Historical side of Phys. geog.

Causes leading up to present condition

Former history interesting

Draw attention to Causes.

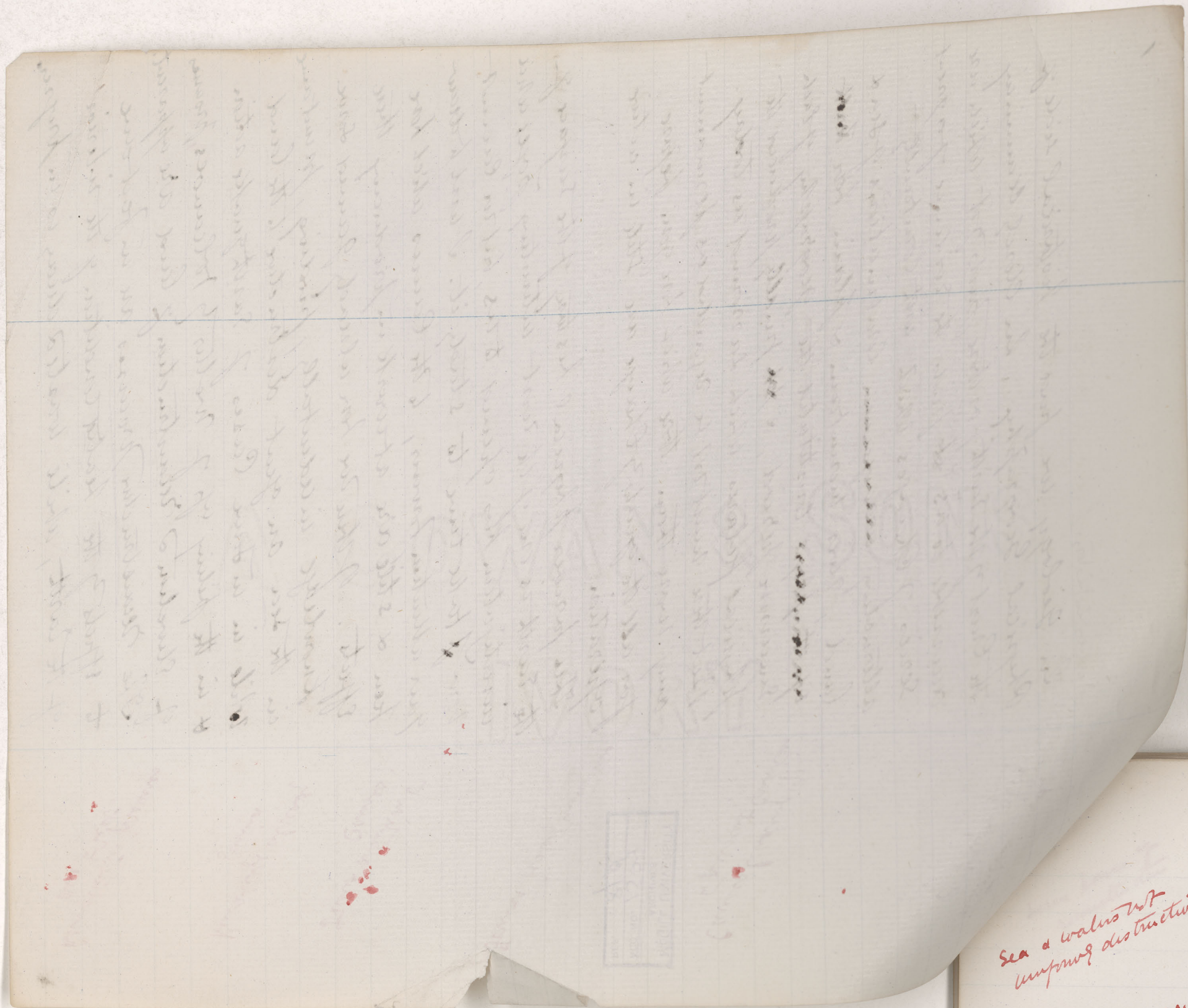
Knowledge already gained

Reconstructive processes due to heat.

Parts in history.

In Geology we find the historical side of Physical Geography. In closely examining the Crust of the Earth, or those parts of it which are accessible to us the geologist finds the evidence of a great series of Changes which with constantly alternating ~~arrangement~~ Combinations of sea & land, river mountain & plain have ~~from~~ ~~time to time~~ constituted the geography of each successive period, & ~~has~~ finally produced the physical features which surround us today. But these must not be regarded as permanent any more than those which have gone before for all the agents of Change are still in active operation.

This former physical history of the surface of the Earth is one of the most interesting pages which investigation has opened to us, but we cannot now ~~at~~ take time to study it. I wish to draw your attention however, to the Causes which have been & still are at work in producing these effects. Of these we have already gained some knowledge incidentally, finding, prominence in the Sea an agent destructive to the land while in in some Cases of Earthquake action & in the piling up of Matter by Volcanoes, proofs of Elevation & Reconstruction of land are apparent. The Reconstructive processes are in fact due to effects of the heated condition of the interior of the Earth, while waste & decay is in progress



by the atmosphere & waters.

Sea & waters not unsparing destructive.

The action of the sea & atmospheric waters is not however unsparing destructive. The surface of the Earth may in fact in this regard be divided into the land areas, undergoing waste & the sea areas into which the products of waste of land are being carried. We have already learned some knowledge of the sea bed & found that over its entire area, but more particularly in the vicinity of the shores, sediments & organic remains are being laid down layer upon layer, forming beds which are generally very nearly flat. It is evident that the lowest of these layers must be the oldest, & in tracing them from the bottom upwards we would in fact pass through the whole series of geological 'formations' now in examining the land we find it to be almost entirely composed of materials such, & arranged in the same manner with those which we know to be in process of formation in the sea beds. Sometimes hardened or otherwise more or less altered but still evidently the same in origin & including not only sands, gravels, & muds of varying character but often the remains of many sea-inhabiting shells, corals, or Crinoids. It is thus evident that what is now land has at one or several times in the past been sea, & that by some process the old sea beds have been raised up in part to produce land.

Deposits in sea bed

Contiguity

Lowest oldest.

"Formations"

Sand, mud, gravel.

Fossils included

Land has been sea.

Serve heroes
vacuolar dens

Some known & unquestionable

Here we find clear evidence of some power at operation acting against those which if unopposed would in the course of time to a uniform plane or part of which would project above the level of the sea. The world appears to be gradually cooling from an original intensely heated state & is doing so continues to shrink. The outer shell which at one time just filled the sphere becomes too large for it & in collapsing upon the central portions now of reduced size has become irregularly wrinkled & folded, much as happens with a shriveling apple.

World cooling & shrinking outer crust folded.

If merely broad areas would only know surface

If however this resulted merely in the formation of broad gentle folds rising above the level of the sea, it is obvious that our knowledge would be confined to a few of the most recent beds, which would be upon or near the surface. The deepest mines do not penetrate the crust of the earth as much as a mile. So great is the pressure brought to bear on the earths crust however, & so long has this shrinking process been continued that in some places it has lead to actual fracture with the production of sharp ridges & rents, while in others the folds produced have been so much compressed that the beds originally deposited in a horizontal position are found nearly vertical, or at various steep angles of slope.

Deepest mines

Fractures & sharp fold.

Where such fractures as lines of compressed folding occur, the heaping up or swelling up of these parts of the crust leads to the formation of mountains

Consequent heaping or swelling.

Sea may cut away as fast as raised.

Sea may cut away as fast as raised.

& mountain Chains in many cases, but not invariably. For, as can in agent that by the leprisy of the Crust be slow the action of the sea may be powerful enough to cut away the projection & remove it as fast as it is formed, leaving instead of a mountain only the truncated edges of the beds which constituted the folds. This may very often occur so ultimately as to prevent altogether the production of Elevations, but in almost all mountains regions there is the clearest possible evidence of immense waste & it is often possible to prove that the existing mountains are but stumps or remnants of great swellings of the Earths Crust from which they have been carved. Thus it is that we are not confined in our examination of the Earths Crust to the last deposited layers, but find exposed on the surface here & there by the processes just opposed to portions of older & still older beds on which are written in Characters more or less distinct the history of former conditions of the globe. The study of this is geology, & Physical Geography we can at most examine the general arrangement & folding of these Continental beds of the Earth's Crust, classifying them as hard or soft in accordance with their powers of enduring waste & decay, or as permeable or impervious in regard to the waters which circulating through the upper portions of the Earths Crust give rise to springs.

Almost always evidence of immense waste.

Elevations a remnant

(Artificial Folds)
(Henry Int. Diagram)
Powells Int.

Thus see lower beds.

(How represented in maps & sections)

How regarded in Phys. geog. aspect

The return of the waters borne from the sea by the atmosphere & discharged upon the Land over the terrestrial

Returning waters cause Waste

Produce sculpture
for land.

Produces sculpture of land.

Renders suitable for man.

Natural waters never pure.

Attacks soil & rocks.

Weak solution. CO_2

Amt. small

Residue on evap.

Surface to the sea again, is the great cause of the wasting & decay of the land. To rain & running waters almost the whole sculpture of the continents is due, & the production of that diversity of form & character which renders them so suitable for the purposes of man, here cleaving the summits of the mountain peaks into picturesque shapes, there throwing out valleys, or spreading fertile soil over deltas & lowlands.

Natural waters are never pure. It will be remembered that in a former lecture it was stated that even rain water when it reached the earth contained various dissolved gases, besides occasional solid particles washed out of the air. As soon as it reaches the surface of the earth it begins to attack the soil or rock of which it is composed appropriating more or less of its substance. The waters of streams lakes & rivers must therefore be regarded as weak solutions of various substances occurring in the earth's crust, among which Carbonate of lime or limestone is the most important, & the solution of this depends to a great extent on the amount of Carbonic acid which the rain water has absorbed from the air. The amount of matter thus dissolved in natural waters is, it is true, small in proportion to the volume of the water but its importance becomes evident when we consider the size & number of the streams rivers & lakes.

A drop or two of water evaporated on a piece of clean glass leaves a film of solid matter more or less distinct, & in Kettles or boilers in which large quantities of water are heated & evaporated this is

Definitions y Calc.
Vuelta!

Definition of Calc. matter.

incrustations of solid matter are frequently found. Portions of the solid Calcareous matter carried by water are also frequently deposited in nature in the form Stalactites in Caverns & the Stony mass which occurs in so called petrifying Springs. In the St Lawrence analyses shows 1·6 parts of dissolved solid matter in 10,000 of weight of water, while the Thames holds about 28 grains weight of similar matter in a gallon of water, or about 4 parts in 10,000. In the waters of Springs which have percolated for a long distance underground the amount of dissolved matter is often much greater.

Waters of St Lawrence Thames Springs.

Sediment.

The dissolved matter just referred to is of course quite invisible, but besides this there is usually in river water a considerable quantity of suspended solid matter, which when the water is allowed to stand for some time subsides. This is of course most abundant in rapidly flowing streams & generally absent in spring water, but ~~adds largely to the~~ represents a great amount of material which the waters are continually stealing from the land & carrying away. But the actual quantity of matter thus carried away we will examine in a few moments, but just I wish to speak of the manner in which water falling upon the land is returned to the sea.

(1)

Rain. how disposed of.

Rain on reaching the surface of the earth is disposed of in three ways (1) a portion is absorbed by the soil (2) a portion is vaporised by the atmosphere & passes away by evaporation, (3) while the residuum discharges itself by the streams & rivers into the Sea.

(as before mentioned)

Water absorbed & earth.

Worms bur

Circulates as it as springs.

action in removing solid matters.

In limestone districts

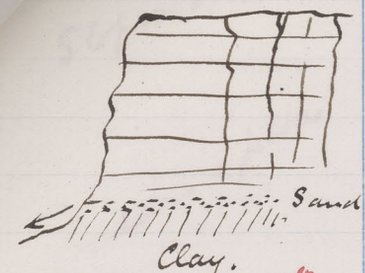
leading formation of caverns.

Mammoth Cave.

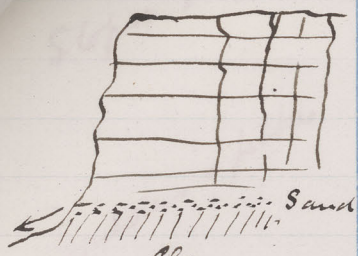
Cause land slips.

The water absorbed by the ground must after a shorter or longer course come to the surface again. Part of it creeping gradually upward prevents the surface soil during periods in which no rain falls in a fit state for the growth of plants. The remainder running underground through the most porous layers of the rocks or subsoil issues eventually in the form of springs, which discharge themselves into some neighbouring stream. There are many interesting circumstances connected with the subterranean circulation of the water & springs, but the only one of these I wish to call attention to at present is the action of the water in carrying away considerable portions of the solid matter of the earth. Here effects are most noticeable in limestone districts, where the rocks are often honeycombed by the action of the water in gradually enlarging natural cracks & fissures by the removal of matter in solution from their sides. This has gone on in some districts till extensive subterranean caverns have been produced, such for instance as the Mammoth Cave of Kentucky which is about ten miles in length & the ramifying passages connected with which are supposed to have an aggregate length of more than 200 miles. The roof of such caverns sometimes falling in cause streams of considerable size to be engulphed, & these continue & extend the work which has been begun by smaller brooks.

Another way in which the underground waters assist the water of land is in causing landslips more or less extensive. These generally depend on the


Sand
Clay.

existence of a permeable layer in the face of a cliff or bank, which in a season of unusual wet leaves saturated with water & enables the whole upper portion to slide down upon it



Let us now trace the journey of that portion of the water which is not absorbed by the soil, but flows away upon the surface, & note its effect on the land. The soil is nothing more than the superficially decomposed portions of the rocky crust, & we shall find that it may be regarded as constantly moving if toward the sea. Drops of rain falling with some force upon the ground disturb the ~~dust~~ earthy particles & little streams of muddy water may be noticed during a shower of rain washing their way in all directions, each flowing toward the lowest ground in its vicinity, & eventually reaching some rill brook or river. This effect is of course best seen on bare ground, but occurs to some extent even when the surface is covered with grass & trees. A little work done in this way during every rain storm is scarcely perceptible but in the long course of time produces important changes.

The rain falling upon the ground, with water issuing from springs, & perhaps also derived from melting snow & ice on the mountains, constitute the sources of rivers. A typical river may be supposed to rise among mountains, or at least in some high hilly district. One can in general scarcely fail amidst a multitude of streams which should be designated as the source of the river. They are mountain torrents, with steep slopes, & if occasionally pausing for a time in some quiet eddy, are marked by frequent

Water flowing over surface.

Soil on way to sea

Rain

Work effected on bare ground.

In long time important

Sources of rivers

Mountain torrents.

Slopes steep.

Boulders & pebbles

Slopes steep.

Boulders & pebbles

In flood

Nature's mill

Wears away its bed

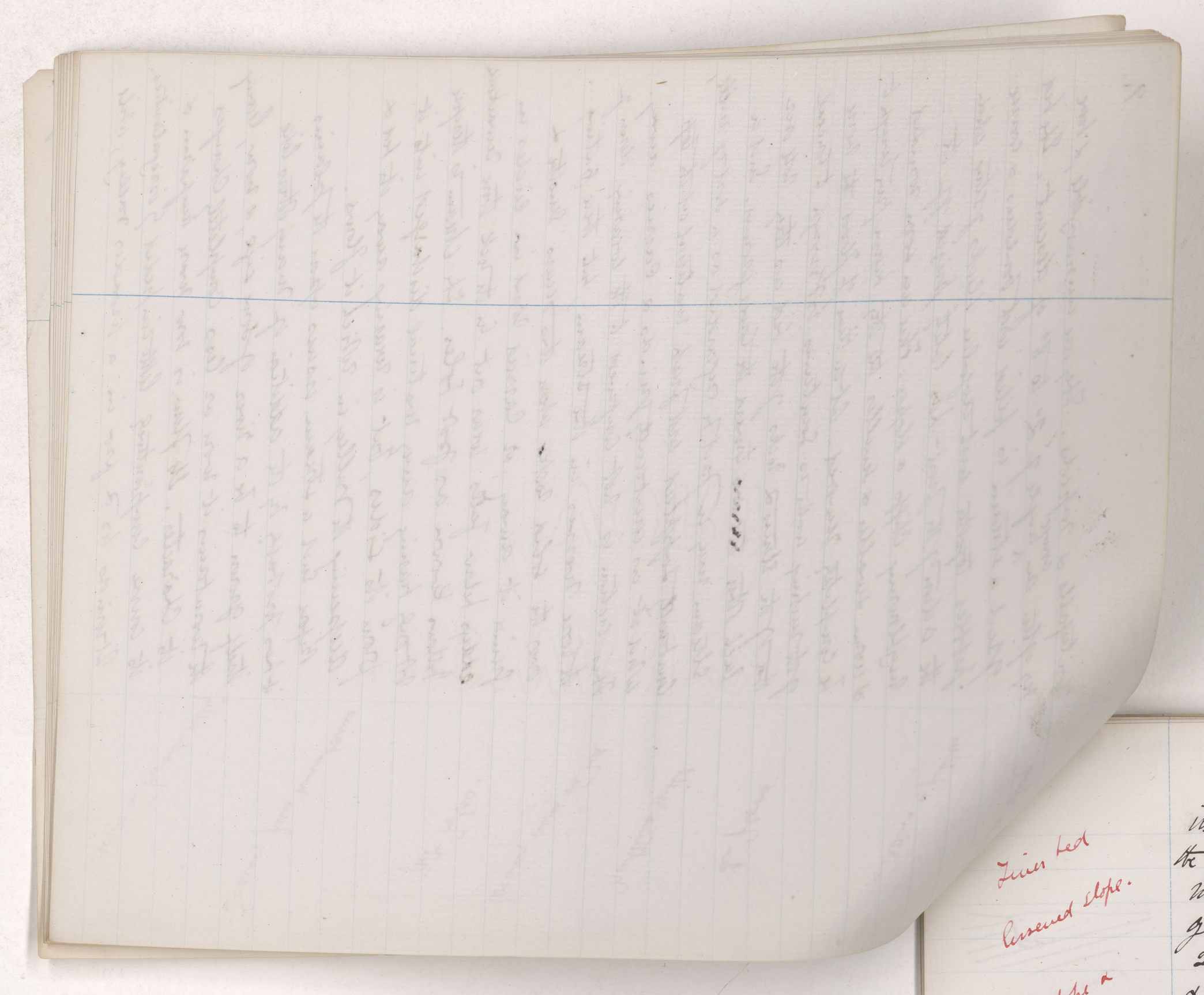
Pot Holes.

Issues from mountains

Winds in broader valley

waterfalls & rapids. They are unnavigible, & have very often an average angle of 2° to 6° of descent. The bed of such a stream is filled with boulders & coarse pebbles, together with angular blocks of stone which the action of the frost has lately prized off the neighbouring cliffs & slopes. These are soon rounded & worn smaller & smaller till they have gone through to be completely removed. At a time of flood the noise of the rushing water is sometimes strong enough to conceal that of the stones & rocks of the bed as they roll over each other ~~towards~~ toward the lower ground. Such a stream may in fact be regarded as a sort of mill, constantly supplied with fresh material at the top which it as constantly grinds & carries away. This action is not confined to the wearing down of the loose stones in the stream, but there grating over the solid rock when the stones smaller & grind it away, or carried round in circles in eddys below falls wear out in the rock those remarkable hollows known as pot holes. The stream is therefore strong having away material discharged into it from its sides, but is wearing away its bed & deepening the valley in which it flows.

Before such a stream issues upon the plains it has probably by the addition of many others like itself grown to be a river of some size, & now, having the mountains it more or less completely changes its character. Its flow is now more tranquil & its course comparatively little impeded by irregularities. It winds in a broader valley, while



Zone of lessened slope.

Rate of slope & flow

State of transporting & eroding

Action on sides of valley.

When flowing along strike.

its power of transporting heavy bodies is diminished & the material of its bed is fine. Its slope is very much less, & if it be a large river is probably not greater than 2 feet in a mile. The Missouri falls 28 inches in a mile, but it is a very rapid river & very turbid. To be well suited for navigation a river should not have an average descent greater than 10 inches in a mile. The rate of flow of large rivers in this part of their course varys from 1 to 3 miles an hour, the latter being considered very rapid. Though the destructive & transportive effect of the river is very much reduced it is not by no means idle. It carries along with the dissolved matter but a fraction of the gravity of the fine mud & sand with which its upper portions has supplied it. Particles too heavy to remain suspended in the water are rolled & pushed along the bottom by the current. The river then has continues to deepen its bed & widen its valley. At every curve bend the stream is usually at work upon its banks Cutting away & undermining them, & while much of the material removed from one side is deposited again on the other where the water is slack. A sediment is always being moved toward the sea. During the night at a time of flood on such a stream the plunge you detached mass of the bank sometimes bearing large trees upon it may often be heard as it drops into the stream current. When again the river in this part of its course happens to flow the outcropping edge of any considerable mass of

relatively soft rocks, it does not produce positively a permanent bed but, but usually naturally as it cuts its Channel deeper frays away its bank upon one side till it may in the course of time produce a broad gently sloping plain with an escarpment at one side against which the river is still flowing. Such a circumstance is found in many cases. It is particularly well marked in the production of the region known as the Weald of Kent, & instances the transport on enormous amount of material from the surface of the land.

Escarpment & wide plain

Weald of Kent

Sandslides and much in enabling rivers to enlarge their valleys. When they flow through regions characterized by rocks not very hard. The stopping of the banks by underground waters in the way already alluded to brings down huge masses of broken & fissured material which the Current rapidly removes

Land slides.

(Smoky R.)

Lakes are generally rare in the middle courses of rivers, being more characteristic of their upper portions. It is very often found however that lakes have formerly existed but become filled with sediment in the course of time forming wide alluvial plains. In other cases rocky ridges or barriers formerly causing lakes by damming back the waters, have been cut through by the prolonged action of the river, producing picturesque cliffs or bluffs & leaving dry the old lake bed.

Lakes & rocky barriers in middle course of rivers.

In the lowest part of the course of a river its destructive action on the surface is generally very small or reduced

Lower Part of Course

Here glue description.

Here the deposition.

to nothing, it being frequently the case that the slope is so light & the current so gentle that the stream can scarcely carry the sediment with which it is already loaded. It often indeed begins to deposit this sediment, producing a delta, or at times of flood gradually adding to the alluvial plains at its sides a portion of the material which it has brought down.

Must include frozen waters in review.

To complete a review of the waters of the atmosphere across the land to the sea, it is necessary to include notice of the frozen waters of the land, & in the phenomena of glaciers particularly, important evidence of the work & sculpture of mountains is obtained.

Glaciers
Frost crumbling rocks

The action of frost in loosening & breaking off portions of rock, & disintegrating soil is very important in preparing material to be carried away by streams. It depends on the remarkable property peculiar to water proving opposed to the rest. that of expansion at the point of solidification. The water filling crevices each time it freezes widens the crevice a little & thus in the course of time may throw down large masses. This action is peculiarly prominent in high mountainous districts where frost & thaw succeed each other by day & night. In such places when the sun is beating upon the mountain sides, a mass of debris may be heard from time to time rolling into the valley.

Expansion on freezing

Above the snow line on high mountains, & in arctic regions such as Greenland snow nearly down

Accumulation of snow.

to the sea level the heat is not sufficient to melt away the quantity of snow which falls. When the slopes are steep, after piling up to a certain depth great masses of snow break off & rush down the hillsides in the form of avalanches. These masses, however, help to relieve exceptional localities from their burden of snow & ice more than other means found, the snow in extensive mountain regions, & more especially in wide land areas like Greenland would go on accumulating indefinitely. A means of relief is, however, found in glaciers. The snow after heaping up to a certain depth in the high alpine hollows, becomes by pressure converted into ice in its lower layers, & as snow is continually added above takes on a slow motion down the lowest line of the valley. This moving mass of ice constitutes a glacier. To the interesting questions connected with glaciers on an more extensive scale might well be devoted, but at present we can glance only at the effects they produce in the great process of denudation.

Though a glacier moves so slowly — scarcely more than a few feet in 24 hours — it resembles a river in many respects, moving for instance faster in the middle than at the sides, faster at the top than at the bottom. Being however unequally rigid this differential motion produces numerous & deep crevasses. Stones detached by frost from the mountain slopes are continually falling upon the surface of the glacier & from there what are known

Avalanches.

Glaciers
Snow changed to ice.

Glance only at action in denudation

Resembles a river

Stones falling into Crevasses.

Moraines.

Blocks fixed in ice.

as moraines, which were on quite the mass & demonstrate to us the fact that the glacier is constantly carrying down solid matter from the mountains to the valleys. Blocks of stone falling down the Crevasses become fixed in the lower ice & as they move on scour & polish the rocky bed & are themselves scratched & ground down. As a consequence of this action a great quantity of fine mud is always found suspended in the water which flows away from the lower end of a glacier, & when we examine the rocky bed from which a glacier has retreated all the asperities are found to be removed & smooth rounded surfaces only remain.

Blocks fixed in ice.

Smooth bed left.

Thus transport & Erosion.

Thus the action of glaciers is like that of running water both as a transport & erosion of the solid matter of the earth. The moraines are finally thrown down when the ice disappears by melting, & form an irregular mound or series of mounds which are known as terminal moraines. These are probably in the course of time carried away by the torrents issuing from the glacier. In Greenland however, where the glaciers instead of ending amidst pine woods & meadows as they do in the alps push out into the sea. Masses of ice with moraine matter & imbedded blocks are broken off & floating away as icebergs, as they melt discharge their freight of stones over the sea-bed.

Terminal moraines

Icebergs.

So much for agents of waste

What next?

So much for the main agents of waste or denudation of land — underground waters, surface waters, frost & glaciers, — What is their aggregate result?

may be measured by rivers.

(How measure)

Way to be measured by rivers.

It is evident that this may be measured by the amount of matter carried away from each continent by its rivers which ultimately receive the gatherings of all their efforts & pass them on to the sea, the material borne onward by each individual river being that which has been removed from its own drainage area.

Thames as an instance. Huxley.

The Thames has already been referred to as containing a considerable proportion of dissolved matter in its water. Prof. Prestwich assuming this to amount on the average to 14 grains per gallon only, & knowing the daily discharge of the river at Kingston to be 1,280 million gallons, calculates that the quantity of mineral matter moving seawards past that place is over 3,000,000 pounds, or 1,500 tons every twenty-four hours, or say roughly, about one ton a minute. The total quantity of solid matter thus carried away in a year will amount to over 548,000 tons.

Baker

Rhine

Bischof totting the mean quantity of Carbonate of lime in the water of the Rhine at 9.46 in 100,000 of water which it is at Bonn, ingeniously illustrates the quantity of solid matter yearly removed by this river from the land by estimating that it is enough to make ~~yearly~~ 332 thousand millions of oyster shells of the usual size. These would form a Cube 360 feet in the side, or would make a square layer a foot thick & upwards of two miles in the side

Not carried as sediment.

By far the greater part of the material carried by the

Sedewick
Manuscripts.

Sediment of Mississippi.

rivers is, however, in the form of sediment mechanically suspended. Estimates of this have been made for many rivers, but for none so carefully & elaborately as for the Mississippi. As a mean of many observations it is found that the sediment amounts to $\frac{1}{1500}$ of weight or $\frac{1}{2900}$ of volume. But besides the matter thus held in suspension much coarser material is constantly being pushed along the bed of the river. This is estimated to amount to 750,000,000 Cubic feet. The weight of suspended matter ~~812,500,000,000 pounds~~ 362,723,000 tons. Adding the whole it was found that each year a mass equal to a block one square mile in length, side & 268 feet high is carried into the Gulf of Mexico.

Some idea of amt. of suspended matt. Seine that 1000 merchantmen each cart 1000 tons arrive every day

What average lowering of basin or average area

A more instructive manner in which to view this denudation or waste of land is to calculate for each river basin what is the average amount removed from all parts of its surface. Treated in this way the Mississippi gives the following result. The area of the basin is 1,147,000 square miles, the annually removed amount of sediment 7,459,267,200 Cubic feet, which if reduced to the density of rock is equivalent to the removal of $\frac{1}{6000}$ of a foot per annum. This great basin is therefore being lowered at the rate of 1 foot in 6000 years, 100 feet in 600,000 years, 1000 feet in 6,000,000 years. Taking the average height of North America at 1496 feet it would therefore, at this rate of waste require about 9 million years for its complete removal down to the sea level

Time required for denudation of N. America

Reste y appliquer
Leurs.

Rate of different rivers.

On comparing the action of different rivers in this way they are found to be very unequal in the rate at which they lower their drainage areas, as the following table will sufficiently illustrate.—

Mississippi	removes 1 foot in	6000	years
Ganges	"	" 2358	"
Hoang Ho	"	" 1464	"
Rhone	"	" 1528	"
Danube	"	" 6846	"
Po	"	" 729	"
Nile	"	" 4723	"

British rivers

An estimate of the amount of material carried away by all the British rivers gives as a probable result a period of 8800 years for the planing away of one foot, & taking the average height of the land at 650 feet a period of about 5½ million years would be required for their removal

Comparison of sea & subaerial waste.

The fretting away of the coast line by the sea & the manner in which it is cut out into bays & inlets but eventually worn back step by step & the material spread over the sea bed, has been alluded to in a former lecture. This form of denudation or waste of land is more evident & might seem to be more powerful than the quiet subaerial denudation which we have last been considering. Let us compare the results.— The entire coast line of the globe is estimated at 116,531 miles. Suppose we take the average height of the coast line at 25 feet, & take also the rate at which the sea is advancing on the land

Croll

at one foot in 100 years, then this gives
15,382,500,000 Cubic feet rock as the total amount
removed in 100 years by the action of the sea" But
working to Subaerial denudation & taking into account
the area of the land we find that if an foot be removed
off the surface in 6000 years 26,763,000,000,
Cubic feet is removed in 100 years, or about
1740 times as much as that removed by the sea.
Before the sea could become as destructive to the land
as rain & rivers are, it would have to advance on
the land at the rate of 17 feet annually.

Denudation not uniform.

It has been supposed however, that the denudation
brought about by rain rivers & ice is uniform, but
this is far from being the Case. It is quite obvious
that the rain falling upon a flat plain covered thickly
with grass can have comparatively little effect on the
soil, while when the same shower falls on a bare
sloping hillside it may carry away a considerable
quantity of mud. Striking upon a hard surface of
rock again it is able to remove only a few particles
in Solution. This, however, does not affect our general
Estimate, for if we allow too much for the loss in
one locality, more must be removed in proportion
from another. We know Certainly that a given amount
of material passes out to sea by the rivers
annually.

Does not affect general Estimate

Inequality due to circumstances causes fluctuations.

It is the inequality of denudation dependent on
the hardness or softness of the rocks or soil, on
the amount of rainfall, on the pointed
or treeless character of the surface, & a hundred

other circumstances [illegible] that the diversity of the features of the land is due.

To appreciate the inequality of this waste let us assume certain figures, which are in all probability not far from the truth. Let it be supposed that of the whole surface of a country one tenth part is occupied by valleys, while the remaining nine-tenths consists of broad undulating plains or table lands forming a comparatively level country. Let us further assume that the rate of waste is nine times greater in the valleys than over the plains. That while one foot has been removed from the valleys but one has been carried away from the uplands. According to calculations already given it may be assumed that the yearly [illegible] loss to the surface is about $\frac{1}{5000}$ of a foot. Apportioning this loss in the ratio just given we find that while it will take 19,800 years to remove one foot from the [illegible] plains a period of 1200 years will be sufficient to effect this much denudation in the valleys. Or to reduce it still further this is equal to a loss of only $\frac{1}{12}$ of an inch from the table land in 75 years while the same amount is excavated from the valleys in 8½ years.

It may seem that such a slow rate of waste as that of the uplands might be disregarded as inappreciable, & it would certainly be very difficult to detect in any ordinary way. Even the wearing down of the valleys by one line in 8½ years seems unimportant, but taking into consideration

the multiplying power of time, it is found that a valley 1000 feet deep may be cut out in 1,200,000 years a period which, Geologically speaking is not very long.

Special instances of denudation.

Of special instances of denudation & the sculpture of the land innumerable examples might be cited. We have time to examine a few only.

River valleys

In river valleys the proof that they were [illegible] gradually excavated by the stream is exceedingly clear. (We for instance see horizontal beds of stone or clay, and layers of gravel &c. corresponding on both sides bed for bed) (In other cases successive terraces marking the lines of the stream when at different levels clinging to the sides of the valley)

Terraces.

Broad open valleys like these are those [illegible] formed under ordinary circumstances, but in exceptional cases the running water cuts out ravines & Canons. In the best known examples of this is found in the Falls of Niagara which between Queenston & the present position have excavated a [illegible] gorge seven miles in length. (Peculiar circumstances here the existence of a hard layer overlying a soft. undermined & thrown down.) The rate at which the crumbling down of the rock & recession of the fall takes place is estimated at about a foot in a year, which may be too much. This rate cannot be very definitely ascertained, as it depends on the comparison of old plans with

Exceptionally large Canons

Niagara

Rock fronts

Modern surveys, & the figures are not generally exact. Taking it at this however the time required for the production of the gorge is estimated at 35 000 years, & there is nothing more certain than that in the course of succeeding ages the falls will continue to retrogress till they reach Lake Erie & more or less completely drain it.

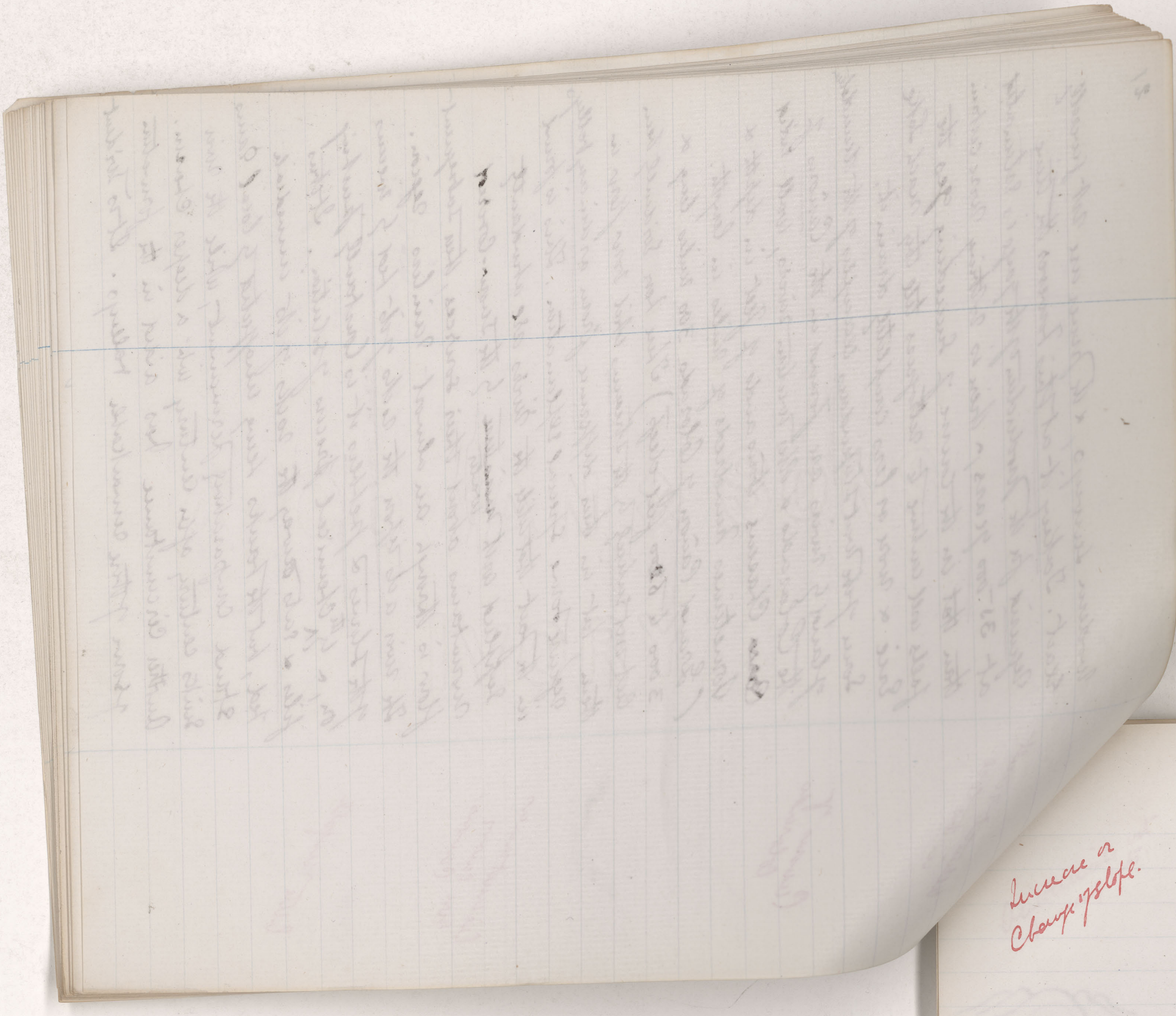
Ultimate result in this case.

Some of the most stupendous examples of the denudation of land by rivers are found in the Cañons of the Colorado & other western rivers, wall-sided Chasms thousands of feet in depth & sometimes hundreds of miles in length. (Grand Cañon of Colorado 300 miles long & 3 000 to 6000 feet deep) These have evidently been cut out entirely by the streams which now flow in them, but in their difference from ordinary valleys require some special explanation. This is found in the fact that while the rivers are abundantly supplied with water by the snow-covered mountains about their sources, their subsequent flow is through an almost rainless region. The river acts upon the rocks it has fed by means of the stones & pebbles it is constantly pushing on, & by the chemical process of solution. It thus files & eats away the rocks of its immediate bed, but the banks being unaffected by local rains stand comparatively permanent, while the river sinks century after century into a deeper chasm. Another circumstance has aided in the formation of some of these remarkable valleys. It is evident

Cañons of Colorado

Circumstances favoring Cañons.

Latter supplied



Increase or Change of slope.

that if a stream cut down gradually the its whole bed from near its sources to its mouth be at a very gentle slope, or almost at the level of the sea, that the water will run with little force & its power of erosion be reduced & at length altogether fail. Under these circumstances unlimited time is given for the slow wearing of the Cliffs & banks at the sides of the stream, & even if a Cañon had at first been produced it would in the course of ages be widened out to an ordinary valley. If however, the land be gradually rising, either ~~suddenly~~ uniformly, or especially about the mouths of the streams, new fuel is being constantly added to the stream, or new masses of strata brought up into its power, & Cañon valleys result.

Volcanic mountains

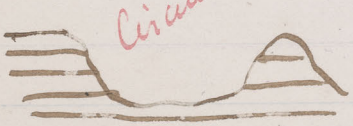
Mountains. Volcanic mountains simplest form. Materials more or less symmetrically piled up, layer on layer. Ashes & lava. Volcanoes several easily recognised, Etna & Crater &c.

Most mountains however have been sculptured out of great earth folds & such processes as we have been considering, complicated by circumstances of the relative hardness & softness of the rocks, the arrangement of the beds &c.

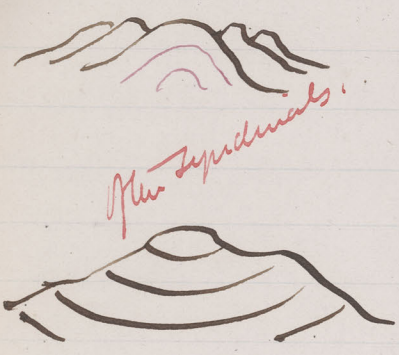
Most mountains sculptured out of folds.

Circumdenudation

Simplest form a hill of Circumdenudation. Outlying portion of a plateau which may perhaps be composed of horizontal beds.



Anticlinals & synclinals.



Plan Synclinals.

Might be supposed that the convex parts of the Earth swellings, rising originally highest would most frequently form mountains. This proves not the case. Generally pressed & cracked. Easily worn away. Slate sometimes found. In Jura range e.g. many mountains like this. Partly summit of arch removed by denudation.
The hollow folds more frequently form mountains. Rocks harder & more consolidated, resist wear. & remain standing out in relief. Whole ranges by frequently in this plan.

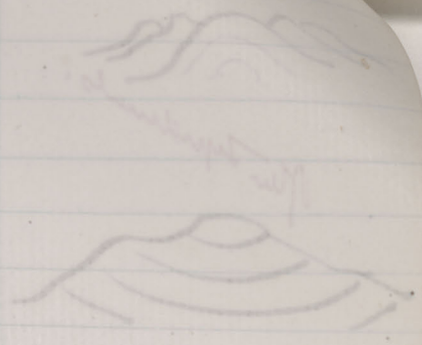
Immense masses removed

Immense masses removed from some mountain regions (Pentland Mountains ?) Evidence in Four Chains of successive periods of uplift. Mountain masses worn down & Elevated several times.

Immense uplifts & wearing down.

Everywhere on the Land Surfaces we find Evidence of Change & decay, of Subsidence & Elevation, Waste & Renewal. Standing on some ~~an~~ Elevated point from which a good view may be obtained over mountain & plain We look, not as we might at first Suppose on permanent features of nature but see everywhere glaring ~~natural~~ written the traces of the prolonged activity of those forces of frost, rain & running water, what we Know to be still in operation. Some lines of Tennyson's, who ~~has~~ often Cabches very happily the ~~characteristic~~ usually modern

Change & decay



investigation, may occur to you. He writes, speculating such Changes as we have been considering. —

"There rolls the deep where grew the tree. ~~O Earth~~ O Earth what Changes hast thou seen! There where the long street roars, hath been the stillness of the Central sea. The hills are shadows, & they flow from form to form, & nothing stands; They melt like mist, the solid lands, like clouds they shape themselves & go."

doubtedly a wealth of material (as for example may be found through the publications of the Canadian Geographical Survey) available as a basis for a truly Canadian text-book of physical geography, and only awaiting selection, arrangement and correlation. In this connection, also, we have been favored, through the kindness of Dr. W. Bell Dawson, Superintendent of Tidal Surveys, with the manuscript of a very complete course of lectures on physical geography, written by the late Dr. George M. Dawson, formerly Director of the Geological Survey. Dr. W. Bell Dawson wishes to place this manuscript freely at the disposal of the National Council of Education should they, at any future time, take steps to have a textbook of physical geography compiled for use in our schools.

hardly too much to predict that, if we had books [illegible] for
"Frye and Atwood" and the revised "Tarr" do for the United
general adoption would be assured.

Passing reference only need be made to the fact—by no means
—that a book which had the whole Dominion for a market could
and sold at a much smaller cost than a similar book whose ci[illegible]uation was
limited to one or two of the provinces.

The Universities and Geography

Unquestionably the very marked progress in the matter of geographical

LADIES' EDUCATIONAL ASSOCIATION.

MONTREAL SESSION, 1879-80.

EXAMINATION IN PHYSICAL GEOGRAPHY.

THURSDAY, APRIL 8TH :—2 TO 5 P.M.

Examiner,.....GEORGE M. DAWSON, D.S.

1. What circumstances tend to produce a heavy rainfall in a given district, and to what is the existence of rainless and desert regions due.

2. What is meant by the dew point? Explain the formation of dew.

3. Explain the essential phenomena of the trade winds, and state by what means a knowledge of these and the upper return currents has been obtained.

4. What is meant by cyclonic and anticyclonic types of disturbance in the atmosphere, and how is each characterized?

5. In what main points are the physical features of the sea bed distinguished from those of the land surfaces, and for what reasons?

6. Sketch the course of the Gulf Stream, and illustrate its effect on climate.

7. Enumerate some of the more important oceanic currents, noting which are characterized as cold and which as warm.

8. How are relative changes of level between land and sea indicated by the facts observed in connection with coral reefs and islands?

9. Explain the manner in which the approximate position of the origin of an earthquake wave may be ascertained.

10. If a thermometer be placed successively at different depths in the earth, in temperate latitudes, what effects in temperature will be observed, and to what are these due?

11. Enumerate the principal agents at work in wasting away the present land surfaces, briefly indicating the mode of action of each.

12. Give an instance in which the present distribution of forms of life serves to indicate past physical changes.

Biology

Distrib. intimately connected with phys. geog.

Map of Europe in Malay Archipelago Symbols.

Map of Britain to explain Isolation.

Table of plants in different regions. Wallace.

Uniformly dispersed

Dep of Station

Dep of Habitat

Geographical Distribution of Plants & Animals

Biology the study of the living things which inhabit the Earth, whether plants or animals. A subject extremely wide. That part of subject most intimately connected with geography the distribution of plants & animals, or mode in which they are spread over the globe. Geography including under this general term all the causes which we have studied bearing on climate & environment constitute the external dominant conditions of life whether plant or animal. A study of these will be found to explain in great measure the distribution of living forms, while in turn the study of distribution throws important light on some of the past phases of geography.

It is a familiar fact that the various animals & plants are not uniformly dispersed over the surface of a given district. If we wish to find a certain flower or insect we must know a certain locality or number of localities in which it may almost without fail be obtained, while we may search in vain for it elsewhere. In making wider excursions in which the distance traversed may be measured by lines of latitude & longitude, the differences in the forms of life will become greater till at length we reach some country where all are unfamiliar. We may search in vain for some well known species in such spots as we have previously been accustomed to find it in, though rocky mountains, swampy tracts, forests or chalky uplands may occur presenting

circumstances such as we have been accustomed to associate with the species in question.

Element of Habitat

The change in the immediate environment of a species, or circumstances in which it lives is known as that of Station & is essentially local. The broad geographical change is of greater importance & is known as that of Habitat or habitation

B.B.

There is yet another difference which might be observed in making such a survey as we have imagined. Some of the plants & animals met with while evidently different from those we have been accustomed to are still not altogether dissimilar from them & constitute representative species, while others are entirely new to us & seem to be formed on distinct types. (From an evolutionary point of view the former may be regarded as those which have undergone comparatively recent alterations & grown up nearly in the locality which they still inhabit, while the latter must have passed through a prolonged course of change possibly complicated with extensive Geographical modifications.)

Representative species & species finds divine

S

Climate & particularly temperature influential

It might be supposed that the cause influencing the distribution of life over the globe is soll Climate & more particularly that element in climate temperature, & that Zones of life would be found to correspond more or less completely with the isothermal lines traced over the Earths surface. Temperature is indeed a most influential circumstance, & affects in number of species, or

Tropical abundance and variety.

number of species.

Wag says, hundreds thousands or millions.

general character of climate difference

Tropical assemblage

Temperate assemblage

Arctic assemblage

Def. of Station as already stated

number of individuals life is exuberant in the warm Equatorial Regions & as we approach the Poles is at last almost entirely absent. It has been estimated that the mean density of species, in proceeding from the Equatorial to the Polar regions is in the following ratio. Tropics 26 Species North temperate 9 Arctic 7.

The general character of the differences due to temperature are well known. In the tropics are found showy & bright tinted flowers, palms, bananas bamboos, with brilliantly colored birds such as parrots & peacocks, & elephants, apes, crocodiles & innumerable other forms. In temperate latitudes these are replaced by a different assemblage. Both plants & animals are more sombre in coloring. The oak, ash, elm, poplar birch, pine & other familiar trees constitute the forests. Song birds are abundant, & such animals as foxes, wolves, rabbits, bears, deer & marmots are characteristic. In the arctic regions both the abundance & variety of life is still further reduced The pine & spruce, willows, & stunted forms of birch & poplar take the place of the forest trees, & still further northward are themselves replaced by grasses, lichens, saxifrages, gentians & similar hardy but generally small & inconspicuous plants. The polar bear & reindeer wander over these desolate regions, & the ptarmigan with peculiar species of owls & falcons are abundant.

Mountains, forests & deserts, again, have each

Different species fitted for different climates etc. do not explain all

their inhabitants peculiarly fitted to the conditions, while the bison lives on the prairie, the Camel & ostrich are adopted only for the desert. It might be supposed that influential Causes such as these taken in connection with climate would explain all the peculiarities of the distribution of life actually found, but this is very far from being the case.

Buffon on sim. climates dissim. Faunas.

Buffon so long ago as 1755 became aware of this fact, & wrote "the same temperature might have been expected, all other ~~circumstances~~ Circumstances being equal, to produce the same beings in different parts of the globe, both in the animal & vegetable kingdoms, yet it is an undoubted fact, that when america was discovered its indigenous quadrupeds were all dissimilar to those of the old world."

Different species in different regions

The phenomena in this case, though few in number were so striking that Buffon saw at once a natural Law, which was still further illustrated & extended to the fact that not only different species inhabited different areas, but that some widely separated regions were inhabited by Creatures altogether differing in type, by the discovery of Australia. Here the Marsupials, represented by the Kangaroo the Tasmanian wolf & other allied animals monopolize the territory. Of these but one genus — the Opossum inhabiting America — was previously known on the globe. The climate of Australia is wonderfully like that of parts of South Africa, but — in Africa we have instead of Marsupials lions, antelopes, Zebras & giraffes.

In Australia wide different types

Australia & Africa

Instances of strict limitation.

Whole groups of animals are again sometimes very strictly limited, thus the birds of paradise are found only in New Guinea, the Sloths in South America, the true Lemurs in Madagascar, while Crows occur in all parts of the world but South America.

Plants depend on climate closely

Plants are more particularly the exponents of Climate, depending so closely on a certain degree of heat & sunlight for the production of their flowers & ripening of their seeds, & it is in the decrease in numbers & size of plants that the approach to the cold polar region is most clearly marked. It may therefore be with surprise that we find each separate district of the globe occupied "in its vegetable as in the animal world by distinct groups of species, & that most of the exceptions to this general rule are traceable to dissimilating Causes now in operation". by human influence

Yet differ in similar regions

Lyell

Humboldt on distribution of plants

Humboldt was among the first to advance philosophical views on this subject. "We can conceive" he writes "that a small number of the families of plants, for instance the Musaceæ & the Palms, cannot belong to very cold regions, on account of their internal structure & the importance of certain organs, but we cannot explain" (by climate) × × "why the one-tree belongs to the southern hemisphere. Analogy of climates is often found in the two continents without identity of productions"

De Candolle

De Candolle, writing on the same subject in 1820 says — "It might not perhaps be difficult to find two points in the United States & Europe, or in

equinoctial America & Africa, which present all the same circumstances; as, for example, the same temperature, the same height above the sea, a similar soil, an equal dose of humidity, yet nearly all, perhaps all, the plants in these two similar localities would be distinct. A certain degree of analogy, indeed, of aspect, & even of structure might very possibly be discernable between the plants of the two localities in question; but the species would in general be different. Circumstances therefore different from those which now determine the stations, have had an influence on the habitations of plants."

Station v.s. habitation

In illustration of this statement De Candolle pointed out that of 2891 species of plants described at that time from the United States but 385 were common to temperate Europe. More recently a comparison between Australia & Europe shows that only 4/100 species known in the former country but 166 are found in the latter. Still more remarkable is the fact that an almost equal degree of difference may exist between regions actually joined by broad land connections. Thus there is an assemblage of species of plants in China common to the Black Sea & also another on the Mediterranean, while a similar fact is shown from the close analogy in the wide difference which exists between the plants of the Eastern & western coasts of North America.

European & american plants

European & Australian

Different flora as in connected land areas.

But this is not all. Not only do we discover that regions with like climates may & if at all remote

Forms may be antagonistic introduced & floras

from each other do, for different faunas & floras, but that foreign species introduced ~~introduced~~ by man in some new district ~~may~~ flourish & ~~[illegible]~~ like ~~those~~ native to the place. Thus it is that man ~~is~~ able to take with him to most parts of the world the plants & animals most necessary for his maintenance & comfort, & as limiting the regions able to sustain civilized man & the plants & animals which he has associated with him, the study of the distribution of climates assumes a far greater importance than it is found to possess in regard to the natural forms of life.

Some species thus carried beyond their natural habitat accommodate themselves so completely to the new circumstances that they become even aggressive & make room for themselves among the aborigines, appearing to be better adapted to the environment than ~~the~~ those. Josselyn, an early writer in New England gives a list of European plants which had sprung up in the Colony in his time twenty-two in number. Most of these were accidentally introduced. The common nettle ~~was~~ was the first noticed & the plantain is said to have been called by the Indians the 'Englishman's foot' as if it appeared to spring from their footsteps. In Linnaeus' time it was scarcely a Century since the ~~[illegible]~~ common Canadian Erigeron had been brought to the botanical garden of Paris, yet, he remarks

Climate as limiting distribution of man & his associates.

Introduced species wearing range

New England

22

appeared to spring from

Erigeron in Europe

Yet its seeds, dispersed by the winds had carried it not only over France but into Britain, Italy, Sicily, Holland & Germany.

Extinction of native plants in St Helena.

When St Helena was discovered in 1506, it was entirely covered with forests trees drooping over the precipices which overhang the sea. Now the greater part of the island is barren & most of the vegetation which still consists of introduced plants, European, American, African & Australian which have grown & multiplied so rapidly that the native flora could not compete with them. More than 100 peculiar species have utterly perished & are known only in some old collections made at an early date in the island. Goats, by cropping down the native trees assisted in bringing about the change in this case.

100 perished

Weeds in New Zealand & N. America.

In New Zealand also it has been noticed that the spread of some foreign plants is exceedingly rapid. The Cow-Grass the dock & the sow-thistle are notorious weeds, while the water-Cress has almost choked up some small rivers by its rank growth. In our own North American fields again many of the most aggressive & strongest weeds are of European origin.

Note some common weeds: Dandelion Shepherds purse Buttercup Common & Canada thistle

Similar facts for animal kingdom.

Similar facts are on record with regard to the Animal Kingdom. Thus in Australia introduced animals are supplanting the Kangaroos & other native forms. The common rat has been spread over the whole world by commerce & has made itself at home wherever man can live. Hogs, goats, Cats & dogs have become wild in different parts of the American Continent.

Human agency

The instances which we have just been considering depend on the agency of man, & apart from human interference the life of the globe, in its distribution may be considered to be in a state of Equilibrium or balance between the natural forces which act upon it, as must be changing very slowly in correspondence with alterations in Geographical outlines & consequent Climatic changes. Transferences of species which in the ordinary course of nature it might take many thousand years to accomplish, or which might never occur, may be brought about by man in a few days or weeks, & thus in attempting to account for the present distribution of plants & animals we must endeavour to eliminate as far as possible these very recent modifications.

Nature balanced or changing very slowly.

Eliminate recent changes.

Permanence of Similar fossil forms

A further proof of the great permanence, relatively speaking, of the Groups of plants & animals inhabiting the different great regions of the Earths surface is found in the fact that in alluvial deposits & Caves the remains of forms of Animals still characteristic, & different from those of adjacent regions are often found. In other cases these prehistoric animals belong to Extinct species, but yet resemble in the main features of their structure those still found in the same province.

The distribution of organic forms as a whole is in fact such as to suggest & not to demonstrate that they have spread in all directions from certain limited areas known as specific Centres, or Centres of

Leads to belief in specific centres.

Ex Australia fossils of recent date exhibit affinities to Kangaroos &c. In S. America extinct animals allied to Llama, & Peccari in Asia Simple Lyell p. 334

need natural barriers

Creation, tho they have met with some natural barriers either inorganic or organic, which have prevented their further extension. In endeavouring to explain the present facts of distribution the assumption of specific Centres is therefore made, & appears most reasonable, for without it the subject is divested of all significance & it becomes impossible to account for facts in distribution & more particularly for the instances in which native species appear to be less completely adapted for the surroundings than others which may be imparted. (Whether we believe in the origin of life by distinct Creations or the evolution of each form from some other, the doctrine of specific Centres is equally reasonable. In the first case it implies the least interference with the ordinary course of nature, while in the second it is scarcely conceivable that the ~~same~~ environment & character of the animals acted on should be so precisely identical in two distinct localities as to produce independently forms specifically the same. This also held by those who believe in an Evolutionary origin of organic forms that the similarity of the extinct & recent faunas, which not actually proving their hypothesis, are to be accounted for only by supposing that the present is related by descent to the past.)

Specific Centres assumed

§

In Endeavouring to examine the subject more systematically it seems necessary in the first instance to divide the world into regions.

A very little consideration will show us that in endeavouring to divide & define the various great provinces of the Earths surface by their characteristic forms of life it is altogether

Natural Classification necessary for argument

Complete Knowledge

Instance of difficulty from imperfect knowledge.

Different classes different values.

Some scattered districts.

natural & satisfactory Classification of organic forms, & a moderately complete knowledge of all the species inhabiting the Earth are among the most essential requisites. It may be that we have three animals a, b, & c which have a general resemblance to each other, & that while a & b inhabit contiguous districts c is found in some distant region separated by wide ocean barriers. We would then have a most difficult problem for it would be necessary if possible to show according to the generally rules by which we account for distribution ~~that~~ in what manner c has reached the place where it occurs. Should some naturalist, however, on closely examining c discover that its resemblance to a & b is merely superficial, we ~~[illegible]~~ no longer have anything to explain.

A complete view of the geographical distribution of plants & animals could be gained (in fact) only by an equally complete knowledge of all organic forms, which we are very far from possessing, & various different Classes of organic forms would (have) a very unequal value in (aiding us) to endeavors to account for the causes by which the present distribution ~~of them~~ has been brought about. We ignore a group which shall depend chiefly for its dispersal on the distribution of land & water, mountains, deserts, & plateaux or other features which it is our purpose to discuss the successive modifications. Forms which are liable to accidental dissemination may have a scattered distribution the (causes) which we may not be able

to trace out & which is in a great degree independent
of natural barriers. As they but known, & in
fulfilling all these conditions most perfectly the Mammalia
are pre-eminent, & merit the first consideration
in the study of geological distribution. A subdivision
of the Earth's surface based on a study of the
Mammalia should if natural however be found to be
sustained where as far as Completely & the subsequent
examination of other groups whether of the lower
animals or of plants. Many attempts at such a
natural division have been made but that which
appears to agree most closely with all the facts,
& I do recommend chiefly most completely to
naturalists, is that elaborated by Messrs Sclater
& Wallace. Under this scheme a division is
made into six great provinces or regions, known
respectively as Palæarctic, Ethiopian, Oriental,
Australian, Neotropical & Nearctic.

It is admitted that these regions are of no means
precisely equal in importance, some being much
better characterized & more isolated than others. There
can be little doubt, for example, that by separating
the Australian region from the rest of the world
the most radical division is made. This has been
done by Prof. Huxley. The isolation & in the peculiarity
of the animals which inhabit them, taken in conjunction
with those forms which are wanting, either Australia
or the Nearctic Neotropical region (South America) are is compared
with the rest of the Earth. But in number & variety of
forms they are both very much inferior. The six regions

Mammalia most useful.

Sustained by other forms.

Division adopted

Tecuslate

Not equal in importance

Shetland ?

Australian & Neotropical.

importance

above named appear to be more nearly equal in rank than any others which can be formed, while they possess an approximate geographical equality & some compactness of area which renders them convenient ones in the study of geographical distribution.

Palæarctic. bears, badgers, otters, lynxes, buffaloes, deer, wild goats, wild sheep, hares, rabbits, moles, hedgehogs, dormice in all about 1/3 peculiar.

Ethiopian. Gorilla, chimpanzee, baboon, lemurs, lion, leopard, civet, hyæna, zebra, rhinoceros, hippopotamus, giraffe, antelope & elephant.

Oriental. orang-utan, long-armed monkeys, flying lemur, tiger, jackal, wild cattle, elephant & rhinoceros. 1/2 genera peculiar.

Neotropical. no native sheep or oxen, but peculiar monkeys, marmots, chinchillas, sloths, armadillos, ant-eaters, racoons, opossums, deer llamas, alpacas, tapirs, & peccaries.

Nearctic. Fauna & N. continental resembles old world, but to S. Puma, lynx, prong-horned antilope, prairie-dog, flying-squirrel pouched-rat, & opossum. about 1/3 peculiar.

in this province [illegible]

Ethiopian

The Ethiopian region includes the whole of Africa, with the exception of the northern portion which is attached to the East region, together with the southern half of Arabia

importance

above named appear to be more nearly equal in ~~work~~ than any others which can be formed, while they possess an approximate geographical equality & some compactness of area which renders them convenient ~~of~~ use in the study of geographical distribution.

Palæarctic

In the Palæarctic division of this classification is embraced the whole of temperate Europe & Asia from Iceland to Behrings Straits, & from the Azores to Japan. To the south it includes that part of Africa which is north of the Sahara & the northern part of Arabia, with Persia, Cabul & Beloochistan. Both the plants & animals of this province are much influenced in their distribution by climate. The arctic portion has a meagre vegetation, ~~and~~ with such genus as Saxifrages, gentians, mosses & lichens. South of the bare Siberian tundras is a broad zone characterized by coniferous trees, pines & spruces, while still further southward is the region of the ordinary deciduous forest with its beech, ash, oak, elm, sycamore walnut, chestnut, &c. In the extreme south are evergreen trees, such as oaks, myrtles & laurels. In correspondance with the climate & distribution of vegetable forms is that of animals, among the most characteristic of which are species of bears, badger, otters, horses, buffaloes, deer, wild goats, wild sheep, hares, rabbits, voles, hedgehogs & dormice. In all about one third of the mammals & birds found in this province are peculiar to it

influence of climate.

Plants &c

Animals.

Ethiopian

The Ethiopian region includes the whole of Africa, with the exception of the northern portion which is attached to the last region, together with the southern half of Arabia

Plants

The western part of Africa south of the Sahara desert is densely wooded with luxuriant fruit & a hot & humid climate. Here the oil-palm, the baobab, Euphorbias, bijonias & tamarinds abound. South & the East lie great elevated plateaus only partially wooded, while in South Africa plateaus of moderate elevation form wide open pasture lands with heaths, fig-marigolds, Stapelias, aloes & pelargoniums. Whether in regard to its plants or animals the Ethiopian is one of the best defined of the great regions. Among the more characteristic Mammals the gorilla, chimpanzee, baboon, Amaus, lion leopard, civet, hyæna, Zebra, rhinoceros, hippopotamus, giraffe, antilope & elephant; while deer, bears, sheep, goats, wild boars, & other wide spread families are altogether absent.

Mammals

Oriental.

The Oriental Region though comparatively small is rich & varied in its forms of life. It embraces India & the Southern part of China, with the Malayan Peninsula & Islands as far East as Java & Borneo. Over the greater part of India & China are considerable areas of open pasture lands, & in some cases an arid climate, but in Ceylon there is a great degree of moisture, & the Southern slopes of the Himalayas with the Malayan region is covered by dense & luxuriant forests. Among the better known plants occur the ginger, arrow-root, screw-pine, yam, bamboo, rice, mango, Ebony-tree & Sandalwood. The fauna includes the orang-utan, long-armed monkeys, flying lemur, tiger, jackal, wild Cattle, elephant & rhinoceros, besides many peculiar & gaily coloured

birds & insects. About one half of the genera of vertebrates occurring in this region are peculiar to it.

Australian. The Australian Region, including with Australia New Zealand & numerous surrounding islands, is the great insular region of the earth. Australia is the largest continental land & presents by far the greatest variety of peculiar types. It is as a whole characterized by an arid climate, & limited area of forest, while the climate of some of the surrounding islands is humid, giving rise to luxuriant forests. The vegetation of Australia is very peculiar in aspect, including in the drier regions the Eucalyptus, Acacias &c, toward the south cycads & pines in addition. In New Zealand ferns & pines are abundant, while in the northern islands of the region the Pandanus, Cabbage-palm, Nutmeg & Sandal-wood abound. The ~~mammals~~ fauna is equally remarkable ~~whether considered from the point of view~~ for the number of peculiar forms which are existing as for the strange marsupial types, represented by the Kangaroo & allied animals, which abound.

Neotropical The Neotropical Region is unsurpassed for the luxuriance & extent of its forests, with the small portion of its surface occupied by deserts. It is essentially a tropical region but has a ~~large~~ great prolongation into temperate latitudes. It includes not only the whole of South America, but the West Indian Islands & the greater part of Central America & Mexico. It is characterized by variety & richness of life, together with its uniformity over almost all parts of the region. It abounds in mangroves, palms

tree ferns, Cactuses, orchids, & passion-flowers, Cinchonas, mahogany, the India rubber tree, & many other plants yielding gums & spices. The fauna includes no native sheep or oxen, but ~~[illegible]~~ peculiar monkeys, marmosets, Chinchillas, sloths armadillos, ant eaters, racoons, opossums, deer, Llamas, alpacas, tapirs & peccaries.

Nearctic.

The Nearctic region includes all North America except the excepting of the portion of Mexico already referred to. It possesses very variety of climate from tropical to arctic & a surface diversified by great, prairie & mountain ranges. Its flora & fauna are not quite so varied as those of the Palæarctic region, which may depend on the fact that the greatest width of the continent is in the far north where the conditions are least favourable to life. Its northern portions form to some extent a transition region to the Palæarctic, & the ~~[illegible]~~ influence of climate while giving rise to ~~[illegible]~~ zones of plants & animals similar to those of the Palæarctic, is here even more pronounced by reason of the absence of transverse mountain barriers.

Climatic conditions

Flora of N. like Palæarctic.

The western flora is not dissimilar as to that of the old World, while in the south the sugar-cane, yucca, Cotton, maize & tobacco are characteristic plants, with peculiar species of Coniferous trees on the west coast. The fauna like the flora shows considerable resemblance with that of the old world, but in the south includes such forms as the puma, lynx, prong-horned antelope, prairie-dog, flying squirrel, pouched rat & opossum. Nearly one-third of the vertebrate forms are peculiar.

Such are the six great provinces into which the world has been divided. We cannot, however, do more than glance at these, without entering into the subdivisions which have been proposed. Nevertheless is it possible to take time to review the evidence on which the division has been made, the collection & discussion of which involves enormous labour. Taking this for granted we are now in a position to ask for the reasons of the present distribution of life, & why it should present itself to us as it does!?

Such facts of distrib

What causes?

Causes classified

On consideration it will be found that these causes may be grouped under the three following heads.— 1. Climate. 2. Migration & transport. 3. Changes of land & sea & accompanying changes of Climate. These are the causes to be examined in answering the above enquiry. We must now review the means of dispersal & migration possessed by plants & animals but more particularly those of animals, for upon the animal kingdom we have proposed chiefly to base our division into provinces. To what extent will these powers of dispersal & migration explain the present state of affairs & how far must we fall back on the agency of past geological phases & bygone climates to account for it?

already examd. climate.

How much will means of dispersal explain?

The natural tendency of both plants & animals is to spread outwards in all directions on all sides but their further progress is opposed by some insurmountable barrier, & they must be considered as continually endeavouring to press outwards in every direction. This is at once evident when we

Natural tendency to dispersal

Rapid natural increase

consider how rapidly they are capable of multiplying, so that if but a single pair of animals, for example were placed in a continent suitable for their habitation as to climate & supply of food, & without enemies they might in a very short time fully stock it. Thus if a bird produce ten pairs of young during its lifetime, & if the life of each bird be taken at five years, there will be about a hundred million of birds in forty years; a number sufficient to people a vast tract. But fishes & insects, & the lower forms of life generally increase at a very much greater rate than this, often several thousand fold in a single year. Animals however, seldom see an unoccupied country in which to breed, & in search of food must roam far & wide as that of the immediate district is exhausted. Mountain ranges, rivers, even arms of the sea must be crossed if the animals can accomplish it, but the means which they possess of doing so are very varied in character & amount.

10 to 100 millions.

but territory not unoccupied.

2. Difficulties in study of plant distrib.

The difficulties in the way of the study of plants as to their distribution, & in regard to possible former geographical changes, is very great, owing to the exceptional means of dispersal which many of them possess & to the absence among them of any group answering in its dependence on the extent of land to the Mammalia among animals. A large class of plants including the mosses, lichens, fungi & ferns are reproduced by spores instead of true seeds, & these are so

Easy carriage of Spores.

minute that they may be carried to immense distances by the winds with as much ease as the finest dust. Some families of plants are in consequence almost universally diffused, so that of little use in studying distribution
200 species of lichen brought by Sir J. Ross from the Antarctic region almost every one was ascertained to be an inhabitant also of the Northern Hemisphere & most of them European.

Antarctic Lichens

Lyell p. 381

Many seeds, again, are furnished with downy or feathery floats or with wings enabling them to be wafted for great distances by steady winds, while others float upon rivers, or are fitted to sustain without injury prolonged immersion in sea water. Beans Cantharides upon the Orkney Islands & Ireland, tony ten have drifted by the Gulf Stream from the West Indian Islands ten germinated, & eight doubtless have naturalized themselves in Britain had the climate favoured. The seeds of the pea & bean family seem specially adapted for ocean carriage as Dr Hooker has shown & an examination of insular floras.

Seeds multiplied means of carriage.

Lyell p. 394.

As animals are capable of voluntary as well as involuntary movements they are often able to extend their range further than plants which have no special means of dissemination. Many of the larger mammals are able to roam over whole continents crossing mountain ranges & other physical obstacles, & are stayed only where the climate becomes unsuitable, or food deficient in quantity or quality. Such is the case with the Elephant,

How far animals. ? means of dissem.

Wide range of large Mammals.

Cases of strict limitation.

tiger, rhinoceros, lion, & many ruminants; while others such as monkeys, squirrels, & opossums are so strictly adapted to arboreal life that it is scarcely possible for them to leave the forest districts. Goats & sheep may be confined to certain high mountain ranges & unable to cross intervening heated lowlands, while such mammals as the otter & ferret cannot leave the rivers & lakes to cross deserts or high ranges of mountains. To most mammals climate becomes a barrier more by depriving them of their proper food than by its direct influence. The tiger is generally considered as a tropical animal but it may be found northward on the banks of the Amoor where the winter climate is almost arctic. Many mammals can cross wide rivers, but few are able to pass by swimming over any considerable extent of sea. Pigs & deer are known to swim well & some facts in their distribution would seem to show that they have often diminished themselves in this way. We have no reason to believe, however, that any mammals could cross a strait 20 miles in width, while in most cases a channel of half this width would prove an effectual barrier.

Climate acting through food as a barrier.

Powers of swimming in water.

Instance of deer & Mr Short

by deer across 20 m on 2.C.

Ice-floes may in some cases carry animals with them to new lands. Polar bears, for instance, have been known to land on Iceland from drift-ice. Rafts of drift-wood are often floated down great rivers to the sea & wafted for long distances, & on these mammals

Ice floes.

Rafts of wood

even y considerable dige may be carried to
new coasts. On the Amazon monkeys, tyger-cats,
& squirrels are often seen on such natural
rafts floating seaward.

Instances rare

In such cases as these the instances would be very
rare in which living animals were carried far &
landed where they were able to naturalize themselves.
Nature, however, can afford to wait, even if but one
such colonization should occur in a thousand years.

Nature can wait.

It is important merely to know that we have in such
facts as this a possible solution of some difficulties
in distribution.

Bats & oceanic Mammals exceptional

Two groups of mammals have quite exceptional
means of dispersal, the bats — species of which
are known to traverse the span from the American
coast to the Bermudas, a distance of 600 miles —
& the oceanic mammals, such as the whales &
porpoises. Temperature however, puts an efficient
barrier to the latter, the northern & southern forms
being unable to cross the warm seas of the equator,
while the polar waters are equally fatal to the
tropical forms.

Birds.

Birds at first sight be supposed from
their exceptionally perfect means of locomotion would be
universally distributed, & little fitted to throw light
on the laws or causes of geographical distribution.

Exceptional

It is actually found, however, that many groups of
birds are almost as strictly limited in range as
mammals. The petrels, gulls, sandpipers & plovers
are among the most widely distributed groups, but

Wide spread groups

Dispersal of animals &c

most species of these even differ in the different great oceanic areas. One striking contrast is that are the smaller perching birds, a species of parrots & pigeons some of which are confined to islands of but a few square miles extent. Wide oceans are as a rule almost impassable barriers to birds, but even the weaker species some are occasionally carried by storms to great distances. Thus Strayglers from America in this way yearly reach the Bermudas, while many cases are known of the occurrence of the smaller american migratory birds even in Europe. For birds which frequent thickets & forests & feed near the ground, straits of comparatively moderate width serve as barriers as their habits do not render them liable to such accidental dispersal by winds.

Other migration?

Reptiles & amphibia

Reptiles & amphibia of as exist the marine forms - the turtles & sea-snakes, are almost equally restricted by natural barriers, with the Mammalia. Snakes & lizards seldom extend into countries with cold climates. Snakes seem incapable of crossing sea of any width as they are not found on such oceanic islands as have often been reached by mammals. Lizards on the contrary appear to have some unknown mode of crossing stretches of sea, probably in the egg state — as they have colonised islands which have often been reached by the families last mentioned. Frogs & toads seem incapable of crossing even narrow straits, salt water being fatal to them.

Lizards on oceanic islands

Fishes

Fishes of the same species are often found inhabiting distant river systems, a circumstance which may be explained in various ways. There are numerous authentic

accounts of fish falling from the atmosphere, having been carried up with the water of spouts & whirlwinds. The eggs of fishes again may adhere to the feet or plumage of aquatic birds & thus be transported for long distances. Most of the ordinary sea fish again inhabit the comparatively shallow waters in the vicinity of coasts, & the great oceans are almost as complete a barrier to their migrations as to those of birds. The temperature of the waters forms also in many cases an efficient barrier.

Shell-fish.

Among the Mollusca or shell-fish very varied powers of dispersion exist. Some species float upon the sea & are limited only by conditions of temperature & food. Others though sluggish when mature are free swimmers in an embryonic state & may be carried to great distances by currents. Fresh water shells are doubtless carried from one river system to another in modes similar to those by which fresh water fishes are spread abroad. Land shells have received considerable attention because of the fact that are frequently found on isolated islands & that their presence or character has been used as an argument in favour of Geographical & Evolutionary Change. Their powers of dispersal appear to be very limited, but they can form a membranous diaphragm over the mouth of the shell which enables them to resist both drought & prolonged immersion in salt water. Shells immersed experimentally for a fortnight in the sea have recovered. This may enable land shells to be carried far in masses of drift wood discharged from rivers.

Fresh water shells.

Land shells

Insects

Insects are so wonderfully adapted to certain combinations of conditions in most cases, that their requirements as

Need of Specialized

to food & Surroundings generally limit their range pretty closely. Their means of dispersal are great probably greater than those of many other highly organized animals. Not only can they fly unassisted for great distances, but storms may carry them over vast expanses of sea. Hawks have been taken on board ship 250 miles from the nearest land. Darwin caught a locust 370 miles from land, & in 1874 great swarms of locusts flew over Madeira after having crossed 300 miles of ocean.

Extremes of flight

Such is a brief sketch of the ways in which different classes of animals possess of traversing the natural barriers which surround them & tend to limit their migrations

Such the Natural barriers & powers of animals to cross.

~~Such are the natural barriers which surround & limit the migrations of species animals~~. But let us suppose that owing to favourable circumstances several animals of a certain species have crossed into some new territory. They must find there, if they are to live, not only suitable climate but suitable & sufficient food & immunity from too powerful enemies. Again the existence of numerous species native to the locality & competing for the same kinds of food & situation required by the new-comers, would render it difficult for them to hold their own. Seldom indeed would all these circumstances favour the immigrants.

Difficulty of establishing themselves.

Thus it is that the vast majority of plants & animals are penned in by barriers seen as unseen, & that notwithstanding the wide range of some peculiarly locomotive forms the surface of the earth is marked off clearly enough into great biological regions each of which has had a long & often very complex history in which fauna has succeeded fauna, each having its day & passing away. Making every allowance for migration & dispersion as witnessed at the present

Thus effectual Barriers.

Residual phenomena explain by geog.

day a great residuum of fact remains, to explain which geographical changes must be studied, & by the examination of which, the plants & animals of a country may be made to give as a part of the history of the land on which they live.

Instances. in which peculiarities of distrib. unaccounted for by above are explicable by taking phys. changes into accot.

Arguing from facts known in the Geological history of Great Britain, we have every reason to believe that it has been repeatedly joined to the Continent of Europe. Evidence of this is found in the similarity of the animals of the Eocene, Miocene & Pliocene of the British area with those of the same periods of the Tertiary on the Continent, while at a still later period the plants & animals now characteristic must have crossed over to it by a land connection.

Land connection of Britain & Europe.

Rept to diagram.

The plains of Central Europe are covered with a collection of plants known as the Germanic flora which also spreads over Britain, but for which no adequate means of transport from the Continent to the British Islands exists at the present day. The land connection by which these find their way to Britain must have existed after the time of cold known as the Glacial Period, & was probably the same which enabled many animals to extend their range in this direction. The Irish Elk & the Mammoth, with other species still living & probably even formerly found the British Islands a part of Europe, at this time. An interesting confirmation of the existence of this land connection & the direction of migration is found in the distribution of the reptiles & amphibia. Of these

Plants of Europe & Britain the same.

Migrations of Elk. Mammoth & Man

Reptiles & amphibia

there are in Belgium 22 species, in England 11 & in Ireland 5 only. From this fact Edward Forbes drew the inference that these animals migrated from East to West & that the land connections between England & the Continent & England & Ireland were broken up before all the species had reached the more remote districts.

Traces of another flora.

There are, however, traces of another flora in Britain. On leaving the plains & lowlands & ascending some of the higher mountains we find that the vegetation not only becomes less luxuriant, but changes its character. New plants not previously seen appear. In the mountains of Wales, Cumberland & Scotland these mountain or alpine plants occur, though absent over all the intervening country. Similar plants are again found between the upper limit of trees & the snow line on the Pyrenees & the alps. Such facts might lead us to suppose that these plants were merely the characteristic of high mountains & always found in such situations, but further Southward, even where mountains rise to a great height, like the Peak of Teneriffe they are not found. [illegible] these plants characterising the Central & Northern Europe as we [illegible] into Scandinavia & Lapland [illegible] the level of the sea, constituting [illegible] country, & not in the mountains [illegible] south we have outlying patches of [illegible] a. ×

Pyrenees & alps

Teneriffe

[illegible] can the presence of hundreds of [illegible] species of plants in these mountain regions

× In the White Mountains of the New England States similar facts occur. Their higher summits are clothed with vegetation identical with that of Labrador & Greenland which is not found throughout the wide-spreading intervening low country.

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Mountain plants

Pyrenees & alps

Teneriffe

In Norway then can the presence of hundreds of arctic species of plants in these mountain regions

How accounted for?

be accounted for? If there were but a few species it would be conceivable that in some chance manner in the course of time they had been transported to the summits which they characterize, but taking into consideration the number of species & unusuality of the phenomenon, it seems that to account fully for it we must

By former arctic Conditions,

suppose an arctic Climate to have overspread a great part of the northern hemisphere. As the climate grew colder the ordinary plants would die out or continue to exist only further & further to the south, while their arctic habit would enable the plants & clothe the whole face of the country. At a later date when the cold period was passing away these plants would continue to spread up to the snow line in the various mountain regions, while the ordinary southern vegetation would return to the plains.

Confirmation of Mrs Henry.

The existence of these colonies of arctic plants may seem a precarious & slight an edifice to build so great a hypothesis, but their evidence is confirmed in other ways. Thus in the lake gravels & in cave deposits are found remains of the musk-ox, the lemming, the arctic fox & the reindeer, animals of the extreme north, & unsuited to the present temperate climate. We find evidence of the traces of the

Confirmed by animals

spread passage of great glaciers from the mountains & evidence of the passage of glaciers & icebergs in the transport, polishing & scoring of the masses of rock. This in fact is the Glacial period of geologists & to this period must be assigned the distribution of the Arctic flora.

Traces of Glaciation

Zool. line in Malay Archipelago.

One of the most remarkable instances of geographical distribution in change without any cause obvious at first sight is found in the line separating the Oriental & Australian provinces in the islands of the Malay Archipelago. The straits of Lombock through which the dividing line passes are less wide than the straits of Dover, yet the contrast between the animals on opposite sides is greater than between those of the Old & New worlds, & equals that which is usually found in countries separated by a wide ocean. In speaking of the Contrast Mr Wallace writes. — "In Australia there are no apes or monkeys, no Cats or tigers, no wolves bears or hyaenas; no deer or sheep or oxen, no Elephant horse, squirrel or rabbit, none in fact of those familiar types of quadrupeds which are met with in the Indian Area. Instead of these Australia has its marsupials, kangaroos, opossums & wombats!" This diversity does not correspond with any of the physical or Climatal divisions of the surface. The islands on the two sides of the line are similar in soil, elevation & fertility & equally covered with forest. We can here without doubt the record of some remarkable Geographical Change, though of precisely what nature it may be difficult to determine. A Clue is found, however, in the fact that while the Philipines, Borneo, Java, Sumatra, & all the islands lying to the North West of the line would be united into a common mass & joined with Asia by an Elevation of 100 fathoms, they are separated from those to the South East by deeper waters. It may

Strait Lombock not so wide as Str. of Dover.

Wallace on the contrast

not in accordance with climate & phys. conditions

Islands N. & W. joined by elevation of 100 fath.

Old migration

Land connection broken

Shallow seas like
land; deep, different.

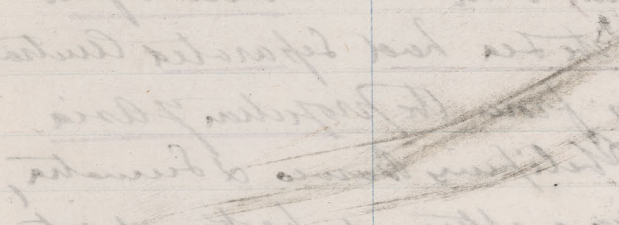
Madagascar
50

Old African &
Madagascar fauna

Middle Tertiary
Migration.

Thus we suppose that at an early period a very considerable
elevation joined Australia with Asia & enabled the
present old fashioned & peculiar fauna to people the
Australian region, when however, at a later period
the more highly organized Oriental fauna began to
extend in this direction, either a subsidence of the
land or the action of the sea had separated Australia
& adjacent islands from the projection of Asia
which included the Philippines Borneo & Sumatra,
& that this projection was afterwards broken up into
the ~~archipelago~~ group of islands & separated by
comparatively shallow water, which now exists.

It is indeed found to be a rule of very general applicability
that those regions which are separated by shallow
seas resemble each other pretty closely in their
plants & animals, while those divided by deep seas
show wide differences. Madagascar, for instance
is separated from Africa by profound waters &
while showing some traces of similarity to Africa in
its animals yet differs radically from it.
Madagascar it appears preserves the remnants of
a group of animals which inhabited Africa &
Madagascar as a united land at a very remote
period, in the earliest Tertiary times, when
Africa was ~~united~~ separated from Europe &
Asia, or the lands then more or less closely corresponding
to these continents by wide seas. In Middle
Tertiary times a land connection being formed
with the northern continents a new assemblage
of animals poured into Africa & Europe &



more highly organized species which speedily exterpated most of the original forms & became the ancestors of the present African fauna. Before this time however Subsidence & encroachment of the sea had separated Madagascar & preserved there, from the destructive competition with the new forms, a portion of the old

Madagascar then separated.

In thoroughly oceanic islands like the Azores & Madeiras which appear never to have been attached to the Continents, but to have been built up from the depths of the sea by the accumulation of volcanic matter, the animals are few in number & limited to such forms as are known to have means of wide dispersal. Mammals are usually absent, unless introduced by man, while insects, birds, & often species of land shells constitute the native fauna.

Fauna of oceanic islands.

There but a few instances of mode in which distrib. of life & geol. & geog. changes explain & throw light one on the other. By applying reasoning of this kind arrive at general idea

In summarizing the past changes & general relations of the terrestrial regions Wallace comes to the conclusion that not only the geological & physical evidence but that afforded by the remains of extinct animals & those still living, points to the great land mass of the Northern Hemisphere as being a immense antiquity, probably the area in which (whether by development or otherwise) the various higher forms of life originated. In the Southern Hemisphere there appears to have been three very ancient land masses, varying in extent at different periods but always distinct & represented more or less completely by Australia S. Africa & S. America of today. In the Palæarctic Province & in North America we find in

Summarizing conclusions

Northern land mass

as being

3. Southern land masses

Tertiary representatives

older

Tertiary rocks strong remains of forms more or less closely allied to those existing over the same northern bottom areas, but by going further back representatives of the Apes of West Africa, the Lemurs of Madagascar, the Edentata of Africa & South America & the Marsupials of America & Australia. It would thus appear that from the great Northern land masses successive waves of life flowed Southward as the Southern lands became temporarily united with them Australia appears to have had but one such union in very early times, while the South African & South American lands must have had several such unions & separations, allowing at each union the immigration of higher forms of life. Some remarkable cases of similarity in animal forms between the Australian, African & South American regions are thereby well probably accounted for not by the supposition of lands bridging the wide Southern Oceans, but as relics of faunas which once spread widely over the Northern lands but have now been displaced by newer forms & continue to linger only in the Southern Continents.

An older rocks of S. American & Australian types.

Southern waves of migration.

Thus

Not therefore to assume land connections to account for similarity between extremities.

The great truth of which the theory of distribution brings us.

The assemblage of animals & plants now peopling each of the great provinces within which is not as a fact isolated in Space or time, but as the result of successive Changes reaching back over great periods of time & complicated with all the processes of the physical features of the earth which it is the province of Geology to explore. The present arrangement of land & sea with their living inhabitants is but one phase of a vast series of coordinations

History of the present arrangement of things.

Subject very complicated

Can study special cases only.

during the lapse which fauna after fauna has perished & been succeeded by new forms of life. The subject in its entirety is one of the most complicated within the range of human investigation & we can never hope to do more than arrive at some of the general laws by means of the study of certain special cases not too difficult for solution.

In the present brief account of the distribution of life on the globe, reference to arguments based on the assumption of the gradual change of organic forms in the manner of the evolution of one from another, has been avoided as much as possible. It has been rendered very probable however on other grounds that change of this sort to a very considerable degree, at least, has occurred; & while it may be said that the certain recognition of this fact introduces a new element of complexity, it brings with it points of interest additional in extent in the tracing out of the origin of the fauna & flora of each region. It is very generally held that the fact that the living forms of each country have been represented in the same locality by region by a series of extinct species resembling them in types, but differing specifically, while actually proving the origin of species by evolution, goes very far toward showing that the present forms are descended from the past. When instead of similarity between consecutive faunas or floras, we find the sudden introduction of new types, it may be supposed that they have arrived by migration from some other region; & taking into account the changes in sea & land which we know to be in progress at the present day & to have happened previously, it is easy to understand how the formation of new land connections might cause this to occur.

One of the best marked cases of the change in organic forms to be drawn from geographical distribution is found in the Oceanic Islands of the Atlantic, especially those of the Azores, Madeira, & the

& one which is looked upon as a strong argument in favour of that change

Canaries. These islands appear never to have formed part of any continent, according to Sir C. Lyell but are volcanic accumulations rising from seas of considerable depth, & seem to have obtained their animal inhabitants in various ways from the continental land masses. That no land mammifer has occurred is indicated not only by the depth of the surrounding seas, but by the fact of the absence of all mammals except the tailless chiropteran bat, which owes its presence to its powers of flight.

The birds & insects found on these islands present the following suggestive facts. — almost all the birds are absolutely the same with those of the nearest mainland. In the Canaries & Madeiras all the species but three are European, & of 99 Madeiran birds but one is peculiar to the islands & this is closely allied to a European form. In the Azores there are only two peculiar species out of 51. The Bermudas again, only 70 miles from the American coast, are stocked altogether with American forms. The continual arrival of stragglers during storms serves to show how these birds originally came & how the continued addition of new comers may tend to support & more promoted the divergence of the inhabitants of the islands from the usual Continental forms. There is nevertheless some evidence of varietal change even in the birds.

~~In fact the time its power a much greater amount of change has occurred, & comparatively few are common to the different islands of the same group~~

The case is otherwise with the insects, & the difference which they present appears to be in direct relation with

their superior facilities as compared with birds for crossing the sea, the rarity of immigrants allowing the uninterrupted action of the causes tending to produce variation. The Azores are the most remote from continental land, but show — probably owing to the direction of the winds & temperature character of the climate — a closer resemblance to the European fauna than the other islands. Taking the case of the Beetles of 212 species, 175 are European. Of the non-European species 19 are found also in other groups of islands, 14 are peculiar & 3 American. Of the European species by far the greater proportion are found also in the other Atlantic islands. This is worthy of special remark, as it shows how certain forms reach almost all these isolated spots while whole families remain inhabiting the continent of Europe are altogether wanting.

In the Madeira group, which has been most carefully studied we find the same. Of beetles inhabiting Madeira 236 genera are known, & no less than 44 of these genera are peculiar to the Atlantic Islands, though closely allied to European genera which they may be modifications. On examining the assemblage of beetles found in these islands two chief peculiarities are noticed. — The absence of whole families & genera of beetles common in South Europe, & the unusual prevalence of wingless insects. Many of the groups peculiar to the islands are altogether wingless, while representatives of genera winged in Europe are here often without wings, & even have species been wingless without any other perceptible change. But another circum-

^ a point alone we have time to glance in this connection & which

fact remains to be stated viz - that many of the species possessing wings have them larger than their European allies. Mr Darwin accounts this fact & accounts for them by supposing that in most cases the sluggish individuals of each species would have a better chance of living & increasing than those which exposed themselves during frequent flights to the liability to be blown away from the islands & lost. Thus processes of natural selection & abortion from disuse may be supposed to go on together in the same genus in the latter case leading to the entire loss of wings in those species to which flight is not necessary. But those species which must fly to obtain their food would be acted on in a different way, those only with the strongest & most powerful wings being preserved.

Though this characterises the wingless beetles, it is a very additional fact significant fact, that those additional South European genera which are entirely absent from Madeira are precisely those which in Europe are wingless. It would thus appear that only the winged forms formed the means of reaching the islands, but that having domiciled themselves there the conditions tended to render their descendants wingless. The principles thus outlined admit of application in still greater detail to individual species, & the hypothesis of the accidental peopling of the islands from the Continent & the subsequent modification of the immigrants appears to be the only satisfactory one to explain the facts met with in this case.

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