and the Alps. *Mosquitoes* go up to 8,500 ft. ; and *peepsies* make themselves very troublesome during the rainy season as high as 13,000 ft.

The existence of *infusoria* seems as little subject to limitation by height in High Asia, as in the Andes and Alps. In a few fragments which we chipped off from the rocks of the Ibi Gamin pass (20,459 ft.) Prof. Ehrenberg of Berlin detected their presence, and found them not insignificant in quantity ; he discovered twelve species new to science.

