Study vast

mass of detail

Leading principles & modes of research

Correction please prof. & Geog. changes

The study of the distribution of forms of life, animals & plants, over the surface of the world is an exceedingly vast one. & To attack it systematically would lead us into an overwhelming mass of detail. I wish therefore, within the brief limits during which I may hope to occupy your attention this evening, merely to endeavour to bring before you a few of the leading principles & modes of research by which the facts of distribution have been within late years systematized, & particularly to illustrate the mode in which the study of the distribution of animals & plants throws light on the later geological changes & changes of climate which have passed over the surface of the Earth

first actual distribution.

regions or provinces.

next Causes

eliminate Climate & nat. dissem.

Instances of geol. & distrib. as geog. & geol.

For this purpose we will first examine the actual present distribution of life in a general way, the problems which it presents & the great regions characterized by peculiar assemblages of animals & plants into which the surface of the earth may be divided.

Next it will be proper to investigate the causes which may have led to the present arrangement & after eliminating those due to climate & the natural powers of retention of plants & animals, to conclude with a few instances in which the circumstances of distribution & geological & geographical changes illustrate Each other.

Review of Lecture 1.

In last lecture began study of Phys. geog. by examining outer envelope of earth, the atmosphere.

Found to be composed of O & N in nearly constant proportions, yet merely a mixture.

Two other important constituents CO_2 & Aq. vap. these, & especially the latter, less constant.

Found air to act as carrier of Carbon in form of CO_2 between plants & animals, & also to form bond of union between land & water by acting as carrier of Aq. vap.

Height of atmosphere great & indeterminate, but condensed in lower layers by its own weight so that at 18,000 half the whole amount of air below us.

Glanced at Bar. in simplest form. Instrument by which determine weight of Atmosphere & study changes of weight.

Even in same place barometer & consequently weight of air constantly changing. Two main causes of change, change of temperature, & change of amt. of aq. vap. When heated, expands flows away & decreases pressure. Aq. vap. by the time it enters occupies its place causes decrease [illegible]

Thus well to note that though we speak of dull heavy weather when the air charged with moisture, pressure really less. Bar. falls because column unsupported.

Heat of air. Glanced at construction of Thermometer. Sole source of heat of air is sun, not directly, but by heating the surface of the ground & air in contact. Atmosphere opaque to dark heat owing to CO_2 & Aq. Vap.

Most heat at Equator, but not regularly distrib. according to lat. chief cause irregularity in distrib. of sea & land. Also by height, diminution of 1° Far. for 300' in alt.

Isothermal Lines represent unequal distribution. Show mean heat of air near surface of earth. Climates of places on same isotherm. not necessarily the same. (Contrast two sides of Atlantic)

Moisture of air. Vast quantity of water conveyed by air in invisible channels. Capacity for moisture increased by greater heat of air. Temp. of Saturation or dew point. Explained by hygrometer (explain) cooled by evaporation. Led us to observe that great quantity of heat rendered latent when evap. occurs, given out again when condensation occurs.

This latent heat neither sensible to our nerves, nor affecting the thermometer, but potent in Economy of the atmosphere. The more aq. vap. the air holds the more heat it has stored up, ready to be liberated when condensation occurs.
This condensation happens in quietest & simplest form in dew. Thus water "falls" from air, not comes out of ground as has been supposed. Swiftly condenses upon formation of cloud because grows & cools quicker at night than the air, & cools that portion of air in contact with it.
When ~~separate~~ Cooling of air happens at the surface at hand to remove moisture, or happens too suddenly, water dust produced in the air. Thus we call fog a mist, a cloud according to position on ground or in higher parts of atmosphere.
Examined simplest mode of formation of Cumulus cloud at summit of ascending column of warm moist air. Study of Clouds important, Strong forms of masses of air of different temp. & degree of humidity, also movements of air in upper atmosphere which otherwise unknown. Thus rounded forms of upper

Part of Cumulus cloud shows work in what ascending column pressing up through upper air. Flat base shows exact elevation at which ascending air lowered in temp. below its dew point.

Classified clouds as Cirrus, Cumulus, Stratus, nimbus. Other clouds named by Combinations of terms as Cirro-cum. Cirro-stratus. Former what called a mackerel sky.

Height of Cloud region

↓ See p. 30

Summary of Lect. II.

Passed from consideration of Condensation of moisture in clouds & mist, to its precipitation as rain & snow. Rainfall in Meteors. Sense wh[ich] amt. of precip., the snow being melted & added. Measured by Rain gauge. Rainfall differs much in different places. ~~Causes of~~ ~~Natural differences depended~~.

Land & especially high Land acts as Condenser. Examined Circumstances by which Mountain chains condensing moisture may produce dry hot regions or even deserts on the side opposite to that on wh[ich] prevailing winds strike. Instanced Victoria on Coast of B.C. & Utah inside the Coast Range. Draw attention to importance in regard to climate as of N.W. Ind. not to greed to produce desert, as further S. modifies climate favourably. Warm air absorbs more moisture. Rainfall greater in the tropics. Heaviest known rainfall by warm sea winds strike mountains of India.

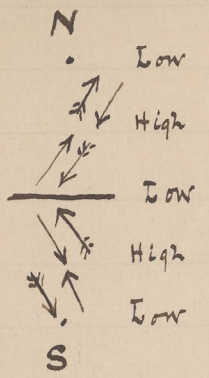
Greatest rainfall along Coasts. Exceptions in Chile &c. Rainless regions. Rainfall divided into Periodic, Variable, & abnormal.

Movements of the air. Simplest Case in Land & Sea breeze.

Blow from cold to warm, a vert. movement causing horizontal circulation. Region of heated & expanded air one of low barometer. Rule. Air flows from areas of high to areas of low pressure.

On extending our view to general circulation of atmos. of globe, found the general principle to be that warm currents rising from the Equatorial regions flowed in upper regions of air towards poles. Colder & heavier currents flowed towards equator on surface, from North & South. Relative difference in rate of motion of different parts of earths surface prevented air flowing in straight lines. Result N.E. & S.E. trades on N & S sides of Equator, with return upper currents in opposite directions above. Blowing perennially & steadily. Great pp. near Equator. Regularity somewhat interfered with by Continents &c. How knowledge of trades & their return currents obtained.

Trades only 30 to 35° wide on each side of Equator. Calms of Cancer & Capricorn. Supposed Crossed descent



Crossing. Not regular, but general result.

In both there have Surface Sw., & Upper N.E., Winds

Convergence of Meridians. Narrowing Bed. Turning back of poleward winds. —

Coupled action
Chiefly by Northern winds
as by coinciding with S & N
apt to lead to Conjunction.
Winds to S. take opposite
directions; as shown.

Summary of Sect. III.

Movement of Calm Equatorial belt, with trade winds & Circulation generally through nearly 1000 m. with the Seasons. N. in Northern Summer. S in Southern Summer. Superposed irregularities, Eddies &c. Most important Seasonal wind the Monsoon. ~~Examples~~ Looking at distrib. of Atmos. pressure as indicated by Isobars or lines drawn through all places where the same pressure prevails, and Cause of Monsoons in High winter pressure, low Summer pressure over Central asian steppes, latter causing influx. In India S.W. Monsoon. The rain-bearing wind. Other Monsoon regions.

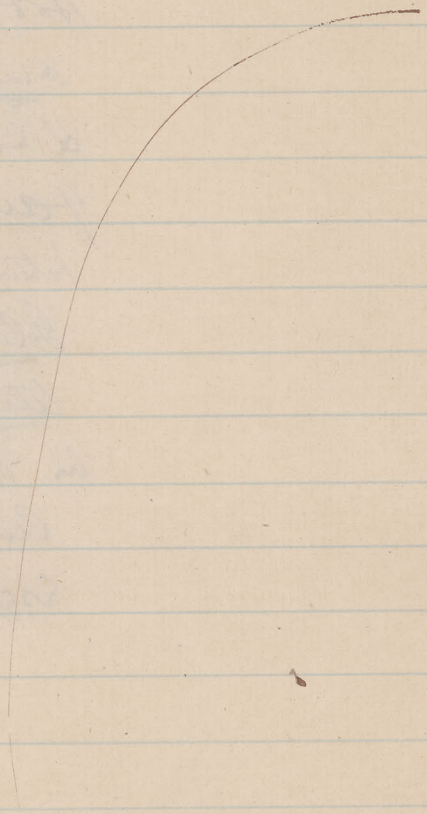
In Temp. lats. North & South of about 30° winds irregular as compared with trades & return currents. but 2 normal winds. In N. Hemisphere S.W. or equatorial Current & N.E. or polar Current. S.W. generally prevails on surface.

Areas of high & low pressure of an irreg. Character producing local winds known as Storms, in general. Contrary to old belief these winds always Spirally approaching an area of low pressure. In N. Hemisphere in direction opposite to hands of watch, or back to wind, low bar. producing always to left. (to mind pr direction) Force of wind depends on Amount of difference of pressure & distance of places. This difference of pressure in given distance spoken of as gradient (need not trouble about numerical representation) Steeper gradients stronger winds. Found then atmospheric disturbances divisible into two great Classes. Cyclones & Anticyclones.

Cyclone depends on low barometer, Column of air ascending spirally. Opposite to watch. Generally strong winds & disturbed atmosphere rain & gales. Areas move pretty rapidly. Here what commonly known as storms.

Anticyclone. Area of high bar. Spirally Descending Column
of air. With winds of watch. Do not travel fast over
surface. Generally clear fine weather. Dry air.
Hot in summer Cold in winter.
origin of Storms in Heating of air on surface of earth
& consequent ascending column. Condensation of moisture
of air & consequent libration of heat, & eddies formed
between opposing Currents.
Glanced finally at mode of following paths of Cyclones
telegraphically & issue of storm warnings for places
in their course. Use of knowledge of position of
Centre of Storm by Buys Ballots' law to vessels in
escaping from Cyclones & hurricanes.

Utility of Study of Currents of air & sea in
shortening passages. Vessels choose the best
routes



Review of Sect. IV.

Examined water in regard to its physical properties. Referring especially to the great amt. of heat rendered latent or liberated when water passes from solid to liquid or liquid to gaseous states, & reverse. Also to its specific heat, or capacity for heat. These 2 properties of particular importance in enabling it to act as climate. Remarkable behaviour of water in freezing. Expands before reaching freezing point enabling ice to float on surface. Mode of cooling of bodies of water by convection.

Water scarcely ever pure in nature. Sea contains a great quantity of salts. Increases its weight as compared to pure water, or sp. gr. Lowering the freezing point & checking too great evaporation.

Besides salts 3 bodies present in very minute quantity of great importance. Carbonate of lime, Silica, & dissolved oxygen.

Proceeded then to examine the great sea basins. Of surface all equally smooth chalk ooze to depth of a mile.
To gain complete knowledge of form of depths must examine not only surface plateau but depth of sea. Saltness still subject unknown.
Mean depths of some oceans & earthquake waves, power of.
Plate fort. expeditions & particularly Challenger.
Broader views of oppositions & elevations. In great triple great land area, triple great ocean area.
In proof of connection of islands & continents & submarine plateaux traced out several continuous lines on sea bottom.
100 fath. joined England & continent. 500 fath. connected Europe & America &c
Deepest seas equatorial. Between 80° N & S average 3 m.
Average of seas of globe 2 m.
Improvements of sounding app. & what knowledge of deep sea rendered possible. Detachable weight & apparatus for bringing up specimen of bottom. Deepest water yet found 4575 fath or 5¼ miles.
Sea bed found not irregular, wide gentle slopes.

Review of Lecture V.

Examined certain submarine plateaux. Depths of the Pacific ocean.

Material of the sea bed. Round edges produced by erosion of shore. Blueish & greenish muds. Oozes sometimes 150 miles from land.

Old idea of depths abyssal region below 300 fath. Life only to greatest depths, but scarce. No plants below 200 fath. Enormous pressure at great depths. Animal existence rendered possible on account incompressibility of water. No light beyond a few hundred fathoms.

At all depths from 250 to 3000 fath. Globigerina ooze. Microscopic animals shells. Live near surface (or sometimes scattered through water at all depths)

2000 & 3000 & + Red Clays. Origin. Very slow accumulation. Sharks teeth & bones of whales.

Currents of ocean. Gulf Stream best known. Taken as type. Caused by trade winds. Equatorial current

Division at C. St Roque. Skirts American Coast. Branch turns Southward. Course indicated by drift-wood, Seeds, nets, bottles &c. Meeting with Arctic Current. Possible origin from banks of Newfoundland. Arctic current slate tinted & thermometer more below Gulf stream. Cold wall.

Review of Lecture VI.

Final disappearance of Gulf Stream about Spitsbergen & Nova Zembla. Examined total amount of heat conveyed by Gulf Stream taking minimum dimensions & temperature. Found quantity of heat very great: more than that carried by winds whole system of air currents. Effect of actual position of Atlantic & Pacific Oceans. Currents carry heat to temperate lats. winds distribute: Causes of movement of water of sea numerous, but they reduce practically to this. — Surface currents due to trades & other prevailing winds. Deep & slow bottom indraft of cold water from the Antarctic. Floods tableland of oceans with cold water. Equatorial Zone of average depth of 500 fath. 40° F. Examined the Gulf Stream currents. Greenland, Labrador Brazil. Equatorial drift, Japan current, Oceanic or Humboldt. Circulation in Indian Ocean Mozambique Current.

Tides. produced by combined attraction of Sun & Moon

And when combined produced spring tides, when acting against each other neaps. Due to action. Causes but not regularity usually found in observancy. Seas not deep or uniform wave ~~Could to~~ Can not follow luminaries regularly. Broken. Constant origin of tides. progress of wave indicated by cotidal lines. Fort in deep slow in shallow Waters. Wave drags bottom. Wave swell in open sea, found to great height in some estuaries. Tsunamis bore. Local irregularities very great owing to complicated form of Channels creeks grooves &c. Establishment or number of hours after noon high passage of full & change found experimentally for each place. Influence of tides in Harbours.

Sect. VII.

Work on the Marine Land. Glanced at position & area, & relation of islands to Continents. Seas included as oceanic islands. Average elevation of Continents. Sphere in elevation. Zonal form of continents. Mountains high opposite deep seas. Characteristic features. Lowlands, Plateaux, Mountains. Three facts to be accounted for.

Action of waves on shore, aided by coastline, leading to production of plains of marine denudation. Slow changes of level.

Sinking & rising of land in Scandinavia. Subsidence in Greenland. Raised beaches. Terraces, Caves, Sea-shells. Submerged forests.

Coral islands & reefs. Appearance & distribution. Conditions of depth, clearness, heat. Fringing, barrier & atoll reefs. Indicating subsidence or stationary & rising.

occupied Last Lecture chiefly in Naming Earthquakes & the Changes of Level & Sea ~~with~~ which they produce as by which they are accompanied. Earthquakes in New Zealand Level suddenly raised a depressed several feet. Fissures formed & traced many miles. Chili 1835. Shore elevated 8 to 10 feet, but in part sunk again. In 1822 suddenly raised 3 feet. Remn of Kutch remarkable instance of Geog. Change. A tract of 2000 Square miles converted to Island sea. S. Carolina & Missouri & other Cases. Temple of Jupiter Serapis at Pozzuoli. - Changes adduced not very great. Effect Volcanic areas. Earthquakes very common. Effect Cumulative. Earthquake really a wave of elastic Compression Caused by blow or shock. Sudden formation of Steam. Sudden Condensation. Recoil from reflexion. Fissures from stress in Earths Crust. Fault most important. Origin. Spreads in Spherical Shells. Experimental determination of Velocity of passage of elastic waves. Agrees with Known velocity of Earthquakes.

Great Earthquake wave range perhaps 30 or 35 miles. Upheaval Crystal rocks. Surface wave. Earthquakes below sea. Elastic Spherical waves, Circular surface waves Tidal sea wave. Great sea wave. Solitary waves to immense distances.

Mode of finding depth & character of origin. In this way discovery & form of Krakatoa causing Java earthquakes ascertained.

Earth Plan in Italy & Teneriffe. Zone of Constant Heat. Same Cause produces both Earthquakes & Volcanoes. Zone of Constant temp. 60 to 70 feet. Below temp. increases 1° in 60 feet. At 20 m. ~~depth~~ temp. of fusion of almost all rocks, but pressure must keep them solid to the Earths Centre.

Volcanoes active & extinct, Same their Cause. Vesuvius instance of Volcano supposed to be extinct resuming activity.

(Count three volcanoes further)

Review of Sect. IX.

Part I says leading up to present Phys. Geog. = Geology. Destructive & reconstructive agents at work. Latter due to heated condition of interior of Earth. Sea & rivers destroying destructive. Piling up in sea bed. Find such deposits in land & conclude that once under sea. Knowledge of strata of superficial but deep layers owing to folding, fracture & erosion. Mountains plateaux valleys. In Phys Geog. Can only look at Earth's crust as formed of rocks hard & soft. Permeable & impervious. Water in reconstructive work of land. (1) by underground waters, whol Chem. (2) by rain & rivers whol both Chem. & mechan. Sediment & dissolved matters carried. Erosion & denudation by rain in all parts of its course. (3) Effect of frost & ice more particularly glaciers. Ice in mass erosion & transport.

Next. — Results of these agents.

Instances of amt. of dissolved matter carried by Thames & Rhine. Enormous quantity transported by Mississippi. Annual flowering of basins of rivers. Time deduced at which present rate continents would disappear. Comparison of work by rain & rivers & the sea. Power of rivers Causes denudation not uniform. Produces plateaus & land.

Special instances. Valleys of different kinds. Gorges & Cañons produced under exceptional circumstances. Mountains. Volcanic & sculptured types.

Astronomically viewed the Earth is but one of a group of planets circulating about a Central Sun, & a member of that group occupying in most respects a mean position, neither to be distinguished as particularly large or small, & in no respect remarkable. To us, however, the Earth is the most important feature of Nature viewed on its inorganic side. It is the dwelling place of man, & our point of Comparison for the universe, & it becomes one of our most important studies to learn the limits & Conditions of this realm which we endeavour to render tributary to our needs. Yet, at the first glance, the world appears almost a chaos in the multiplicity of its details, a mass of phenomena too complicated to be mastered. Science has only by degrees gained some knowledge of these phenomena bringing them from the realm of the Supernatural under the reign of law.

Physical geography in its most comprehensive sense

regards broadly all the facts bearing on this our world, the study of its inorganic side, leading on to that of its organic, the whole being regarded as endowed with a species of Cosmical life & centering round man himself. It is not so much a science or branch of science as a collection of the facts scattered in many departments & the probable conclusions which have been arrived at by their study. It therefore calls for information from all departments of science in so far as they advance its object in fact helping to give additional distinctness to the broad conception of the daily economy of the Globe, of which, as a habitable planet, it is its aim to draw a clear & luminous picture. It should not, however, be a mere bald enumeration or collection of facts, which, however extensive & accurate, might have no scientific merit. It should be, essentially a study of the relations, the cause & effect of what we see around us inducing the student constantly to fall back on facts within

his own observation in illustration of the workings of Nature on the largest scale, & enabling everyone to find matter of study in his own district, & to see, as Humboldt says in his Kosmos, in every little nook & corner but a reflexion of the Whole of Nature.

The Educational value of the subject depends on its continued appeal to observation, which alone can give firmness & reality to our Conceptions. Setting out from this 'solid ground of Nature' we may then proceed to search for the causes of the phenomena.

may take up in rainy weather models. Shoppe filepaper. Stereoscope Atmosphere

No branch of knowledge has probably suffered more from erroneous methods of teaching than Physical Geography. The heights of mountains, lengths of rivers, depths of seas are items of information useful enough in their way, but learnt by rote, without the least Educational Value. It has therefore been proposed by Prof Huxley not long since to use the term Physiography for the scientific treatment of the aspects of the Earth.

The latter up in various modes.

Propose beginning with atmosphere. Has advantage that not removed from knowledge of anyone. Almost all parts world equally well situated for observing its phenomena. Here examined its Composition, temperature, moisture &c pass next to the Ocean, in which find the great reservoir of atmospheric moisture, & modifyer of climates. Next treat of the Solid lands; first on the aspect as at present, next of the Causes which have brought about the present state of affairs including with these the Study of the Completion of the aqueous Circulation of the globe in the return of the waters over the surface of the land to the Sea. Lastly the effects of climate & terrestrial Conditions as we have found them on the distribution of plants & animals over the Surface of the globe.

The Earth is surrounded by two great oceans, the first an universal all embracing atmospheric ocean, the second an ocean of waters. This atmosphere, or vapour sphere, naturally as the outer casing of the Earth, presents itself as the first thing to be considered. of what is it composed, what are its laws & movements? & what purposes does it subserve in the terrestrial economy?

atmosphere, composition & origin.

The atmosphere is essentially a mixture of two gases, O & N in the proportion of about 78 parts of N to 20½ parts of O by volume or more precisely as in the table. Though not a chemical compound of these gases, they are so thoroughly mingled by the property of gases known as diffusion (by virtue of which diverse gases — even when unaffected by currents — in the course of time become uniformly mixed) that from whatever parts of the Earths atmosphere specimens be taken for analysis they are found to be nearly identical. That the Oxygen & Nitrogen of the air are only mechanically

O.	20·61
N.	77·95
CO_2.	·04
Aq. vap.	1·40
	100

mixed is shown in various ways, most clearly perhaps by the fact that a mixture possessing all the properties of the Atmosphere may be artificially made, & that in so doing some of the effects generally accompanying what is known as Chemical Combination are observed.

also O in excess of N. dissolved in Natural waters

As to its origin, the atmosphere may be looked on as an uncombined gaseous residuum which has escaped incorporation with the Crust of the Earth. That this might not have been the Case we see exemplified in the moon, which has neither atmosphere nor water on its surface. We can easily understand why the greater part of the Nitrogen of our planet should be found free in the air, as we observe experimentally that its Chemical affinity, or desire to Combine with other substances is very slight. Oxygen on the Contrary has very powerful affinities, & it is Conceivable that had the Earth not been made just as it is, there ~~would~~ might have been no residuum of free O in the atmosphere. It has been

Calculated, indeed, that the uncombined O of the air amounts to only about $\frac{1}{2,000,000}$ of the whole belonging to our planet, but it is upon this margin that the existence of life upon the Earth depends. So nicely balanced are the circumstances which render it a habitable world.

Besides the O & N of the air, & various suspended solid particles generally present in it, the vapour of water, & Carbonic acid, may be looked upon as essential ingredients. The Carbonic acid —→

gas is nearly uniform in quantity varying between narrow limits & generally not more than 1/10 of one per cent by volume. The vapour of water on the contrary is exceedingly variable in amount its quantity depends on temperature & local circumstances which will subsequently be considered more at length.

(CO2)

Living plants depend on the small quantity of CO_2 present in the atmosphere for the Carbon which they build into their tissues & which we see in the form of Charcoal when wood is burnt. They have the power of decomposing the CO_2 returning the O which enters into its composition to the air & appropriating the Carbon. Animals, on the contrary taking Oxygen from the air, combine it with Carbon in the process of slow Combustion which goes on in the lungs & return CO_2 to the air to be incorporated again in the green plant. Dry and ~~ground~~ burnt in our fires, or Coal—which is merely fossil vegetable matter — returns a portion of CO_2 to the air, while this gas is also given off from volcanic regions & the earths surface in considerable quantity. It has

during the decay of organic matter, & by respiration

Coord ~~[illegible]~~ ~~tons of~~ (.1) tons

estimated

Ton ~~Calculated~~ Hot ~~over 150 000 000 of~~ CO_2 is given off by the great city of London in a single day, but nevertheless owing to the rapid dispersion of gases & the circulation ~~of~~ of the atmosphere it is difficult to detect much difference in the quantity of CO_2 present in the air of the City as compared with that of County districts. The size of the atmosphere is so great indeed that ~~it~~ if the supply of CO_2 to the air & all the process of respiration & Combustion were to cease entirely it would probably be some thousands of years before a Chemist could detect any great diminution in its quantity. As a vehicle for the circulation of Carbon in the Economy of nature the atmosphere fulfills one of its most important functions.

~~Calculated for Paris~~
By prop. of animals
11,895,000
92,101,000
by processes of combustion &
total of
103,996,000

See pages & quot.

Height pressure & Physical effects of the air.

The lower strata of the atmosphere, or those nearest the surface of the earth are comparatively dense, being pressed down by the superincumbent mass of air (Compare a pattress or other light bodies with some elasticity) The height to which the atmosphere extends is usually stated at about 45 miles, but it must exist in a tenuous condition very much higher

Height therefore indefinite.

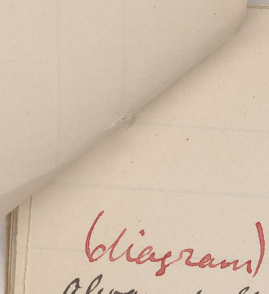
for Meteorites, by means of Simultaneous Observations at remote Stations have been proved to be visible at a height nearly or quite 100 miles, & it is known that these bodies flash out only by reason of the intense heat caused by the friction of their passage through the air, & the compression of the air in front of them. The upper portion of the atmosphere is however so very thin as to be totally unfit to sustain respiration, which becomes impossible at a height of 6 or 7 miles. At the Comparatively moderate height of 3 miles or about that of Mt Blanc half the atmosphere by weight lies below one.

Glaisher & Coxwell ascended to 6½ or 6¾ miles. nearly fatal to both

16,000 ft much greater than the height of Mt Blanc

In early times it was not suspected that the atmosphere had any weight nor did it at first seem possible to attribute weight to a substance so volatile & intangible. As we now know, however, the air actually presses upon the Surface of the Earth with a weight equal to about 14 3/4 lbs. to the square inch which is inappreciable only because it is applied equally on all sides of the bodies immersed in it. We weigh the air, or ascertain the atmospheric pressure

or 27,000,000 tons per square mile.


(diagram)

by means of that very simple instrument the barometer (~~the~~) balancing by means of it a column of Mercury – the heaviest liquid we know – against the atmospheric column. Now it is clear, from the construction of the barometer that if we move it from a station at the level of the sea & carry it up the slope of some mountain or high land, as we leave layer after layer of the Atmosphere below us the weight pressing on the open end of the barometer tube must decrease & the column in the closed end of the tube being unsupported descend lower & lower. Such we find to be the case, & by means of the Mercurial barometer or its more portable substitute the aneroid barometer we can in fact measure the elevation of mountains with considerable accuracy. Without however removing the barometer from its original station we may, however, by observing it from time to time soon convince ourselves that the Mercurial column is scarcely ever at rest but rises & falls in an apparently capricious manner through a certain range in inches on the scale. From such observations we learn that changes in the weight of

(diagram)
Always well to learn what is known about a certain subject but exactly how the information has been obtained.

(Similar experiment with bladder of air)

In Cotwell & Glaciers balloon ascent just referred to the barometer fell to 6·5 inches

the atmosphere continually occur, & as these changes are ultimately connected with the temperature, moisture & movements of the air, the barometer becomes our most important instrument in the study of the atmosphere; & is also found useful incidentally as a weather glass, for though it be scarcely correct to say that differences of pressure give rise to all wind storms & atmospheric disturbances they always accompany them, & can generally be observed so long in advance as to give some warning of their approach. The origin of atmospheric disturbances is usually involved in obscurity, but we know of two Chief Causes by which the atmospheric pressure is affected. These are variations in Temperature & in the amount of aqueous Vapour. So important is the barometer in the study of the atmosphere, that the Mercury Column has been said to be the true Language of the atmosphere, which tells us in distinct symbols all the changes going on there.

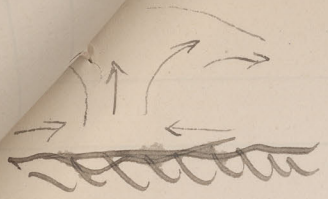
Two main causes of change of pressure

The average height of the mercurial column capable of

the pressure of the atmosphere, or in other words, the mean height of the barometer, at the sea level, is about 30 inches. It is found that in some parts of the world the mean pressure is higher than in others, but this fact, having to do with the atmospheric circulation will be considered subsequently.

(heat) When a portion of the atmosphere becomes heated by resting on a part of the Earth's surface upon which the Sun's rays are beating, it expands, following in this respect the law found applicable to other gases, & becoming lighter than the neighbouring air, ascends, & flowing away on all sides causes a diminution of atmospheric pressure or fall of →

Tremendous motion of air ascends from heated land surface known to all.



the barometer. Currents of air flowing in from less heated regions tend to supply the place of the ascending column, producing winds, which are therefore consequent on the fall of the barometer. This subject however will be more fully considered further on.

Moisture

We have seen that aqueous vapour is a constant constituent of the atmosphere, & of that part of it with which we come in contact, for the vapour of water is present in sensible appreciable quantities when we reach a height of 6 or 8 miles above the earths surface, & is always found in much greater quantity in the lower layers. The aqueous vapour passing into the atmosphere from the damp surface of the land, or from the sea, tends to a certain extent the place of so much dry air, thereby aside the gaseous atoms to make room for itself. Now were the vapour of water of the same weight volume for volume with dry air, its presence would have no influence effect on the atmospheric pressure & our instrument for measuring this — the barometer — would not be affected. The vapour of water is however much lighter than air, being in fact 1/33 times lighter volume for volume at in the proportion of 5 to 8 at all temperatures

at a ~~temperature of 50°~~ & the effect of the introduction of a great quantity of water vapour into the air, from any Cause, is to produce as an increase of temperature was found to do, an intumescence & outflow on all sides of the upper portion of the ~~earth~~ atmosphere, The quantity of aqueous vapour which may be dissolved in the air, increasing with the temperature, the changes of pressure may be greater at high temperatures than at low. Should the temperature of the air ~~fall~~ & the ~~vapour~~ aqueous vapour be condensed, & fall to the ground as rain, dry air taking its place, the barometer again rises.

• becomes lower

(End of pressure barometer &c.)

Thermometer

The thermometer is instrument by which we measure the ~~temperature~~ temperature of the atmosphere is fortunately almost equally simple with the barometer, & is familiar to us all. The contraction & expansion of any body might be used as a measure of temperature but it is found most convenient for ordinary temperatures to use Mercury or alcohol, & to enclose these liquids in strong tubes from which all air has been removed & which are sealed to prevent the fluctuating pressure of the atmosphere from complicating the result due to changes of temperature. Such

is the thermometer, & it matters not much by what arbitrary System of degrees we measure the temperature. The notation of Farenheit is that usually employed in this country.

Heat of the air

We believe that the globe was once a sphere of molten matter & find that the temperature of the earth increases pretty rapidly as we descend into it as in mines, but the Crust is now so thick & so poor a conductor of heat, that it is probable that the internal heat of the earth affects its surface by less than 1/20 of one degree of temperature, & this we may safely disregard. The source of the heat of the atmosphere is therefore to be found altogether in the Sun. The Sun's rays however warm the atmosphere directly to a very small degree.

Average amt. of heat in 1 cu. capable of melting layer of ice 1½ inch thick over the world.

The air ____ is almost perfectly transparent to the rays of heat from the Sun, but these falling on the surface of the ground are absorbed & given out again as dark heat, which the air to a small degree, but more particularly the Aqueous vapour & Carbonic acid which it contains are capable of absorbing. The source of heat

in the Sun may be regarded as practically Constant, but those parts of the Earth receive most on which the Suns rays fall directly as in the vicinity of the equator. Towards the Poles the Suns rays strike the Earth more & more obliquely. It has been Calculated that a belt extending 23° 44½' on Each side of the Equator, actually receives as much heat as the whole of the remaining terrestrial Surface. If no Counteracting influences Came into play the temperature of any part of the Earths Surface would depend on its latitude & the season of the year & at the Same date & place would be Constant. This as we Know is however far from being the Case. The air receiving the greater part of its heat at second hand from the Surface of the Earth, those Layers most nearly in Contact with the Soil are generally the warmest. These layers are also protected by a greater thickness of atmosphere from the loss of heat by radiation into Space, which is the mode by which all the heat falling upon the Earths Surface is finally

& Cost
dissipated. The rate of diminution of temperature in
ascending is not constant, but may be taken approx-
imately at about 1° F. pr 100 300 feet in height. At
a height of 15000 or 16,000 feet at the Equator we reach
a region of perpetual snow & ice, & tracing this thermom
of the atmosphere northward & southward we discover that it
reaches the surface of the earth in the vicinity of the poles.
One of the most important Causes of the variation of Atmospheric
temperature still however remains to be mentioned. This is the
unequal distribution of Sea & Land. Heat falling upon the
Land warms the surface for an inconsiderable depth only &
is quickly conveyed to the superincumbent air, or, lost in
great part by radiation when the atmosphere is Clear & dry.
Heat falling however, upon the ocean penetrates to a considerable
depth, warming its mass, & is not easily lost again by
radiation. The sea thus heated is found to Circulate in a
regular system of Currents, ~~Having~~ becoming a great

Nagasaki a source of supply of heat to various parts of the world. The temperature of the atmosphere on the ocean & oceanic islands, or along sea margins, is therefore less affected by sudden changes & gives rise to an insular climate. While that over the land lands, in sympathy with the land surface, to vary more rapidly & through wider limits. On a larger scale the greater proportion of land in the northern hemisphere affects its climate as compared with the southern in a similar manner.

Temperature is thus regulated to a great extent by the distribution of sea & land, & when we collect all the observations we possess bearing on the temperature of different parts of the ~~earth~~ surface of the globe & reduce them so as to obtain the mean or average temperature of each locality for the year we can draw Isothermal lines, or lines running through all the places on the Earths surface which have the same mean annual temperature, of 60°, 70°, 60° or any other number of

Mean temp. = mean of hourly observations of thermom. throughout year. but may obtain by adding Max. & Min. of Rapers to temp. pair a few feet from ground

degrees. It is then found that while approximating to regular Zones on each side of the Equator, their parallelism to the lines of latitude is by no means strictly preserved, but is affected to a great extent by the positions of the greater land masses & by other Circumstances which we shall be able to enter into more fully when we have studied all the Causes influential over that Combination of Effects to which we speak as Climate.

Moisture. Among the Constant Constituents of the atmosphere moisture, in the form of aqueous vapour has been mentioned. Its quantity is very variable, but it is always present & in all parts of the air however clear & transparent it may appear & however 'dry' it may be said to be. In the aggregate an immense amount of water is held thus in Suspension in the atmosphere. This moisture is ~~[illegible]~~ obtained by the air both from the surface of the Land & Sea, but more particularly from the latter, for while the supply afforded by many parts of the Land may be comparatively limited, the →

wind sweeping over the surface of the ocean is always in contact with an unlimited reservoir. The surface of the ocean is also very much greater in area than that of the land. Evaporation, or the absorption of water by the air, goes on somewhat less rapidly from the surface of salt water of the sea than it would from a corresponding area of pure water under like temperature & conditions. It has been estimated that within the tropics, where evaporation is most active, that it is sufficient annually to remove a column of water 70 to 76 feet thick from the surface of the sea. To give the reader a general idea of the vast scale on which the circulation of water through the invisible channels of the atmosphere between the surface of the ocean & its returning flow through rivers occurs. By endeavouring, however, to appreciate the quantity of water carried to the sea by any one great river, as by the St Lawrence, & then to pass in review the diurnal

flow of rivers after rain systems, some conception might be formed of the gigantic scale on which the atmosphere, however quickly, acts as a carrier of water between the sea & land. The outflow of all the rivers of the world indicates to only what may be called the amount of effective Evaporation per annum but under of the moisture falling upon the land is returned directly to the air without passing to the sea.

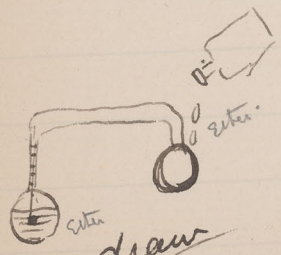
The Capacity of the air to contain moisture increases with its increase of temperature. Evaporation therefore goes on with increased rapidity in the tropics & is also more active during the day when the sun's rays are heating the atmosphere, than at night. Wind also increases the rate of evaporation, as it brings comparatively dry portions of the air in contact with the Evaporating surface & removes those layers which have become Saturated with moisture. By Saturation is meant that state of the atmosphere at any temperature when its Capacity for moisture is fully satisfied. If it be cooled never down so little below

Familiar illustration in homes, where when cold outer air heated, requires to supply it with additional moisture in some way to prevent it from being [illegible] excessively "dry".

this temperature it must deposit a portion of its moisture, but if its temperature be raised a degree or two, it is capable of absorbing a further quantity. The idea of the presence of a great quantity of moisture in an invisible form in the air is so familiar that it scarcely requires illustration. (Condensation of water on outside of glass containing ice. Condensation of frost on window panes)

but is in some danger of escaping notice merely from its familiarity

The temperature of saturation of the air with moisture is known from a meteorological point of view as the Dew point. During the day the air is seldom fully saturated, but we can ascertain how much water it holds if we can reduce its temperature to the point at which precipitation begins, or the Dew point. The dew point is an important item of knowledge in the study of the atmosphere & climate. It may be ascertained directly by such an instrument as Daniels hygrometer in which the temperature of a quantity of ether contained in a glass bulb is reduced by evaporation till a



draw

~~Contained thermometer~~ dew forms on the surface of the bulb. Contained thermometer then read & the indication called the dew point. In practice however, the dew point is usually ascertained by comparing the readings of two similar thermometers of one of which the bulb is cooled by the evaporation of a film of water. The difference of reading of the dry & wet bulb thermometers gives data from which by an ~~empirical~~ Empirical formula the dew point & hygrometric state of the atmosphere at any time may be ascertained.

The circumstances taken advantage of in Daniell's hygrometer & observations must be wet & dry bulb thermometers, leads us to the consideration of another point in connection with evaporation & the moisture of the atmosphere. During the process of evaporation heat is absorbed, or rendered latent, & when condensation occurs a like amount of heat from the latent or concealed state becomes sensible or may be said to be given out. The process of evaporation & condensation as ~~occurring~~ occurring on the

large scale in Nature, has therefore a very important effect on the temperature of the air & Climate.

To illustrate meaning of latent heat

We may take a quantity of water weighing say one pound, & apply heat to it from some constant source, regulating the supply of heat, let us suppose, so that in one minute of time, we raise its temperature by one degree of Farenheit's scale. If, instead, we take a pound of ice at the freezing point, or 32°, & apply heat in the same way, in this case we might continue to do so for about 140 minutes before we succeeded in melting all the ice & before it became possible to raise the temperature of the mixture of ice & water at all. The 140° of heat imparted in our experiment have been lost, or have become latent. Beyond this point the increase in temperature will continue regularly under the conditions we have supposed till a temperature of 212° F, or that ~~of ebullition~~ is reached, when the temperature again ceases to rise, though heat is still being steadily poured into the water, till a

At which the water is said to boil

quantity sufficient to raise the temperature about 1000 degrees has been absorbed. By this time the whole of the water has passed into vapour & during the process the heat has become latent. The heat thus absorbed during the passage of water from the liquid to the gaseous state, is supposed to be spent in overcoming a certain molecular attraction among the atoms.

We need not enquire further into the mode in which the heat is rendered latent, it suffices for our present purpose to know that it is stored up in the aqueous vapour of the atmosphere ready to be again restored as sensible heat when the process is reversed & condensation occurs. The thermometer which we have used before in determining the temperature or sensible heat of the air, is incapable alone of giving us any information on the actual quantity of heat stored up. Molecularly in a given volume of air. Here again we find it impossible to realize the marvellous scale on which these forces, discovered & measured in the laboratory, are at work in the vast realm of Nature. Maury has calculated

our senses of feeling fail us in this respect as the thermometer.

Nancy.

that if we had a pool of water one mile square & six inches deep to be evaporated by artificial heat we would require about as much as is evolved in the Combustion of 30,000 tons of Coal! Let us take this great unit of measure & apply it to an instance in nature

many. The area of the Mississippi Valley is said to contain about 982,000 Square miles, & upon every Square mile there is an average annual rainfall of 40 inches. If we now multiply the number of square miles by the number of times that 6 will go into 40 we shall have the number of pool miles of heat that are annually set free among the clouds which give rain to the Mississippi Valley. The enormous statistical announcement that the amt. of heat equal to that evolved by a quantity of Coal represented by 30,000 tons multiplied by 6,540,000 times!!

Dew. In the formation of dew we find the most direct & simple method of the return of moisture from the air to the earth, the shortest Cycle of Circulation of the moisture of the earth through the atmosphere & back to the earth again. When the sun has set & no further heat is imparted to the earth or air, if the sky be clear the earth begins to lose heat rapidly by radiation, or rather to lead the loss of heat from this cause

is not greater than before, but the supply of radiant heat from the sun being cut off the temperature of the surface of the earth is rapidly lowered. The presence of clouds in the upper part of the atmosphere greatly diminishes earth's loss of heat, & frequently prevents the temperature from becoming so low as to lead to the deposition of dew, which is in consequence generally seen only in abundance on clear & calm nights. When the surface of the ground becomes so cool that the air in contact with it reaches its point of saturation, or dew point, its moisture begins to separate & is deposited in a visible form, but not equally on all parts of the surface. In some cases objects, such as grass blades part with their heat much more readily than others, the air surrounding them is more rapidly cooled & a greater quantity of dew in consequence collects upon them. Thus it may often be observed that grass & foliage are thickly covered with dew while bare ground in the neighbourhood has received very little. To speak of dew as falling is not quite correct, for as mist or a cloud is formed under ordinary circumstances

but the invisible moisture of the air condenses directly on the exposed surfaces objects & most obviously on those which themselves give off condenses abundantly a warming the lower ...ts which ...r night. In this ...day in a latent ...ts liberation ...d, we find ... so frequently in ...the evaporated ...to the ...occasions a place

Simple as the explanation of so familiar a fact as the deposition of dew may be, it is remarkable that it was never fully understood or explained till 1818, when a London physician Dr Wells, published, just before his death, the result of a long series of experiments on it. His experiments were carried on in a garden in Surrey with small weighted locks of wool which he exposed under different circumstances. As an example of the effect of clouds in stopping radiation, & the resulting dew fall he noticed the thermometer lying on the grass, on one occasion to be 12° lower than in the air a few feet above the ground, but a few clouds passing across the clear sky caused the thermometer to rise 10° in a short time.

When a comparatively large body of air is rapidly cooled below its dew point of ... temperature of saturation, the result is what we call a mist or fog.

but the invisible moisture of the air condenses directly on the exposed ~~surfaces~~ objects & most copiously on those which possess rough surfaces, the globules either attaching themselves to the fibres & little asperities of the foliage. The condensation of moisture as dew of course implies the liberation of a considerable amount of latent heat which warming the lower strata of the atmosphere prevents the occurrence of frosts which might otherwise happen on almost every clear night. In this slaking of the heat of the warm hours of the day in a latent form in the moisture of the atmosphere, & its liberation to moderate the temperature of the hours of cold, we find one of those beautiful compensations which meet us so frequently in nature & are found on all hands favorable to the augmented activity & particular ~~phases~~ agent(?) to the distribution of life, which appears to hold so prominent a place in the universe.

When a comparatively large body of air is rapidly cooled below its dew point of ~~moisture~~ temperature of saturation, the result is what we call a mist or fog.

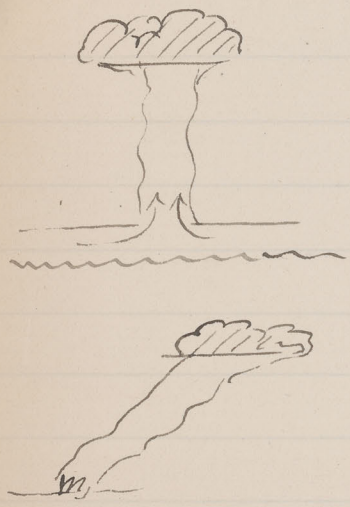
There is not a sufficiency of surface on which the liberated moisture may condense, & it is therefore separated in minute visible particles in the midst of the air itself. The cooling of the air usually in the form of mist may arise from the mixture of a body of warm air with cold, or the covering of the heat of the atmosphere by radiation proceeds so rapidly as to admit of the deposition of the moisture as dew. In autumn we often see the surface of rivers & lakes become covered of an evening by a stratum of mist, rendering visible the moisture which the lower part of the atmosphere in contact with the comparatively warm water surface has become charged during the day.

It has been a matter of some dispute in what mode the visible particles of water forming a mist, or cloud in the clouds, are supported in the atmosphere, & it was at one time very generally believed that that it was in the form of minute Vesicles or hollow spheres which remained suspended by reason of their small size & hollow structure. It

is probable, however, that ~~[illegible]~~ it is merely condensed in by fine solid particles, which must have a spherical form, & remain suspended in the air ~~[illegible]~~ just as fine dust is. Tyndall indeed has applied the term water dust to them.

Clouds.

Clouds are nothing more than mists or fogs in the higher parts of the atmosphere, & when the condensation of atmospheric moisture occurs high in the air either by the mixture of warm & cold currents or the ascent of warm & moist air into the higher & colder regions, clouds are formed. Some clouds are however, composed of minute particles or spicules of ice. This is generally the case in winter & with the higher & lighter clouds of storms even in summer. Let us take the simplest mode in which a cloud may be formed. — A layer of the atmosphere near the surface of the ground becomes strongly heated & charged with a considerable amount of invisible moisture. It is specifically lighter than the overlying layers



& its tendency is to ascend. At some particular place where the resistance happens to be least a mass of air begins to rise through the superposed layers. Once heated a current air flows from all sides to take its place & an ascending column is produced of considerable dimensions for the lower air being thus transformed a channel for ascent a considerable region may be relieved through it. The ascending stream rises in an invisible form till it meets at a certain elevation a part of the atmosphere so cold that it becomes reduced below its ~~point of saturation~~ dew point. A cloud of globules or ice is then formed, its upper surface being rounded irregularly & shows the slope imposed on the summit of the ascending column as it presses against the superincumbent air. Its lower surface is generally cut sharply off by a plane below which the temperature is too high to admit of condensation. (Instance prairie fires).

When the weather is very fine & tranquil the pressure gradually

in this manner. They occur with considerable regularity. This may be observed especially on extensive uniform land surfaces like those of the great western plains, where in summer the sky in the morning may be Cloudless, but as the sun begins to acquire power on the surface little masses of Cumulus clouds are formed in the manner above explained. These floating gently along with the prevailing upper wind are constantly added to & become larger until by the afternoon the sky is to a great extent clouded & by the condensation & accumulation of clouds local falls of rain accompanied by lightning & thunder may take place. These seldom continue beyond sunset, after which the upper layers of the atmosphere having rapidly cooled by radiation begin to descend into the lower & warmer regions layers in which the clouds are again absorbed in the form of invisible moisture. Before morning the sky becomes bright & cloudless & all is prepared for the repetition of this diurnal Meteorological Cycle.

The study of clouds is important, as it indicates the forms of masses of air in the upper parts of the atmosphere & their movements, which cannot otherwise be beyond our reach. In these connections the forms of clouds become interesting & it is necessary to have some means of describing them. From pon an unscientific point of view it is convenient to be able to designate the appearance of the clouds which form so important a feature in most landscapes. Their forms are known so varied that it would seem almost impossible to include them under any moderate number of classes. Thus Toaten down, Towers, & the most generally adopted nomenclature distinguishes but four main forms. Cirrus, Cumulus Stratus & Nimbus. (Describe) curl. rain-medium. bed. rain down. forms of cloud are designated by combinations of terms (Illustrate) (Map of Cat 1.)

The mode of formation of clouds is further illustrated

Luke Howard's classification. (Nimbus - generally C-S) dis- indep.

Cirrus at least 3 m high sometimes double. By balloon ascents in England cloud region 2000 to 6000 feet & 2000 to 3000' thick

Pas à naturalis
symphonie

y a circumstance which may often be observed in mountainous countries, the adhesion of little clouds like pennons to the mountain tops which are not blown away by the wind but appear to remain attached to the lee sides of the peaks. ~~This is especially the case~~ Clouds are often formed thus where wind laden with moisture after having swept over a great ~~breadth~~ breadth of sea strikes high mountains on the coast. It is forced upward by the impediment, the air at the same time expanding & cooling till a portion of the moisture is ~~thrown down~~ precipitated (This may not occur to such an extent as to produce rain clouds in all cases, but serves to illustrate explain the reason of the great precipitation along some sea coasts, a subject to be mentioned subsequently)

Our is naturally surprised to see a cloud thus apparently maintain its own against the wind, & the question occurs why does it not blow away? It does blow away. Its steadiness is only apparent. Its particles eternally dissolved & renewed to resemble vapour.

Rain.

When the little particles of "water dust" in a cloud run together to form larger drops, their weight becomes too much increased in proportion to the surface by friction of the air that it ceases to be able to support them, & they begin to fall, producing rain. Snow is but another form

produced ~~by~~ the same process of condensation of atmospheric moisture, being that ~~[illegible]~~ which it takes when the temperature is below 32° F. Condensation continues ~~[illegible]~~ most actively about certain points where it has commenced & the particles of moisture ~~[illegible]~~ previously arrange themselves in ~~certain symmetrical crystalline shapes~~ which are characteristic of the substance or ~~call~~ snow or water in its solid state. ~~[illegible]~~ these differ only in form from the crystals which might be produced from other substances if the particles were similarly free to arrange themselves. ~~[illegible]~~ is a somewhat exceptional phenomenon, as ~~[illegible]~~ for the larger part of the surface of the globe ~~it~~ snow never falls, at the sea level.

More beautiful symmetrical crystalline shapes

The condensation & precipitation of atmospheric moisture as snow

(Explain apparent contradiction on Mercators projection.)

Rain disposed of
in 3 ways

Rain disposed of in 3 ways

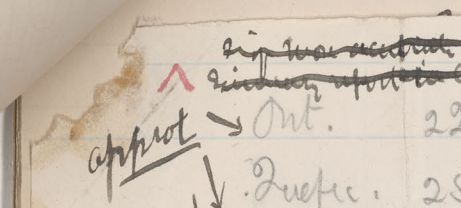
Rain falling to the earth is disposed of in three ways a portion runs off at once by the streams & rivers. A portion is absorbed by the soil, & a portion lost by evaporation. The proportion removed by these ~~various processes~~ means varies in each locality & we must look somewhat more closely into the matter when studying that part of the general system of water circulation by which the water returns to the sea. In

"Rainfall"

speaking of the rainfall of a district in a meteorological sense we mean that if the whole annual precipitation of moisture were collected, none being lost by any of the modes above stated, it would have a certain depth, which is generally stated in inches. We say for instance

Rainfall of Montreal &c.

that the average rainfall of Prov. of Quebec is ~~25~~ 25.5 inches, meaning that if it were all collected on a flat surface of ground it would cover that surface to a depth of ~~25~~ 25 1/2 inches or over 2 ½ feet. The snowfall of winter is supposed to be melted & included in this ~~ratio~~ average. Now as an inch of


appui
Ant.
Quefic.

~~Sir Isaac Newton in~~
~~Windsor upon the College.~~

Ont.	22·5
Quebec.	25·4
N.B.	32·8
N.S.	39·2

approx

ments to about 100 tons to an acre y surface
- y water precipitated from the atmosphere on
~~of Toronto~~ this province must be no less than ~~3500~~ 2500 tons.
per annum
te scale on which the irrigating operations y
e Carried on.

~~I want to know the mode in which results with which we~~
~~now to what are arrived at, & in this Case it is very simple,~~
Explain rain gauge. mode in which rainfall y place determined, very simple

Observations ~~upon~~ with ~~variance~~ an instrument such as this have
been carried on in many parts y the world for a number
Rainfall over the globe of years, & though by no means complete, we have some knowledge
y the rainfall y almost very extensive area y the Earths surface.
From these observations it has been estimated that the average rainfall
y the world is about 5 feet. This, however, is probably a very
rough approximation to the truth, as we all know from
personal experience that some localities are much wetter than
others, & this general knowledge is confirmed when the rainfall

rain amounts to about 100 tons to an acre of surface
the weight of water precipitated from the atmosphere on
an acre ~~in Toronto~~ in this province must be no less than ~~3~~ 2500 tons.
Such is the scale on which the irrigating operations of
nature are carried on. per annum

~~This will to know the mode in which results with which we~~
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others, & this general knowledge is confirmed when the rainfall

On what does difference in aut. depend

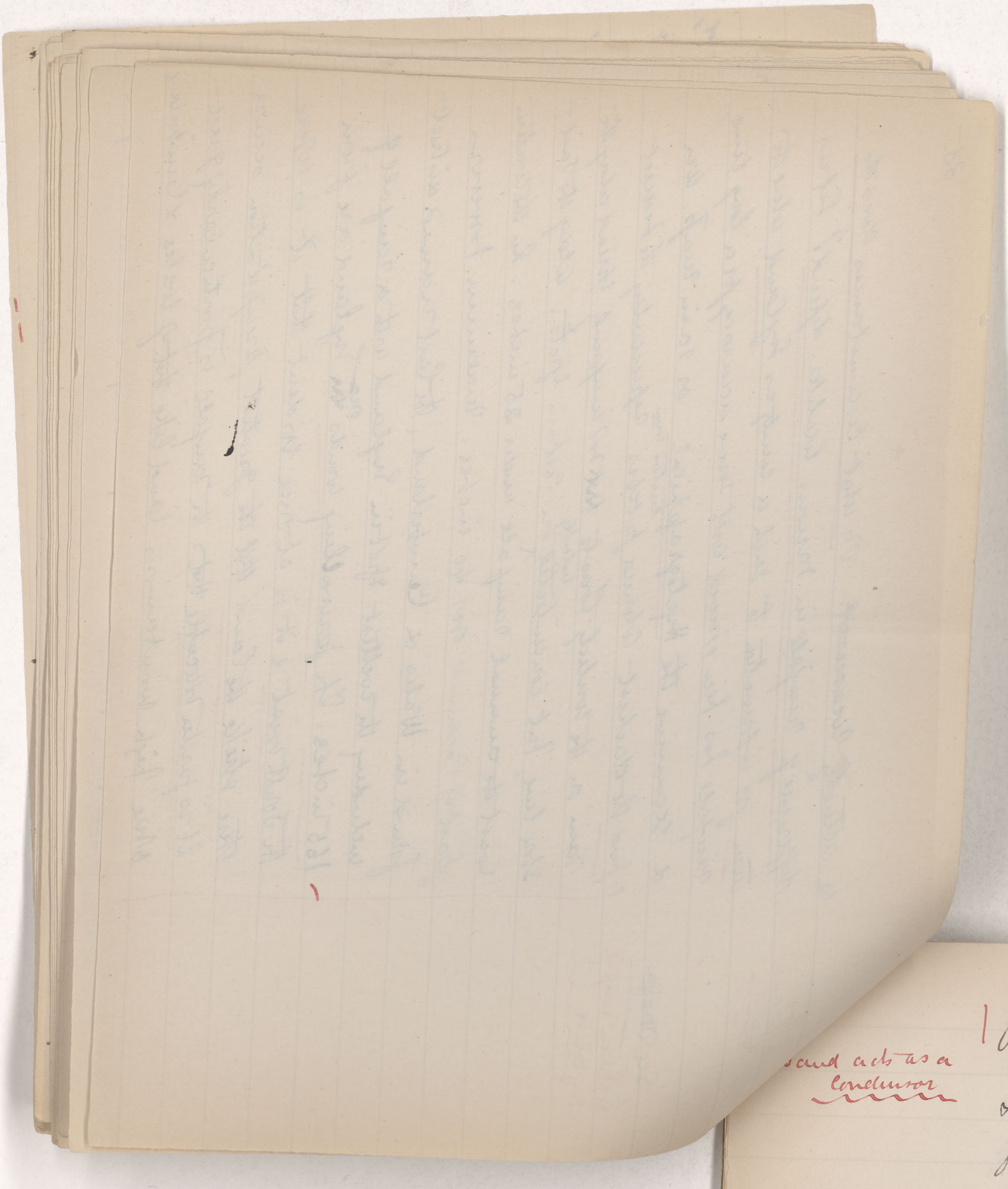
See Map

On what does difference in amt. depend

is actually measured. On what Circumstances does the difference of rainfall in various localities depend? Let us turn for information to such a country as England, where the rainfall has been observed with some accuracy for a long time, & examine the Hyetographical or rain maps. We find the darkest colored patches (notes rain) representing the heaviest rain on the western Coasts, not unequally spread along the shore line, but concentrated (notably) in certain spots. along the East-Coast the annual rainfall under 25 inches. In the western part of Cornwall over 40 inches. Maximum however found in Wales & Cumberland, the last named district including the wettest spot in England with a rainfall of 165 inches. The prevailing winds over England are from the South west & it is at once evident that it is where there strike the Land that the greatest precipitation occurs. It is further noticeable that the rainfall is particularly great where high mountainous land like that of Wales & Cumberland.

See Map

Explain map of England



fronts the Western Sea. The land therefore, & especially high land acts as a condenser of atmospheric moisture, & it is found that while the greatest amount of evaporation occurs from a given surface of the sea, the rainfall is greater over the land. This rule appears to be one of very wide applicability, for in the Northern Hemisphere as a whole there is a preponderance of land & a greater amount of precipitation of moisture.

land acts as a condensor

there two we find

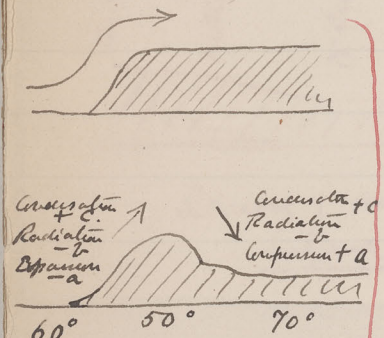
The action of high land in leading to the condensation of atmospheric moisture in the form of rain has already been alluded to. Suppose the air in motion across an extensive ocean. The lower strata soon become highly charged with moisture. Meeting an opposing mountain chain, the whole is forced to rise bodily to a considerable elevation. The air expands, being relieved from a certain amount of superincumbent pressure, as in expanding Coals. The mere fact of its being raised to a great height tends by increasing the facility for radiation to cool it still more, & though the condensation of the moisture, as we have already seen, liberates a considerable amount of heat, this is not sufficient to counteract the cooling influences

Reason of ppt. given by high land

Expansion
Radiation
Condensation

Loss of heat by

& a copious rainfall takes place. If instead of meeting an ordinary mountain range of considerable breadth the moist air flowed up & over a high continental plateau, the greatest precipitation would occur where it first reached the full elevation, a — Supposing the temperature of the surface of the plateau to be nearly that of the air — the remaining moisture would be precipitated gradually as the air lost its heat by radiation. In most cases, however, the air after having passed over the Crest of a mountain range descends again into comparatively low country, & the heavy rainfall in consequence terminates very abruptly. (The reason of this may be seen very clearly by constructing a rough diagram. (Explain)) Regions thus sheltered by mountain ranges are apt to be very dry, & where very high or wide mountainous regions prevent the access of moisture bearing winds deserts are found.



May lead to formation of deserts

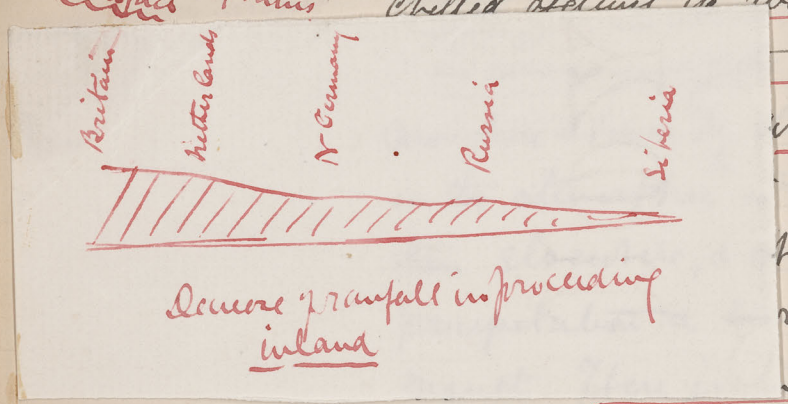
Good case in point in B.C. Victoria rainfall 28½ inches
Spence's Bridge 10 inches.

Examples from B.C. & alps

From the Alps while the fall of rain & snow is

incessant, one may sometimes descend to the plains of Lombardy over which the wind is flowing towards the mountains, & find there the sun country enjoying tranquil sunshine. Below the vapour in a transparent state, but lifted up, expanded & chilled against the mountains.

Reason of heavy rains in tropics



greater capacity for the absorption of warm air, the volume of water contained greater in the tropical regions of the earth where suitable conditions occur for its correspondingly heavy rainfall is the the vicinity of the equator a zone of almost constant & very heavy rainfall which, in connection with the circulation of the atmosphere, we must again examine. Where high mountains lie in the way of the movement of this very warm & humid region of the atmosphere the heaviest known rainfall occurs. The winds called the S.W. monsoons gathering their moisture from the Indian ocean sweep up against the Himalaya mountains & here in the Khasi Hills the greatest rainfall of the world is

Country of heavy rainfall in India

of India

incessant, one may sometimes descend to the plains of Lombardy over which the wind is flowing towards the mountains, & find the sun country enjoying tranquil sunshine. Below the vapour in a transparent state, but tilled up, expanded & chilled against the mountains.

Reason of heavy rains in tropics

In consequence of the greater capacity for the absorbtion of moisture shown by warm air, the volume of water contained in the atmosphere is greater in the tropical regions of the earth than elsewhere, & when suitable conditions occur for its precipetation a correspondingly heavy rainfall is the result. There is in the vicinity of the equator a zone of almost constant & very heavy rainfall which, in connection with the circulation of the atmosphere, we must again examine. Where high mountains lie in the way of the movement of this very warm & humid region of the atmosphere the heaviest known rainfall occurs. The winds called the S.W. monsoons gathering their moisture from the Indian ocean sweep up against the Himalaya mountains of India, & here in the Khasi Hills the greatest rainfall of the world is

Causes of heavy rainfall in India

over 43 feet

Exceptions to rule
greatest rainfall
along coast. Ch

found. During a stay of 9 months in this region Sir J. Hooker recorded upwards of 500 inches of rain & the total annual fall is about 524 inches!

over 43 feet

We can now readily understand how it is that taking the world over we find the greatest rainfall in the vicinity of the coast lines, where the winds coming up from the sea first meet with the land. To this there are known some notable exceptions, one of the most striking which is found in Chile & Peru. These countries lie along the western coast of S. America near a vast expanse of ocean from which moisture is constantly being distilled, but are nevertheless almost rainless. The cause of this apparent anomaly is to be found in the direction of the prevalent wind, which is here a nearly constant current known as the S.E. trades. This wind, which forms a portion of the great general System of Circulation of the atmosphere, sweeps across the South Atlantic, becomes heavily laden with moisture & reaches the East Coast of S. America. Not meeting here extensive or continuous Mountain Ranges it is rather gradually deprived of this burden, which

Exceptions to rule of greatest rainfall along coast. Chile

forms the perennial supply for the mighty river systems of the Amazon & La Plata. At last they reach the Andes & here the last particle of moisture which a very low temperature can extract is wrung from them among the snow clad summits. Falling down the western slope of the Andes, they reach the Pacific ocean from which to replenish their store of moisture, & for the reasons before explained are dry winds. The coast regions of Peru & Chile depend for water almost entirely on the mountain streams, receiving scarcely any from the air.

Rainless regions

Other regions remarkable as being almost rainless are — the western coasts of Mexico, the deserts of Northern Africa, Central Asia, Australia & parts of North America. A study of the geographical features surrounding these reveals in each case the cause of the exceptional drought in circumstances like those of the districts we have examined before.

(See chart)

Rainfall uncertain in temperate latitudes

In the temperate regions the circulation of the atmosphere does not proceed with the regularity which is found to characterize it in the tropics, & in consequence of the more varied manner

in which Currents of warm & cold air are mingled the rainfall is uncertain; though in most cases some definite period of the year may be named as that of greatest rain. It is otherwise in the tropics, where owing to the regularity of the Circulation the rainfall is more strictly periodic, the year being divided into a wet & dry season.

Coasts of Europe bordering Mediterranean generally winter rains. W. of Europe Autumn rains. St Petersburg winter only about 1/3 of summer Same in Siberia.

Classification of rainfall Page.

B.B.

Rainfall of the Globe may therefore be divided into three Classes The periodic of the tropics. The variable of higher latitudes, & the Abnormal including districts when it is exceedingly heavy owing to local causes, or almost absent.

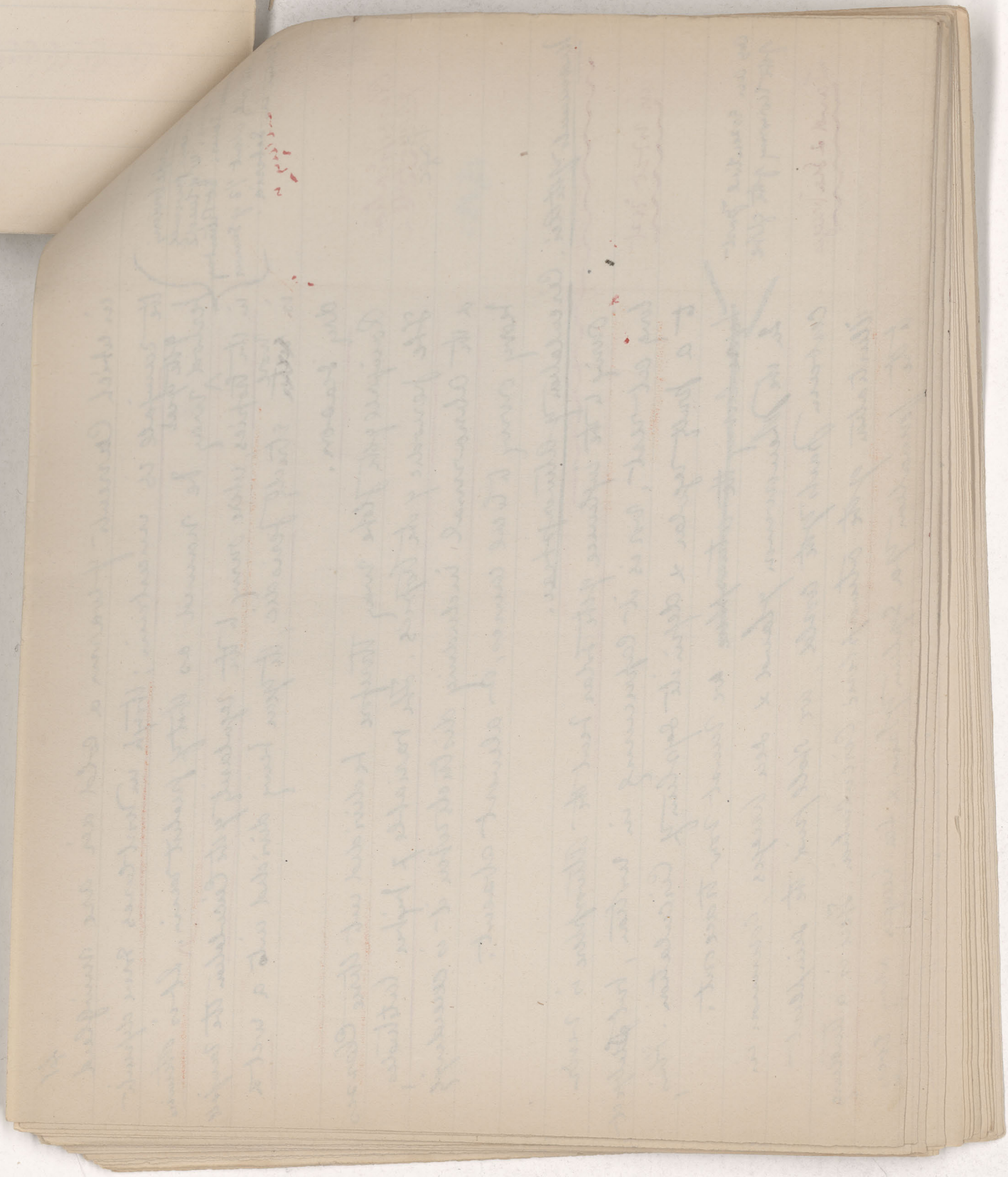
Movements of the Air. Circulation of Atmosphere.

Air not at rest

Owing to the influence of the Solar Heat the Atmosphere is never long at rest, nor is it capricious in motion, but subject to a pretty regular & definite System of Circulation. This, as an essential part of the economy of the Globe ~~here having the atmosphere~~ we must now trace out.

Land & Sea Breezes

In the Movements of land & sea breezes, common in certain parts of the world, we shall find the simplest illustration of the atmospheric Circulation. Here is a tendency to the formation of a System of land & sea breezes along every



Coast, but they are found blowing with their greatest regularity in the tropics. In extra tropical regions they are generally well marked during the Summer & Autumn only. The Sea breeze usually sets in about nine or ten o'clock in the Morning when the surface of the land has been thoroughly warmed by the Sun. An indraught of air toward the land is often first indicated near the shore when light Cats'paws begin to ruffle the surface, extending gradually over a wider field of sea. Light puffs of air are followed by a less pitpul Current which, increasing in strength soon turns the surface of the sea to a dark blue.

Setting in of Sea breeze

Maury describes the regular sea breeze of the Summer in Valparaiso as gathering strength till "pebbles are torn from the walks & whirled about the streets, people seek shelter; the Almendral is deserted, business interrupted, & all Communication from the shipping to the shore is cut off." Late at Sunset the wind becomes suddenly lulled.

at Valparaiso

After a period of Calm, in those regions where the land breeze is well developed, a return Current is established

from the land to the sea which continues to blow during the greater part of the night. In tropical climates Mitigate climate often the damp heat of the coast might otherwise be almost insupportable, the climate is mitigated & made both refreshing & healthful by these alternating winds. Lieut. Jansen Land & sea breeze in Java discribes the land & sea breezes as blowing with the utmost regularity in Java & other islands of the Indian Archipelago. as the sun ascends the sky the land breeze goes to rest. Here & there a little playes on the water but finally becoming exhausted is followed by a perfect calm. The atmosphere sparkles & glitters becoming clear under the increasing heat while the finely swelling surface of the sea reflects the sun's rays like a mirror; the shore seems to approach & all objects become distinct & more clearly delineated. When the sun nears the Zenith the air begins to put itself in uncertain motion but it is sometimes still one or two hours before the sea-breeze has regularly set in with its cooling & refreshing breath. When the sun disappears the sea-breeze ceases, & in Java during the period of calm

On what Law
& sea breezes depe

heavy rain often follows before the land breeze is felt.

On what Land & Sea breezes depend

It is to the Cause, however of these land- & sea-breezes that I wish chiefly to draw your attention. They depend on the unequal heat of the surfaces of the land & sea & blow always from the coolest & toward the warmest locality. Their temperal effect on climate depends on this circumstance as they bear ~~always~~ invariably the coolest air to be found in the region. The air in contact with the surface of the land, heated by the sun, becomes also heated & rarified & tends to ascend. The heavier & cooler air resting upon the surface of the ocean is drawn in to take its place & from an initial tendency to vertical movement a horizontal Circulation is set up.

Blow from Cold to warm

Vert. movement causing horizontal Circulation

During the night the surface of the land is rapidly cooled by radiation & as soon as it becomes colder than the sea — (which unless affected by Stray currents may have nearly the average temperature of the place) — the direction of the Circulation is precisely reversed. The warming & cooling hours of Calm represent the time during which the temperature

nd & Soil tamen Sima fower not ripetur, causing fale
Summer & fall in Extra-tropical zyms ←
in hopsies p. 135-.

of the sea & land is the same, or differs so little that its influence is not sufficient to overcome the resistance of the atmosphere to movement.

Illustrate by fire

(Illustrated on small scale in fire, or larger in building prairie & forest)

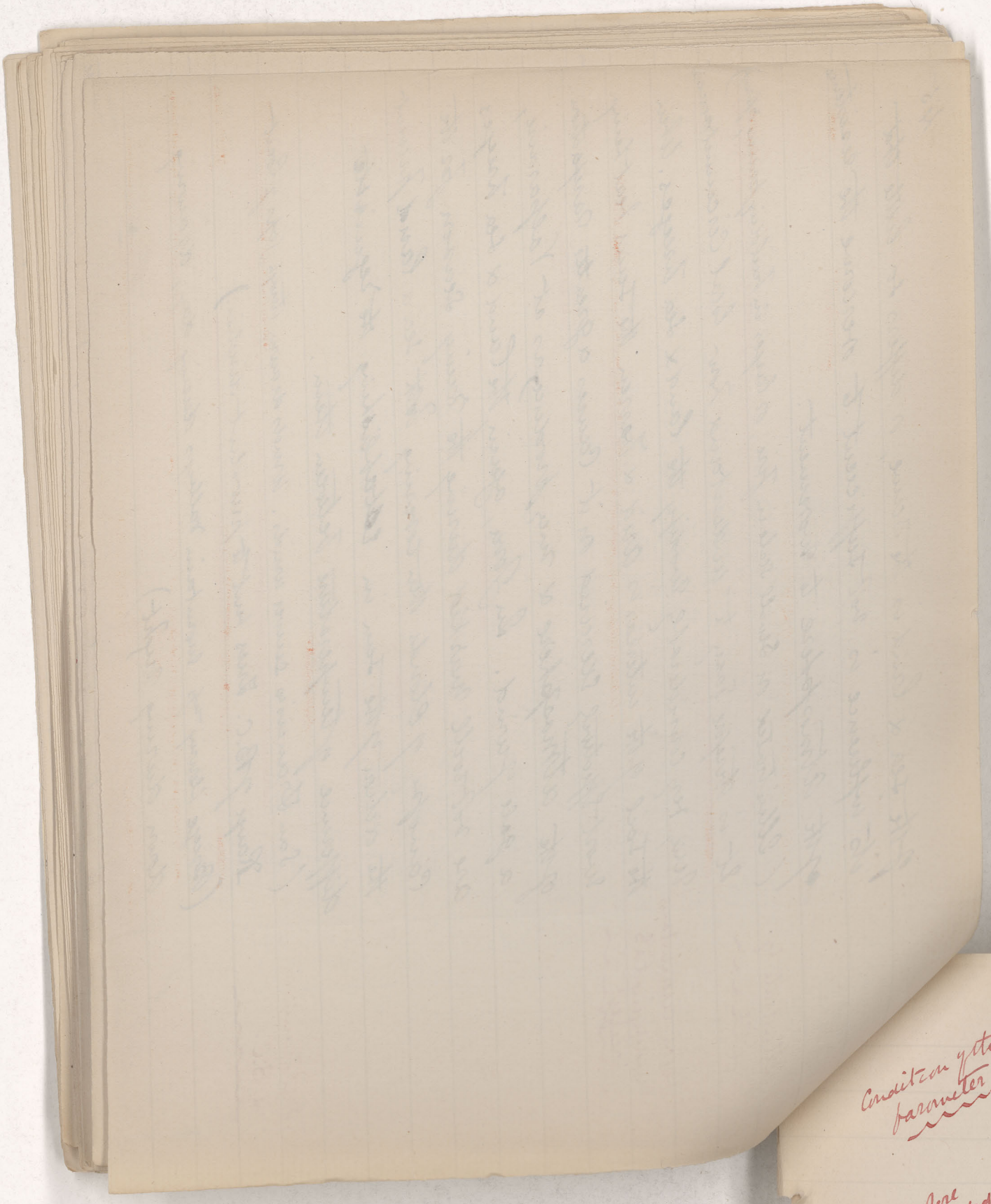
It is therefore easy to understand how local circumstances may very considerably modify the land & sea breezes. When the soil of the interior is arid & barren the sun's heat being most effectively exercised on it causes a greater rarefaction of the atmosphere & may produce, as at Valparaiso, a gale of wind. In Java, again, the land & sea breezes are not well marked during the rainy season for the canopy of clouds then covering both sea & land prevent the action of the sun in establishing the requisite difference of temperature between them.

Local circumstances modifying L & S breezes

San Francisco & B.C.

(San Francisco summer winds. Winds drawing through gaps of Coast Range of B.C. Trees bent to prevalent direction.)

(Breeze blowing up mountain valleys during day, drawing down during night)



Condition of the barometer

were we able during the prevalence of the Sea Breeze in any region to Compare the reading of a Barometer placed on the Land with one out at sea we should find that the former was low while the latter stood relatively higher. The low

Low where air expanded

Barometer over the Land indicates a deficiency of atmospheric pressure Caused by the expansion of the atmosphere before referred to. This expansion is due to the sun's heat, but as the actual weight at which the barometer may stand is affected not only by the amount of rarefaction of the air but by the amount of aqueous vapour contained in it & other Circumstances, & as the amount of difference of pressure between the barometers on Land & Sea is found to stand in strict quantitative relation to the force of the wind, it is preferable to speak of the movement of the atmosphere as dependent on its difference of weight as indicated by the barometer. We thus arrive at the statement that the air always flows from areas of high to areas of low pressure its force depending on the relative difference of pressure.

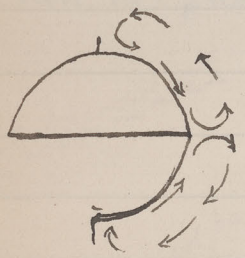
Speak movement as caused by barom.

Rule (repeat)

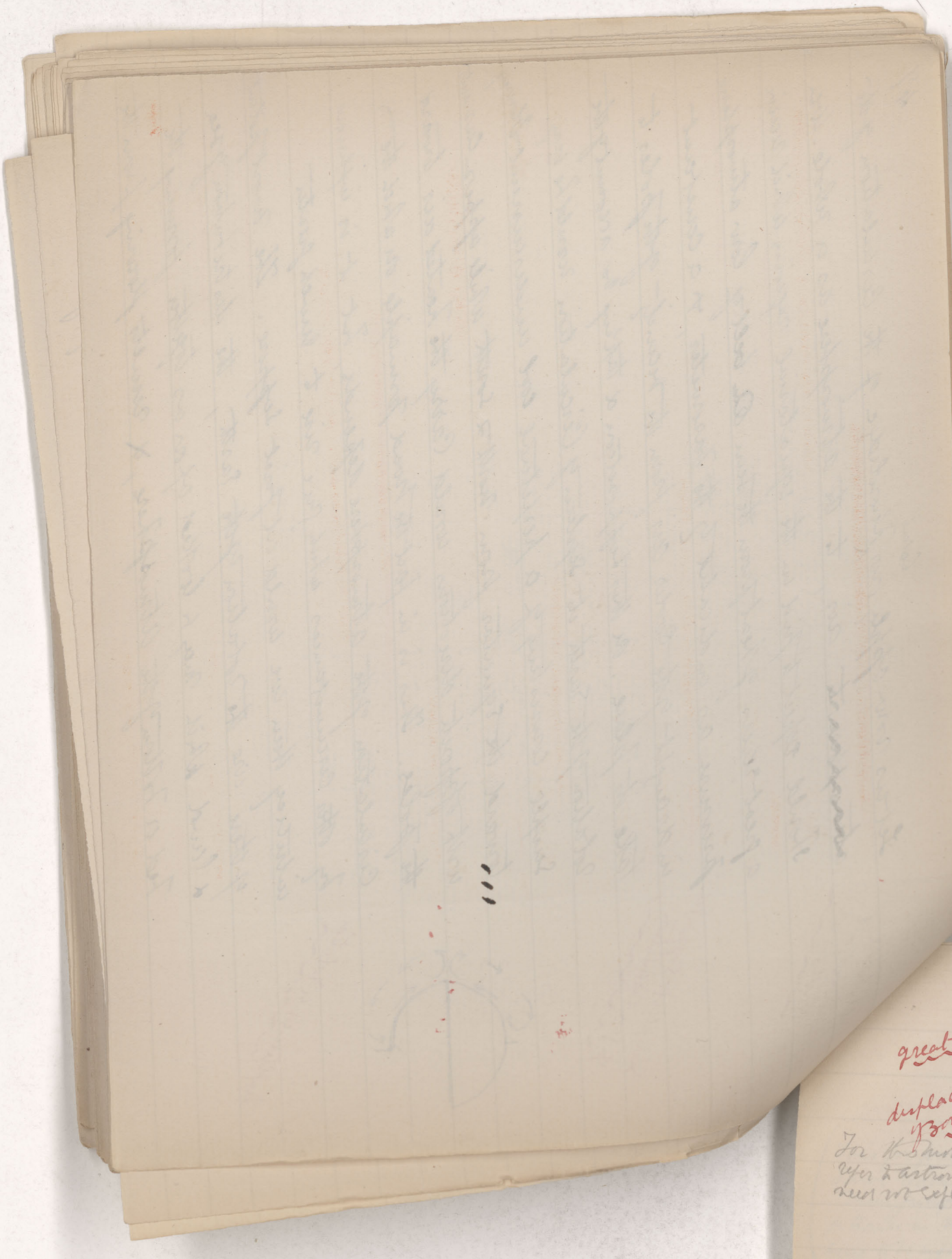
Apply local knowledge to earth as whole

Let us now apply our local knowledge of the circulation of the air, to the atmosphere as a whole. We should expect to find in the equatorial regions which receive a great excess of heat from the sun a belt of low atmospheric pressure as indicated by the barometer, & a constant indraught of the cooler air from the vicinity of the poles to take its place. On this supposition & taking no account of the rotation of the earth, its system of circulation would be very simple, consisting of a perpetual cool undercurrent flowing toward the Equator from north & south while upper currents with opposite directions would carry the heated air toward the poles. This is in fact the broad principle on which the circulation of the atmosphere depends, but it is influenced by other circumstances which give rise to much greater intricacy than we would at first suppose. The most potent of these are the rotation of the earth, the distribution of sea & land which may be looked upon as together forming the bed or bottom of the atmosphere, & currents flowing from the

Simplest supposition of gen. circulation



Influenced by rotation



great thinness

displacement of zone of heat

For the movement refer to astronomy need not explain.

great thinness of the atmosphere in comparison with its horizontal extent, & the displacement of the zone of greatest ~~heat~~ heat with the annual movement of the sun from one side of the equator to the other. (Into all these must examine)

Let us for a moment suppose that the circulation of the atmosphere is a simple exchange between the equator & the poles. It becomes evident when we take also into consideration

Cannot flow in straight lines

Can not flow

the diurnal ~~revolution~~ rotation of the Earth that the currents ~~xxx~~ ~~xxxxxxx~~ in straight lines from point to point. ~~xxxxx~~ ~~xxxxxxxxxxxxxxxxxxxxxx~~ The atmosphere when

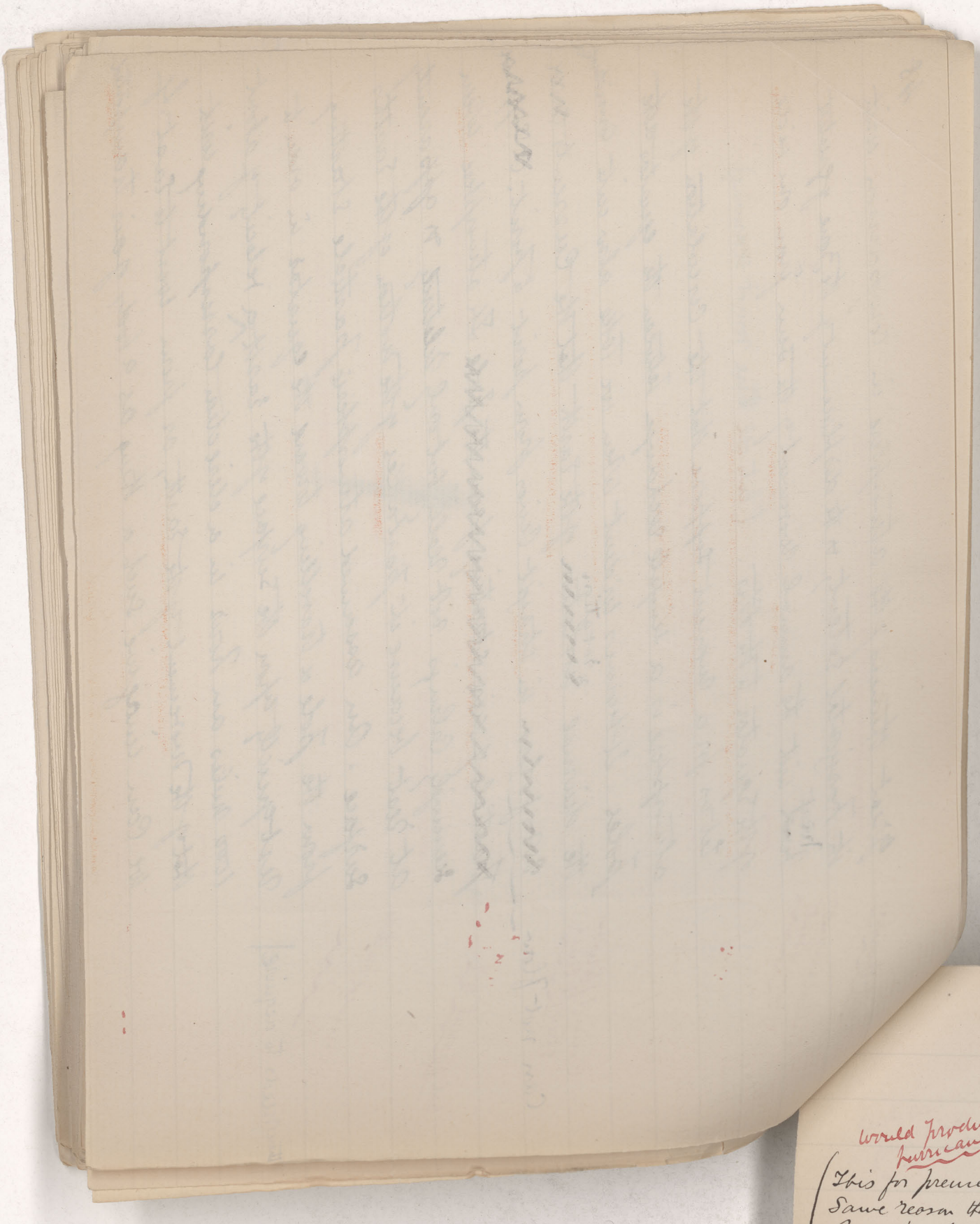
Calm apparent only

seemingly calm, is not really so, but only relatively & apparently at rest because it partakes of the motion of the earth's

Assumed particle from pole

there, needs to acquire

surface. An assumed atmospheric particle starting from the pole & travelling toward the equator in order to rest quietly upon the surface of the earth ^ a velocity of about 1000 miles an hour in a direction corresponding with ~~that~~ of the movement of the earth, or from west to east. If we can imagine such a thing as a body of air transported

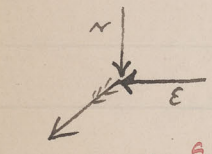


instantaneously from the pole to the equator, the
movement of the earth in turning beneath it, & consequently
the apparent velocity of the wind would be ten times greater
than the most severe hurricane & nothing could stand
before it. In nature however, no such sudden transference
of air occurs, & an atmospheric current in moving toward the
equator forms an exceedingly thin stratum in proportion
to its breadth soon acquires by friction & contact with
the earth the velocity which the surface may happen to
have. The earth however, to a greater or less extent slips
away beneath the current & its actual path is
one resulting from the combination of its original direction
of motion toward the Equator with that of its motion relatively
to the earth's surface. As the earth moves from west to
east a northward current coming from the south of the S. side of the Equator appears
to an observer stationed on the surface to be blowing from
the S.E. To an observer north of the Equator a current
from the north pole appears to be coming from the north-east.
Now such a system of currents as we have supposed actually

would produce hurricane

(This for precisely the same reason that a man jumping from a train in motion is sure to be injured)

acquires motion by friction & contact



Such currents from trade winds

But marked on sea

Temp. moisture & resistance & land effect

together with the resistance offered by mountain chains &c.

Effective atmosphere only a few miles

7

Trade winds most important & best known of regular atmospheric Currents. Called trades from influence on commerce, especially Steam.

Among all the marvels discovered by the great Spanish & Portuguese Navigators the Trade winds most surprised them. The Sailors of Columbus terrified by finding winds there so constant blowing them away from home.

North & South of the equator

their Effect on the Commerce of

, & blow perennially & at

10 to 20 miles an hour

broken & might be called a

are, however, ~~xxxxxxxxxxx~~

regular over the sea, especially

uninterrupted & wide. In

particularly over the surfaces

— in their temperature & the

producing local inequalities in

the trade winds, turning

neutralizing or reversing them

nearly examine into.

& broad & superficial Currents

When the Barometer that —as

bearers of the atmosphere or the

all the phenomena of winds

rs is only a few miles

exists

Such currents
form trade winds

form

the wa

exists for 30 to 35 degrees north & south of the equator forming what are known from their Effect on the Commerce of the world as the Trade Winds, & blow perennially & at all seasons at a rate of from 10 to 20 miles an hour which winds are ordinarily spoken of might be called a fresh breeze. The trade winds are, however, ~~xxxxxxxxxxx~~ best marked & most regular over the sea, especially in the Pacific where the ocean is uninterrupted & wide. In proximity to extensive land & more particularly over the surfaces of the continents the irregularity in their temperature & the amount of moisture in the air producing local inequalities in the atmospheric pressure affect the trade winds, turning them from their direct path & neutralizing & turning them in a manner which we shall presently examine into.

The great Effect of land surfaces on such broad & powerful currents as the trades is fairly understood when we remember that — as already stated — the Effective thickness of the atmosphere or the thickness of that portion in which all the phenomena of winds & the Circulation of moisture occurs is only a few miles

Such currents from trade winds

But marked over sea

Temp. moisture & resistance & land effect

together with the resistance offered by mountain chains &c.

Effective atmosphere only a few miles

while its surface of Contact with the Earth is so vast.

Equatorial Calms

The trade winds coming from opposite directions & meeting in the vicinity of the equator are lost in a belt of Calms ~~known as the Equatorial Calms~~ & variable winds generally spoken of as the Equatorial Calms in which the opposing Currents neutralize each other or alternate irregularly.

The boiler

This region is in fact the boiler which sets the system of circulation in motion. The air rarefied by heat & further expanded by the great amount of moisture which it has collected in sweeping over a great expanse of sea forms an ascending Current, which flowing out to the north & south more towards the poles in the upper regions of the atmosphere & completes the system of circulation of which the trades ~~are~~ are the surface Currents.

Ascending Current

Great Evp. Caused

The ascent of so great a mass of heated & moist air into the Cooler upper regions of the atmosphere, on the principles previously explained in connection with the subject of rainfall ~~could~~ can not fail to cause a great precipitation of moisture. We find accordingly that this Equatorial

belt of Calms & low barometric pressure is one of almost constant & very heavy rains. A portion of this Zone near the Cape Verde Islands has received the name of the rainy sea & is described by Guyot as "a region doomed to Continual Calms, broken only by terrific storms of thunder & lightning, accompanied by torrents of rain. A suffocating heat prevails, & the torpid atmosphere is disturbed at intervals by short & sudden gusts, of little extent & power, which blow from every quarter of the heavens in the space of an hour — each dying away ere it is succeeded by another. In these latitudes vessels are sometimes detained for weeks."

The trades & their upper return currents do not however include the whole atmosphere, but are limited ~~to~~ to a belt of 30 to 35 degrees in width on each side of the equator at which distance we find two more Zones of Calms, that in the Northern Hemisphere being known as the Calms of Cancer, that on the South side as the Calms of Capricorn

Bar. high.

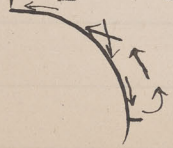
The barometer in these belts instead of standing exceptionally low as in that of the Equator is exceptionally high, indicating a greater atmospheric pressure. We could not expect therefore to find here a repetition of the circumstances which give rise to the Equatorial Calms, & discover indeed that the circumstances are almost precisely reversed. The upper currents leaving the region of the equator, being deposed in the high atmosphere soon loose nearly all their moisture & are rapidly cooled down by radiation. At about 30 degrs from the Equator, & after having travelled as an upper Current for about 2000 miles these layers of the atmosphere, owing to the causes above mentioned, become so heavy that they sink to the surface & pursue their course toward the pole as a surface Current. This necessitates the existence of a return Currents from the regions of the poles, & these reaching the Calm belts of Cancer & Capricorn are supposed to descend there also, flowing off toward the Equator as the trade winds. It is not to be supposed that this crossing of the winds from opposite directions proceeds in a very

circumstances reversed

descent of upper trades

? see Guillemin Spindell

Return polar currents which in general flow in the lower part of the atmosphere

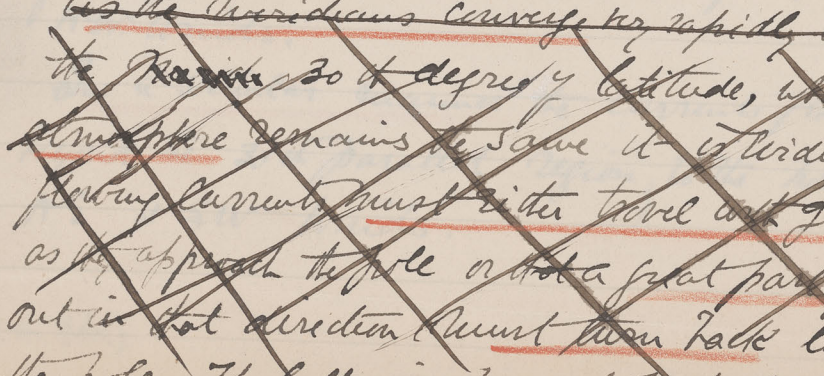


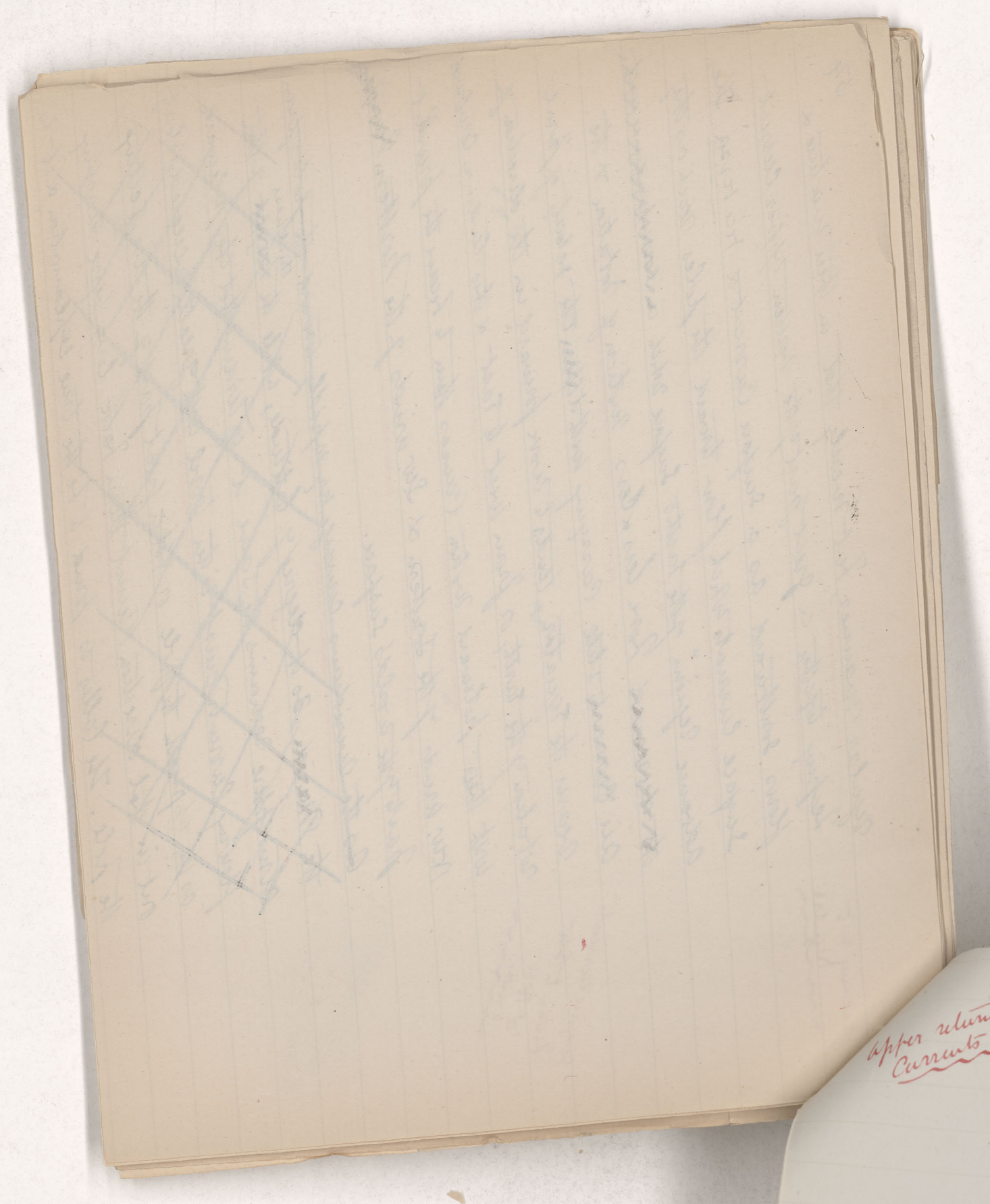
Crossing not regular

regular manner, but merely that in their mixture & keeping together a great part of the bottom upper current flows southward as a surface current & vice versa. The surface currents which flow toward the poles reach as they advance regions of the earths surface which ~~in~~ ~~the~~ have less & less motion of rotation & the air ~~current~~ still carrying with it ~~from~~ the velocity of points near the Equator, tends to move forward in the direction of rotation of the earth, or from west to east & this tendency combined with their poleward motion causes them to become the prevalent N.W. winds of the Southern & S.W. winds of the Northern ~~hemisphere~~ parts of the worlds surface.

Surface currents turn to SW & NW winds

~~As the meridians converge very rapidly toward the poles from the 30th degree of latitude, while the thickness~~ ~~of~~ ~~the~~ ~~atmosphere~~ remains the same it is evident that the poleward flowing current must either travel with greatly increased velocity as it approach the pole or that a great part of the air setting out in that direction must turn back long before reaching the pole. The latter is found to be the true explanation & it is





Upper return Currents

The Currents which I have described so far are the lower or surface Currents, but these are mearsarely counterbalanced by return Currents flowing in the upper regions of the atmosphere. Thus from the Equatorial region where the trade winds meet & flow upward, Currents set out on both sides toward the poles, in the lighter ~~atmosphere~~ air. Now a particle of air ~~from the Equator having~~ travelling northward has the velocity in a direction from West to East due to the Earths motion at the Equator, or about 1000 miles an hour, & becomes deflected from a due northward course in precisely the same way as happens with the trade winds, but in a contrary direction. Thus the return currents of the trades are in the Northern Hemisphere SW, in the Southern NW. winds.

Particle going northward

In a similar manner the Currents flowing from the poles beyond the 30th parallel region, to the North & South, become NE & SW winds.

(Experiment on globe)

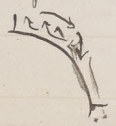
Effect of convergence of meridians

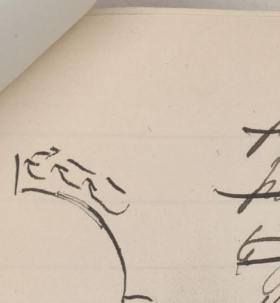
Let us take two Meridians or lines of longitude at the Equator, & trace them toward the pole. We shall find them at first embracing a wide strip of the earth's surface but gradually narrowing away to nothing at the pole. Now as the thickness of the Atmosphere remains practically the same, it is evident that the winds flowing toward the pole, must either travel with greatly increased velocity as they approach it, or that a great part of the air setting out in that direction must turn back long before reaching the pole. The latter is found to be the true explanation. On tracing out the Meridian lines on a globe, it will further become evident that the diminution in width from the Equator to about 30° of latitude is comparatively small while beyond that point they narrow rapidly. In this Circumstance & the consequent forcible piling up of air near the 30th degree we may find part of the reason of the zone of high barometer which there exists, & it is probable that from the 30th degree to the pole there are important ascending Currents, irregular in position & extent, but by which a great part of the surface Current mounts to join the upper return Current.

Turning back of poleward winds

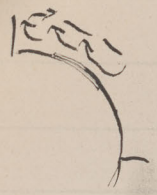
Convergence South of 30°

Illustrate return & progress





~~probable that there are secondary Currents ~~ ~~similar in position & extent~~ ~~by which the Surface Currents~~ ~~to join the upper return Current in all parts of the area between~~ ~~the parallel of 30° & the Poles.~~



It is evidently to the known chiefly thinness of the layer which is formed by the atmosphere that we owe the ~~Crossing of the Calm belts &~~ descent of the upper Currents; were the atmosphere sufficiently thick to prevent the great loss of heat by radiation affecting the upper Currents its Circulation would take ~~place~~ place in an unbroken round from Equator to pole.

Chief reason of descent at 30° at the Calm belts & more or less complete crossing which occurs there

Halley in his explanation of the trade winds long ago accounted for the Circulation of the Atmosphere in so far as it could be explained by Currents flowing toward the Equator & influenced by the rotation of the Earth. The intricacies of the general Circulation were not noticed till a later period & cannot yet be quite satisfactorily explained in all respects. It is somewhat uncertain, for instance, to what the rise of the poleward-flowing Surface Currents North & South of 30° latitude is due. This may however,

Halley

still uncertain

probably be explained on the supposition that the surface current becomes gradually lighter by the addition of vapour from the ocean, & warmer by contact with its surface than the air above it.

Method in which Knowledge [illegible]

The method by which our knowledge of the surface currents of the several atmospheric circulation over the ocean is obtained – where it is best marked, – is obtained, is to some extent unsatisfactory & exceedingly laborious. It involves the collection discussion & arrangement of the observations on the wind & weather from the log-books of vessels. Log books

While for some regions much honored the data are ample, for others the information is exceedingly scanty. When Maury wrote his great work on the Meteorology of the sea he was able to include results obtained from the examination of over one million observations on the direction & force of the wind, & since that time our knowledge has been still further added to, though as yet by no means perfect

Morne Garou

Another remarkable instance of the carriage of ashes by the upper or return current of the Trade winds is quoted by Dove, who writes — On the night of April 30th, explosions like those of heavy artillery were heard at Barbadoes, so that the garrison at ~~Barbadoes~~ Fort St Anne remained all night under arms. On May 1, at daybreak, the Eastern portion of the horizon appeared clear, while the rest of the firmament was covered by a black Cloud, which soon extended to the East, quenched the light there, & at length produced a darkness so dense that the windows in the rooms could not be discerned. A shower of ashes descended under which the tree branches bent & broke. Whence came these ashes? From the direction of the wind we should infer that they came from the peak of the Azores. They came however, from the volcano Morne Garou in St Vincent, which lies about 100 miles S. of Barbadoes. The ashes had been carried into the Current of the upper trade.

The

The upper Currents of the atmosphere which have been referred to are not hypothetical only. The motions of clouds high in the atmosphere frequently render upper Currents flowing in directions different from those we meet with on the Surface, apparent. ~~[illegible]~~ Westerly winds are generally found to prevail while the North-East trades are blowing at the Sea level. On the 25th of February 1835 the Volcano of Coseguina in Guatamala threw into the air a great quantity of volcanic ashes which must have reached upward into the return Current of the trades for though the regular Easterly Surface ~~Currents~~ winds were then blowing the ashes were Carried Eastward a portion falling after four days on Jamaca 800 miles off. ashes also fell on the Ship Conway, in the Pacific at a distance of 700 miles S.W. of Coseguina. There had been Carried by the regular trade wind.

On the Mediterranean a red dust sometimes falls which appears to have been gathered, probably by dust-Whirlwinds, in the Sahara desert thrown to a great height in the air & Carried northward by the upper Currents. (end of Sect I)

So high are the return Currents of the trade winds, however, that not on the highest peaks of the Andes has any traveller found them. But on the Summit of the Peak of Teneriffe, nearly 30 degrees N. of the Equator, a volcano more than 12,000 feet high

Teneriffe

Coseguina

B.B.

Red dust & rain

(Numerous instances in England of tabulation of Earth on Current reaching)