hill is quite conformable to what we see in other cases, iu which a heavier under-stratum has a definite set towards a slope; and whilst the existence of such a westerly set is, *ex hypothesi*, a necessary consequence of the southerly movement of the Arctic underflow, no other explanation of it has been suggested. We now see that the cold Labrador Current overlies a band of water as cold as itself; and the southward extension of this cold band, far beyond that of any definite current-movement, and its entrance into the Gulf of Mexico, through the Florida Channel, at the side of and beneath the outflowing Gulf Stream, are thus accounted for.

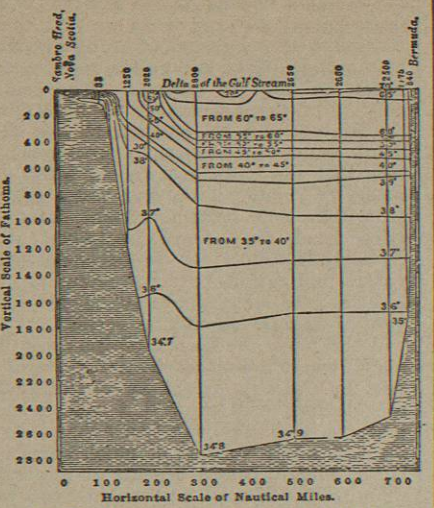

Fig. 6.—Section from Bermuda to Halifax.

The remarkable accordance of so many facts or actual observation, in the Atlantic area, with the probabilities deducible from a theory whose soundness can scarcely be disputed, seems now to justify the admission of the general (vertical) oceanic circulation sustained by opposition of temperature as an accepted doctrine of terrestrial physics.

Distribution of Organic Life.—All that will be attempted under this head will be to indicate the general conditions that seem, from recent researches, to have the greatest influence on the distribution of plants and animals through this great oceanic basin.

The distribution of marine plants seems mainly determined by light, temperature, and depth,—a further influence being exerted by the character of the shores. The diminution of light in its passage through sea-water is so rapid, that the quantity which penetrates to a depth of 250 or 300 fathoms may be regarded as almost infinitesimal; and in conformity with this we find a very rapid diminution of Algal life below the depth of 100 fathoms. The upper stratum is occupied for the most part by the larger and coarser forms of the *Fucaceæ*, or olive-green sea-weeds, whilst the more delicate *Ceramiaceæ*, or red sea-weeds, frequent deeper waters; and, as it appears from experiments made in aquaria that the latter do not flourish in full light, but grow well in shadow, it may be concluded that their preference for a moderate depth is rather for reduced light and stillness than for depth *per se*. At a depth of 150 fathoms very few ordinary sea-weeds maintain their ground; and below this we seldom find any Algæ, save the Corallines and Nullipores consolidated by calcareous deposit. The distribution of particular types over different parts of the Atlantic area appears to be mainly regulated by temperature; and this would seem to be remarkably the case with the floating *Diatomaceæ*, which, though they form green bands in the surface-water of polar seas, have not been encountered in like abundance in the Atlantic, and do not contribute largely, by the subsidence of their siliceous *loricæ*, to the composition of its bottom-deposit. Although it is the habit of the larger Algæ to grow from a base of attachment (their roots serving no other purpose however, than that of anchorage), the enormous mass of Gulf-weed found in the Sargasso Sea seems quite independent of any such attachment. It was at one time supposed that this originally grew on the Bahama and Florida shores, and was torn thence by the powerful current of the Gulf Stream; but it seems certain that if such was its original source, the "Gulf-weed" now lives and propagates whilst freely floating on the ocean-surface, having become adapted by various modifications to its present mode of existence.

The distribution of the animals that habitually live in that upper stratum of the ocean whose degree of warmth varies with the latitude, seems mainly determined by temperature. Thus the "right whale" of Arctic seas, and its representative in the Antarctic, seems never to enter the inter-tropical area, generally keeping away from even the temperate seas, whilst, on the other hand, the sperm-whale ranges through the parts of the ocean where the "right whales" are never seen.

The distribution of fishes seems generally to follow the same rule; as does also that of floating mollusks. Thus the little *Clio* (a Pteropod mollusk), which is a principal article of the food of the "right whales" in polar seas, is rarely met with in the Atlantic, where, however, other pteropods, as *Hyalæa*, present themselves in abundance. On the other hand, the warmer parts of its area swarm with Salpa-chains, which are not frequent in higher latitudes; and the few representatives of the Nautiloid Cephalopods, that were so abundant in Cretaceous seas, are now restricted to tropical or sub-tropical areas. And the distribution of the mollusks, echinoderms, and corals, which habitually live on the bottom, seems to be determined, within certain limits at least, by temperature rather than by depth.

The bathymetrical range to which animal life of any higher type than the Rhizopodal might extend, was until recently quite unknown; but the researches initiated by Prof. Wyville Thomson and Dr Carpenter in 1868, and since prosecuted by the "Challenger" expedition, have fully established the existence of a varied and abundant fauna in ocean-depths ranging downwards to 2000 fathoms. And these researches have further established that the distribution of this fauna is mainly determined by the temperature of the sea-bed; so that whilst in the channel between the north of Scotland and the Faroes there were found at the same depths, and within a few miles of each other, two faunæ almost entirely distinct—one a boreal and the other a warmer-temperate—on sea-beds having respectively the temperatures of 30° and 43°, various types to which a low temperature is congenial are traceable continuously along the whole abyssal sea-bed that intervenes between those northern and southern polar areas within which they present themselves at or near the surface. And hence it becomes clear that, since glacial types are even now being embedded in the strata which are in process of formation beneath the equator, no inferences as to terrestrial climate can be drawn from the character of marine deposits.

One very remarkable feature which presents itself over a large proportion of the Atlantic basin is the abundance of the minute *Globigerinæ* and other Foraminifera, the accumulation of whose shells, and of their disintegrated remains, is giving rise to a calcareous deposit of unknown thickness, that corresponds in all essential particulars to Chalk. This deposit, in some parts of the North Atlantic, is replaced by an Arctic drift of fine sand, whilst in other parts there is a mixture of arenaceous and of calcareous components, such as is found in certain beds of the Cretaceous formation. Now on the surface of this deposit there have been found so many living types, especially belonging to the groups of Echinoderms, Corals, Siliceous Sponges, and Foraminifera, which closely correspond with types hitherto regarded as characteristic of the Cretaceous epoch, that the question naturally suggests itself whether

the existing are not the lineal descendants of the fossil types,—the differences they present being not greater than may be fairly attributed to the prolonged action of differences of temperature, food, pressure, &c. And when these facts are taken in connection with those previously stated as to the probable remoteness of the period when (if ever) the present sea-bed of the Atlantic was dry land, the doctrine first put forth by Prof. Wyville Thomson, that there has been a continuous formation of Globigerina-mud on the bottom of the Atlantic from the Cretaceous epoch to the present time—or, in other words, that the formation of chalk on the sea-bed of the Atlantic did not cease with the elevation of the European area, but has been going on through the whole Tertiary period,—must be admitted as (to say the least) a not improbable hypothesis. That some considerable change took place at the conclusion of the Cretaceous epoch, by which the temperature of the upper stratum was lowered, so as to be no longer compatible with the existence of the fishes and chambered cephalopods characteristic of the Cretaceous fauna, may be fairly assumed from their disappearance; but this would not so much affect the deeper part of the basin, in which those lower types that seem more capable of adapting themselves to changes in external conditions would continue to hold their ground. That the like conditions had prevailed also through long previous geological periods, may be surmised from the persistence, over various parts of the Atlantic sea-bed, of the *Apiocrinite* type, which carries us back to the Oolitic formation, and of the *Pentacrinus* type, which has come down with very little alteration from the Liassic; whilst many existing *Terebratulidæ* do not differ more from Oolitic types than the latter differ among each other. Going back still further, we find in the persistence of certain Foraminiferal types from the Carboniferous limestone to the present time, and in the character of its deep-sea beds, a strong indication that they originated in a Foraminiferal deposit, representing in all essential particulars that which is now going on; while the persistence of the *Lingula* from the early Silurian strata to the present time suggests the question whether certain oceanic areas may not have remained in the condition of deep sea throughout the whole subsequent succession of geological changes.

Bibliography.—In addition to the ordinary sources of information, the following publications may be specially referred to for recent information in regard to the physical geography of the Atlantic:—"Reports of the Deep-Sea Explorations carried on in H.M. Steam-vessels 'Lightning,' 'Porcupine,' and 'Shearwater,'" in *Proceedings of the Royal Society* for 1868, 1869, 1870, and 1872; "On the Gibraltar Current, the Gulf Stream, and the General Oceanic Circulation," in the *Journal of the Royal Geographical Society* for 1871; and "Further Inquiries on Oceanic Circulation" (containing a summary of the "Challenger" Temperature Survey of the Atlantic), in the same journal for 1874; *Currents and Surface-Temperature of the North and South Atlantic*, published by the Meteorological Committee; and *The Depths of the Sea*, by Prof. Wyville Thomson. (W.B.C.)

ATLANTIS, Atalantis, or Atlantica, an island mentioned by Plato and other classical writers, concerning the real existence of which many disputes have been raised. In the *Timæus*, Critias relates how his grandfather Critias had been told by Solon some remarkable events in early Athenian history which he had learned from the Egyptian priests at Sais, whose records went much further back than the native accounts. "The most famous of all the Athenian exploits," Solon had been told, "was the overthrow of the island Atlantis. This was a continent lying over against the pillars of Hercules, in extent greater than Libya and Asia put together, and was the passage to other islands and to another continent, of which the Mediterranean Sea was only the harbour; and within the pillars the empire of Atlantis reached to Egypt and Tyrrhenia. This mighty power was arrayed against Egypt and Hellas and all the countries bordering on the Mediterranean. Then did your city bravely, and won renown over the whole earth. For at the peril of her own existence, and when the other Hellenes had deserted her, she repelled the invader, and of her own accord gave liberty to all the nations within the pillars. A little while afterwards there was a great earthquake, and your warrior race all sank into the earth; and the great island of Atlantis also disappeared in the sea. This is the explanation of the shallows which are found in that part of the Atlantic ocean."—(Jowett's *Introduction to the Timæus.*) Such is the main substance of the principal account of the island furnished by the ancients,—an account which, if not entirely fictitious, belongs to the most nebulous region of history. The story may embody some popular legend, and the legend may have rested on certain historical circumstances; but what these were it is (as the numerous theories advanced on the subject may be held as proving) impossible now to determine.

ATLAS (Ἄτλας), in *Greek Mythology*, called sometimes a son of Japetus and the nymph Asia, or of Uranus and Gaia, and at other times traced to a different parentage, but always known as the being who supported on his shoulders the pillars on which the sky rested. He knew the depths of the sea (*Odyssey*, vii. 245), and in the first instance seems to have been a marine creation. The pillars which he supported were thought to rest in the sea, immediately beyond the most western horizon. But by the time of Herodotus (iv. 184), a mountain is suggested as best suited to hold up the heavens, and the name of Atlas is transferred to a hill in the N.W. of Africa. Then the name is traced to a king of that district, rich in flocks and herds, and owning the garden of the Hesperides. Finally, Atlas was explained as the name of a primitive astronomer. He was the father of the Pleiades and Hyades. Perseus encountered him when he searched for Medusa. Heracles took the burden of the sky from his shoulders, but cleverly contrived to replace it. Atlas bearing up the heavens is mentioned as being represented on early works of art, *e.g.*, on the chest of Cypselus (Pausan., v. 18, 1), and on the throne of Apollo at Amyclæ (Pausan., iii. 18, 7); and this subject occurs on several existing works of art.

ATLAS, a mountain-chain of Northern Africa, between the great desert of the Sahara and the Mediterranean. The range has been but partially explored, and geographers differ as to its extent, some considering it to reach from Cape Ghir on the Atlantic to Cape Bon, the north-east point of Tunis, while others include under the name the whole mountain system between Cape Nun and the greater Syrtis. In this latter sense it forms the mountain-land of the countries of Marocco, Algeria, Tunis, and Tripoli. It is composed of ranges and groups of mountains, enclosing well-watered and fertile valleys and plains, and having a general direction from W. to E. The highest peaks are supposed to attain an elevation of nearly 15,000 feet; and although none of them reach the height of perpetual snow, some of their loftiest summits are covered with snow during the greater part of the year. Mount Miltsin, 27 miles S.E. of the city of Marocco, was ascertained by Captain Washington to be 11,400 feet high. The greatest heights are in Marocco, from which point they appear to diminish in elevation as they extend towards the E. These mountains, except the loftier summits, are, for the most part, covered with thick forests of pine, oak, cork, white poplar, wild olive, and other trees. The inferior ranges seem to be principally composed of Secondary limestone, which, at a greater elevation, is succeeded by micaceous schist and quartz-rock; and the higher chains are said to consist of granite, gneiss, mica-slate, and clay-slate. The Secondary and Tertiary formations are frequently disturbed and upraised by trap-rocks of comparatively modern date. Lead iron copper. antimony, sulphur, and rock-salt occur frequently; and in the Marocco portion of the range gold and silver are said to exist. In the Algerian division are mines of copper, lead, silver, and antimony. The lion, hyena, boar, and bear are common throughout the mountains. None of the rivers which take their rise in the system are of any great importance. The Tafilet is absorbed in the sands; the Tensift and Draa flow into the Atlantic; and about five or six find their way to the Mediterranean. Dr Hooker has explored the botany of many parts of the range, and the travels of Rohlfs have added largely to our general knowledge of it.

ATMOSPHERE

ATMOSPHERE is the name applied to the invisible elastic envelope which surrounds the earth, the gaseous matter of which it is composed being usually distinguished by the name of air. Storms and weather generally, solar and terrestrial radiation, the disintegration of rocks, animal and vegetable life, twilight, and the propagation of sound, are some of the more striking phenomena which are either to a large extent or altogether dependent on the atmosphere. That air possesses weight may be shown by the simple experiment of taking a hollow globe filled with air and weighing it; then removing the contained air by means of an air-pump, and again weighing the globe, when it will be found to weigh less than at first. The difference of the two results is the weight of the air which has been removed. From Regnault's experiments, 100 cubic inches of dry air, or air containing no aqueous vapour, under a pressure of 30 English inches of mercury, and at a temperature of 60° Fahr., weigh 31·03529 grains; and since 100 cubic inches of distilled water at the same pressure and temperature weigh 25,252½ grains, it follows that air is 813·67 times lighter than water.

Air as an elastic fluid exerts pressure upon the earth or any substance on which it rests, the action of a boy's sucker and of a water-pump being familiar instances showing the pressure of the atmosphere. When air is removed from a water-pump, the water rises in the pump only to a certain height; for as soon as the water has risen to such a height that the weight of the column of water in the pump above the level of the surface of the water in the well just balances the pressure exerted by the atmosphere on the surface of the well, it ceases to rise. If the pressure of the atmosphere be increased, the water will rise higher in the pump; but if diminished, the level of the water will sink. The height to which the water rises within the pump thus varies with the pressure of the atmosphere, the height being generally about 34 feet. Since a given volume of mercury weighed *in vacuo* at a temperature of 62° Fahr. is 13·569 times heavier than the same volume of water, it follows that a column of mercury will rise *in vacuo* to a height 13·569 times less than a column of water, or about 30 inches. If we suppose, then, the height of the mercurial column to be 30 inches, which is probably near the average height of the barometer at sea-level, and its base equal to a square inch, it will contain 30 cubic inches of mercury; and since one cubic inch of mercury contains 3426·7 grains, the weight of 30 cubic inches will be nearly 14·7304 ℔ avoirdupois. Thus the pressure of the atmosphere is generally, at least in these latitudes, at sea-level equal to 14·7304 ℔ on each square inch of the earth's surface. Sir John Herschel has calculated that the total weight of an atmosphere averaging 30 inches of pressure is about 11⅔ trillions of pounds; and that, making allowance for the space occupied by the land above the sea, the mass of such an atmosphere is about $\frac{1}{1200000}$ part of that of the earth itself. This enormous pressure is exerted on the human frame in common with all objects on the earth's surface, and it is calculated that a man of the ordinary size sustains a pressure of about 14 tons; but as the pressure is exerted equally in all directions, and permeates the whole body. no inconvenience arises in consequence of it.

A pressure agreeing approximately with the average atmospheric pressure at sea-level is often used as a unit of pressure. This unit is called *an atmosphere*, and is employed in measuring pressures in steam-engines and boilers. The value of this unit which has been adopted, in the metrical system, is the pressure of 760 millimètres (29·922 Eng. inches) of the mercurial column at 0° C. (32° Fahr.) at Paris, which amounts in that latitude to 1·033 kilogrammes on the square centimètre. In the English system, *an atmosphere* is the pressure due to 29·905 inches of the mercurial column at 32° Fahr. at London, amounting there to nearly 14¾ ℔ weight on the square inch. The latter atmosphere is thus 0·99968 of that of the metrical system.

As regards the distribution of atmospheric pressure over the globe, there was little beyond conjecture, drawn from theoretical considerations and for the most part erroneous, till the publication in 1868 of Buchan's memoir "On the Mean Pressure of the Atmosphere and the Prevailing Winds over the Globe."[1] By the monthly isobaric charts and copious tables which accompanied the memoir, this important physical problem was first approximately solved. Since then the British Admiralty has published charts showing the mean pressure of the atmosphere over the ocean.[2] The more important general conclusions regarding the geographical distribution of atmospheric pressure are the following:—

There are two regions of high pressure, the one north and the other south of the equator, passing completely round the globe as broad belts of high pressure. They enclose between them the low pressure of tropical regions, through the centre of which runs a narrower belt of still lower pressure, towards which the north and south trades blow. The southern belt of high pressure lies nearly parallel to the equator, and is of nearly uniform breadth throughout; but the belt north of the equator has a very irregular outline, and great differences in its breadth and in its inclination to the equator,—these irregularities being due to the unequal distribution of land and water in the northern hemisphere. Taking a broad view of the subject, there are only three regions of low pressure,—one round each pole, bounded by or contained within the belts of high pressure just referred to, and the equatorial belt of low pressure. The most remarkable of these, in so far as yet known, is the region of low pressure surrounding the south pole, which appears to remain pretty constant

[1] *Trans. Roy. Soc. Edin.*; vol. xxv. p. 575.
[2] *Physical Charts of the Pacific, Atlantic, and Indian Oceans*, Lond. 1872.

during the whole year. The depression round the north pole is divided into two distinct centres, at each of which there is a diminution of pressure greatly lower than the average north polar depression. These two centres lie in the north of the Atlantic and Pacific Oceans respectively. The distribution of pressure in the different months of the year differs widely from the annual average, particularly in January and July, the two extreme months. In January the highest pressures are over the continents of the northern hemisphere,—and the larger the continental mass the greater the pressure,—and the lowest pressures are over the northern portions of the Atlantic and Pacific, South America and South Africa, and the Antarctic Ocean. In the centre of Asia the mean pressure of the atmosphere in this month is fully 30·400 inches, whereas in the North Atlantic, round Iceland, it is only 29·340 inches, or upwards of an inch lower than in Central Asia. The area of high barometer is continued westwards through Central and Southern Europe, the North Atlantic between 5° and 45° N. lat., North America, except the north and north-west, and the Pacific for some distance on either side of 15° N. lat. It is thus an exaggerated form of the high belt of annual mean pressure, spreading, however, over a much greater breadth in North America, and a still greater breadth in Asia.

In July, on the other hand, the mean pressure of Central Asia is only 29·468 inches, or nearly an inch lower than during January; or, putting this striking result in other words, about a thirtieth of the pressure of the atmosphere is removed from this region during the hottest months of the year as compared with the winter season. The lowest pressures of the northern hemisphere are now distributed over the continents, and the larger the continental mass the greater is the depression. At the same time, the highest are over the ocean between 50° N. and 50° S. lat., particularly over the North Atlantic and the North Pacific between 25° and 40° N. lat., and in the southern hemisphere over the belt of high mean annual pressure, which in this month reaches its maximum height. Pressure is high in South Africa and in Australia, just as in the winter of the northern hemisphere pressures are high over the continents.

Over the ocean, if we except the higher latitudes, atmospheric pressure is more regular throughout the year than over the land. In the ocean to westwards of each of the continents there occurs at all seasons an area of high pressure, from 0·10 inch to 0·30 inch higher than what prevails on the coast westward of which it lies. The distance of these spaces of high pressure is generally about 30° of longitude; and their longitudinal axes lie, roughly speaking, about the zones of the tropics. The maximum is reached during the winter months, and these areas of high pressure are most prominently marked west of those continents which have the greatest breadth in 30° lat.; and the steepest barometric gradients are on their eastern sides. It is scarcely possible to over-estimate the importance of these regions of high and low mean pressures, from their intimate bearing on atmospheric physics, but more particularly from their vital connection with prevailing winds and the general circulation of the atmosphere. This relation will be apprehended when it is considered that winds are simply the flowing away of the air from regions where there is a surplus (regions of high pressure) to where there is a deficiency of air (regions of low pressure). Everywhere over the globe this transference takes place in strict accordance with Buys-Ballot's "Law of the Winds," which may be thus expressed:—The wind neither blows round the space of lowest pressure in circles returning on themselves, nor does it blow directly toward that space; but it takes a direction intermediate, approaching. however, more nearly to the direction and course of circular curves than of radii to a centre. More exactly, the angle is not a right angle, but from 45° to 80°. Keeping this relation between wind and the distribution of pressure in mind, the isobaric lines give the proximate causes of the prevailing winds over the globe, and through these the prominent features of climates. As regards the ocean, the prevailing winds indicate the direction of the drift-currents and other surface-currents, and thereby the anomalous distribution of the temperature of the sea as seen in the Chili, Guinea, and other ocean currents, and the peculiarly marked climates of the coasts past which these currents flow, are explained; for observations have now proved that the prevailing winds and surface-currents of all oceans are all but absolutely coincident.

As regards the annual march of pressure through the months of the year, curves representing it for the different regions of the earth differ from each other in every conceivable way. It is only when the results are set down in their proper places on charts of the globe that the subject can be well understood. When thus dealt with, many of the results are characterised by great beauty and simplicity. Thus, of all influences which determine the barometric fluctuation through the months, the most important are the temperature, and through the temperature the humidity. Comparing, then, the average pressure in January with that in July, which two months give the greatest possible contrasts of temperature, the following is the broad result:—

The January exceeds the July pressure over the whole of Asia except Kamtchatka and the extreme north-east, the greatest excess being near the centre of the continent; over Europe to south and east of a line drawn from the White Sea south-westward to the Naze, thence southward to the mouth of the Weser, then to Tours, Bordeaux, and after passing through the north of Spain, out to sea at Coruña; over North America, except the north-east and north-west. On the other hand, the July exceeds the January pressure generally over the whole of the southern hemisphere, over the northern part of the North Atlantic and regions immediately adjoining (the excess amounting in Iceland to 0·397 inch), and over the northern part of the North Pacific and surrounding regions. Thus the pressure which is so largely removed from the Old and New Continents of the northern hemisphere in July is transferred, partly to the southern hemisphere, and partly to the northern portions of the Atlantic and Pacific Oceans.

Atmospheric pressure is more uniformly distributed over the globe in April and October than in any of the other months. In May and November, being the months immediately following, occur the great annual rise and fall of temperature; and since these rapid changes take place at very different rates, according to the relative distribution of land and water in each region, a comparison of the geographical distribution of May with that for the year brings out in strong relief the more prominent causes which influence climate, and some of the more striking results of these causes. This comparison shows a diminution of pressure in May over tropical and sub-tropical regions, including nearly the whole of Asia, the southern half of Europe, and the United States. An excess prevails over North America to the north of the Lakes, over Arctic America, Greenland, the British Isles, and to the north of a line passing through the English Channel in a north-easterly direction to the Arctic Sea. The excess in the southern hemisphere includes the southern half of south America and of Africa, the whole of Australia, and adjacent parts of the ocean. The influence of the land of the southern hemisphere, which in this month is colder than the surrounding seas, brings about an excess of pressure; on the other hand, the influence of land over those regions