PHYSICAL GEOGRAPHY

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by

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INTRODUCTION

§1 Let us suppose that it is summer-time, that you are in the country, and that you have fixed upon a certain day for a holiday ramble. Some of you are going to gather wildflowers, some to collect pebbles, and some without any very definite aim beyond the love of the holiday and of any sport or adventure which it may bring with it. Soon after sunrise on the eventful day you are awake, and great is your delight to find the sky clear and the sun shining warmly. It is arranged, however, that you do not start until after breakfast-time, and meanwhile you busy yourselves in getting ready all the baskets and sticks and other gear of which you are to make use during the day. But the brightness of the morning begins to get dimmed. The few clouds which were to be seen at first have grown large, and seem evidently gathering together for a storm. And sure enough, ere breakfast is well over, the first ominous big drops are seen falling. You cling to the hope that it is only a shower which will soon be over, and you go on with the preparations for the journey notwithstanding. But the rain shows no symptom of soon ceasing. The big drops come down thicker and faster; little pools of water begin to form in the hollows of the road, and the window-panes are now streaming with rain. With sad hearts you have to give up all hope of holding your excursion to-day.

§2 It is no doubt very tantalizing to be disappointed in this way when the promised pleasure was on the very point of becoming yours. But let us see if we cannot derive some compensation even from the bad weather. Late in the afternoon the sky clears a little, and the rain ceases. You are glad to get outside again, and so we all sally forth for a walk. Streams of muddy water are still coursing along the sloping roadway. If you will let me be your guide, I would advise that we should take our walk by the neighbouring river. We wend our way by wet paths and green lanes, where every hedgerow is still dripping with moisture, until we gain the bridge, and see the river right beneath us. What a change this one day's heavy rain has made! Yesterday you could almost count the stones in the channel, so small and clear was the current. But look at it now! The water fills the channel from bank to bank, and rolls along swiftly. We can watch it for a little from the bridge. As it rushes past, innumerable leaves and twigs are seen floating on its surface. Now and then a larger branch, or even a whole tree-trunk, comes down, tossing and rolling about on the flood. Sheaves of straw or hay, planks of wood, pieces of wooden fence, sometimes a poor duck, unable to struggle against the current, roll past us and show how the river has risen above its banks and done damage to the farms higher up its course.

§3 We linger for a while on the bridge, watching this unceasing tumultuous rush of water and the constant variety of objects which it carries down the channel. You think it was perhaps almost worth while to lose your holiday for the sake of seeing so grand a sight as this angry and swollen river, roaring and rushing with its full burden of dark water. Now, while the scene is still fresh before you, ask yourselves a few simple questions about it, and you will find perhaps additional reasons for not regretting the failure of the promised excursion.

§4 In the first place, where does all this added mass of water in the river come from? You say it was the rain that brought it. Well, but how should it find its way into this broad channel? Why does not the rain run off the ground without making any river at all?

§5 But, in the second place, where does the rain come from? In the early morning the sky was bright, then clouds appeared, and then came the rain, and you answer that it was the clouds which supplied the rain. But the clouds must have derived the water from some source. How is it that clouds gather rain, and let it descend upon the earth?

§6 In the third place, what is it which causes the river to rush on in one direction more than another? When the water was low, and you could, perhaps, almost step across the channel on the stones and gravel, the current, small though it might be, was still quite perceptible. You saw that the water was moving along the channel always from the same quarter. And now when the channel is filled with this rolling torrent of dark water, you see that the direction of the current is still the same. Can you tell why this should be?

§7 Again, yesterday the water was clear, to-day it is dark and discoloured. Take a little of this dirty-looking water home with you, and let it stand all night in a glass. To-morrow morning you will find that it is clear, and that a fine layer of mud has sunk to the bottom. It is mud, therefore, which discolours the swollen river. But where did this mud come from? Plainly, it must have something to do with the heavy rain and the flooded state of the stream.

§8 Well, this river, whether in shallow or in flood, is always moving onward in one direction, and the mud which it bears along is carried towards the same point to which the river itself is hastening. While we sit on the bridge watching the foaming water as it eddies and whirls past us, the question comes home to us—what becomes of all this vast quantity of water and mud?

§9 Remember, now, that our river is only one of many hundreds which flow across this country, and that there are thousands more in other countries where the same thing may be seen which we have been watching to-day. They are all flooded when heavy rains come; they all flow downwards; and all of them carry more or less mud along with them.

§10 As we walk homewards again, it will be well to put together some of the chief features of this day's experience. We have seen that sometimes the sky is clear and blue, with the sun shining brightly and warmly in it; that sometimes clouds come across the sky, and that when they gather thickly rain is apt to fall. We have seen that a river flows; that it is swollen by heavy rain, and that when swollen it is apt to be muddy. In this way we have learnt that there is a close connection between the sky above us and the earth under our feet. In the morning, it seemed but a little thing that clouds should be seen gathering overhead; and yet, ere evening fell, these clouds led by degrees to the flooding of the river, the sweeping down of trees, and fences, and farm produce; and it might even be to the destruction of bridges, the inundation of fields and villages and towns, and a large destruction of human life and property.

§11 But perhaps you live in a large town and have no opportunity of seeing such country sights as I have been describing, and in that case you may naturally enough imagine that these things cannot have much interest for you. You may learn a great deal, however, about rain and streams even in the streets of a town. Catch a little of the rain in a plate, and you will find it to be so much clear water. But look at it as it courses along the gutters. You see how muddy it is. It has swept away the loose dust worn by wheels and feet from the stones of the street, and carried it into the gutters. Each gutter thus becomes like the flooded river. You can watch, too, how chips of straw, corks, bits of wood, and other loose objects lying in the street are borne away, very much as the trunks of trees are carried by the river. Even in a town, therefore, you can follow how changes in the sky lead to changes on the earth.

§12 If you think for a little, you will recall many other illustrations of the way in which the common things of everyday life are connected together. As far back as you can remember, you have been familiar with such things as sunshine, clouds, wind, rain, rivers, frost, and snow, and they have grown so commonplace that you never think of considering about them. You cannot imagine them, perhaps, as in any way different from what they are; they seem, indeed, so natural and so necessary that you may even be surprised when anyone asks you to give a reason for them. But if you had lived all your lives in a country where no rain ever fell, and if you were to be brought to such a country as this, and were to see such a storm of rain as you have been watching to-day, would it not be very strange to you, and would you not naturally enough begin to ask the meaning of it? Or suppose that a boy from some very warm part of the world were to visit this country in winter, and to see for the first time snow fall, and the rivers solidly frozen-over, would you be surprised if he showed great astonishment? If he asked you to tell him what snow is, and why the ground is so hard, and the air so cold, why the streams no longer flow, but have become crusted with ice—could you answer his questions?

§13 And yet these questions relate to very common, everyday things. If you think about them, you will learn, perhaps, that the answers are not quite so easily found as you had imagined. Do not suppose that because a thing is common, it can have no interest for you. There is really nothing so common as not to deserve your attention, and which will not reward you for your pains.

§14 In the following pages I propose to ask you to look with me at some of these common things. You must not think, however, that it is my wish merely to set you certain lessons which you have to learn, and to give you some rudiments of knowledge which you must commit to memory. I would fain have you not to be content with what is said in this little book, or in other books, whether small or great, but rather to get into the habit of using your own eyes and seeing for yourselves what takes place in this wonderful world of ours. All round you there is abundant material for this most delightful inquiry. No excursion you ever made in pursuit of mere enjoyment and adventure by river, heath, or hill, could give you more hearty pleasure than a ramble with eyes and ears alike open to note the lessons to be learnt from every day and from every landscape. Remember that besides the printed books which you use at home, or at school, there is the great book of Nature, wherein each of us, young and old, may read, and go on reading all through life without exhausting even a small part of what it has to teach us.

§15 It is this great book—Air, Earth, and Sea—which I would have you look into. Do not be content with merely noticing that such and such events take place. For instance, to return to our walk to the flooded river; do not let a fact such as a storm or a flood pass without trying to find out something about it. Get into the habit of asking Nature questions, as we did in the course of our homeward walk. Never rest until you get at the reasons for what you notice going on around you. In this way even the commonest things will come to wear a new interest for you. Wherever you go there will be something for you to notice; something that will serve to increase the pleasure which the landscape would otherwise afford. You will thus learn to use your eyes quickly and correctly; and this habit of observation will be of the utmost value to you, no matter what may be the path of life which lies before you.

§16 In the following Lessons I wish to show you what sort of questions you may put about some of the chief parts of the book of Nature, and especially about two of these—the Air and the Earth. Each of us should know something about the air we breathe and the earth we live upon, and about the relations between them. Our walk showed us a little regarding these relations when it enabled us to connect the destruction of fences and farms with the formation of clouds in the sky. Many other relations remain for you to find out. In tracing these you are really busy with science, with that branch of science called Physical Geography, which seeks to describe this earth with all the movements which are going on upon its surface. And yet you are not engaged in anything very difficult or uninteresting. You are simply watching with attentive eyes the changes which are continually taking place around you, and seeking to find out the meaning of these changes, and how they stand related to each other.

THE SHAPE OF THE EARTH

§17 Before observing what takes place on the surface of the earth, it may be well if you form a clear notion about the shape of the whole earth as a mass, and if you fix in your minds some of the great leading features of the connection between the earth and the sun.

§18 When you stand in the middle of a broad flat country, or look out upon the wide sea, it seems to you as if this world on which we live and move were a great plain, to the edge of which you would come if you went far enough onward. This is the first notion we all have as children. It was also the firm belief of mankind in early times. The sun and moon were then thought to rise and set only for the use of people here; and the sky, with all its stars, was looked upon as a great crystal dome covering and resting upon the earth.

§19 But you can easily prove to yourselves that the eye is deceived about the flatness of the earth, and that what seems quite level is in reality curved. In a wide level country, such as many parts of the midland and eastern counties of England, you cannot see trees and houses farther away than some four or five miles. If you climb to the top of a church tower, you find many objects come into sight which you could not have seen from the ground. And if there should happen to be a range of hills in the neighbourhood, you would note from their tops a still larger number of points which before were hidden. The higher you climb above the ground, therefore, the further you can see.

§20 Again: suppose you were at the bottom of a tall sea-cliff, and on looking out to sea were to note the sails of a distant ship. If you mounted to the top of the cliff, you might see not only the sails, but the whole vessel, and your eye would probably pick out ships still further away, appearing as mere specks along the line of meeting between sea and sky, and which you could not see at all from the beach.

§21 Suppose further, that you were to sit down on the top of that cliff, and watch these vessels for a time. Some of them, which at first were so far away that they could hardly be seen, would probably seem to grow bigger and clearer. You would begin to make out the tops of the masts and sails; by and by the rest of the sails would appear, until at last the hulls too came into sight. These vessels would seem to you to have sailed up over what used to be thought the edge of the world.

§22 On the other hand, some of the ships which were near you at first will gradually sail away towards the same distant parts. Their hulls will dip down into the sea, as it were; then the sails will slowly sink, and in the end all trace of the vessels will have vanished.

§23 Now, in making these observations, you will have gathered facts which prove that the world we live in is not a flat plain, but has a curved surface, or in other words is a globe. To use your eyes in this way, and seek out the meaning of that which you see, would neither be a hard nor a dull task; and yet you would really be engaged in what is called observational science. When you watch how the ships at sea appear to you as they come and go, you observe **facts**. When you put the facts together, and reason out their connection and meaning, and find that they prove the roundness of the earth, you make an **induction** or inference from them. Now it is this union of observation and induction which makes **science**.

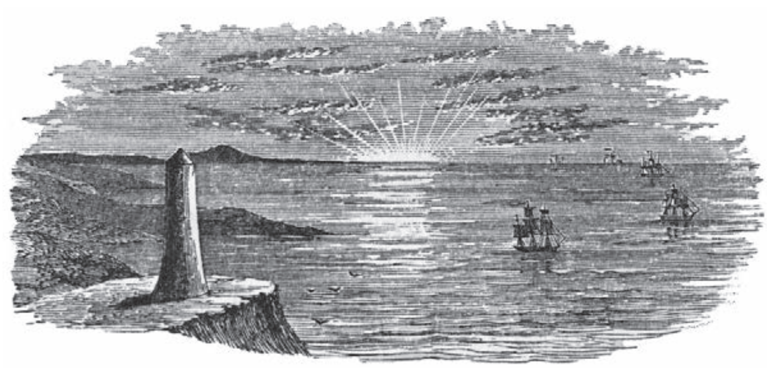

Figure 1 — Disappearance of a Ship at Sea owing to the curved surface of the Earth

§24 You may observe, then, and prove that the old and natural-enough notion about the flatness of the earth is quite untrue; and that, flat as the sea and land may appear, they are only parts of a great curve. If you were to set sail from England, and keep sailing on in the same general direction without turning back, you would in the end come to England again. You would sail round the world, and prove it to be actually a globe. Now, this has often been done. Many voyages have been made round the world, and, instead of coming to its edge, the voyagers, or "circumnavigators," as they are called, have always found the land and sea to wear the same curved surface which we can see for ourselves at home.

§25 Though you may find it easy enough to believe that the surface of the earth is part of a curve when you look out upon the broad sea, yet when you see a landscape where the ground is very uneven, such, for example, as a region of high mountains and deep valleys, you may find perhaps some difficulty in understanding how it can possibly be that such an irregular surface can be spoken of as part of a curve. In reality, however, the earth is so big, that even the highest mountains are in comparison merely like little grains on the surface. It is only when the surface is level, as on a great plain or on the sea, that we can usually judge by the eye as to the real form of the earth. But even in the most rugged ground the curve is there, though we may fail to notice it.

§26 But the curve, after all, is a very gentle one. You can see the vessels at sea for many miles before they sink down out of sight. The fact that the curve is so gentle shows that the circle of which it forms part must be of great size. Now, it has been measured by astronomers, and found to be so big that if a railway train could go completely round the earth at a rate of thirty miles an hour without stoppage, it would take more than a month to complete the circuit.

DAY AND NIGHT

§27 Day by day, as far back as you can remember, you have been accustomed to see the sun travel across the sky. Night after night, when the air has been free from cloud, you have seen the moon and stars sailing slowly overhead. You cannot be more confident of anything than you are that the sun will appear again to-morrow, and move on from year to year as it has done in the past. You have seen that a slow, regular, and unceasing motion seems to be going on all round the earth. Have you ever wondered what can be the cause of this motion?

§28 When the sun shines it is warm, when clouds obscure the sky the air is more chilly, and at night, when the sun does not shine at all, we feel a sensation of cold. Again: by day the sky is filled with light, but when the sun sinks in the west darkness begins. You see from this that we depend upon the sun for light and heat. It is evident that we cannot properly understand what takes place upon the earth until we learn something about the relations of the earth to the sun.

§29 Perhaps your first impression has been like that of mankind in general long ago. They believed the earth to remain as the fixed central point of the universe, round which sun, moon, and stars were ceaselessly, revolving. To this day we speak of these heavenly bodies as **rising** and **setting**, as if we still regarded them as performing a journey round the earth.

§30 But instead of being the centre of the universe our earth is in reality only one of a number of heavenly bodies which travel unceasingly round the sun. The sun is the great central hot mass which warms and lights the earth, and round which the earth is continually circling.

§31 The succession of day and night seems to be owing to the movements of the sun, but in reality it is caused by the turning or **rotation** of the earth itself. You can readily illustrate this. Set a humming-top spinning as rapidly as you can. It seems to stand for a while motionless upon its point, but actually it is rotating with great rapidity. Imagine a line passing straight up from the point below, to the top of the stalk above. Every part of the top is spinning round this central line, which is called the **axis of rotation**. In the same kind of way the earth is spinning rapidly on its axis.

§32 Again: take an ordinary school-globe, and place a lighted candle a few feet from it, in a line with the brass circle. You can make the globe turn round on its axis. Whether it is allowed to remain at rest or is sent spinning round rapidly, the half of it next the candle is lighted, and the other half away from the candle is in shade. When it is at rest, the places marked on one side remain in the light, while those on the opposite side remain in the dark. As you turn it round, each place in succession is brought round to the light, and carried on into the shade again. And while the candle remains unmoved, the rotation of the globe brings alternate light and darkness to each part of its surface.

§33 Instead of the little school-globe in this illustration, imagine our earth, and in place of the feeble candle, the great sun, and you will see how the rotation of the earth on its axis must bring alternate light and darkness to every country.

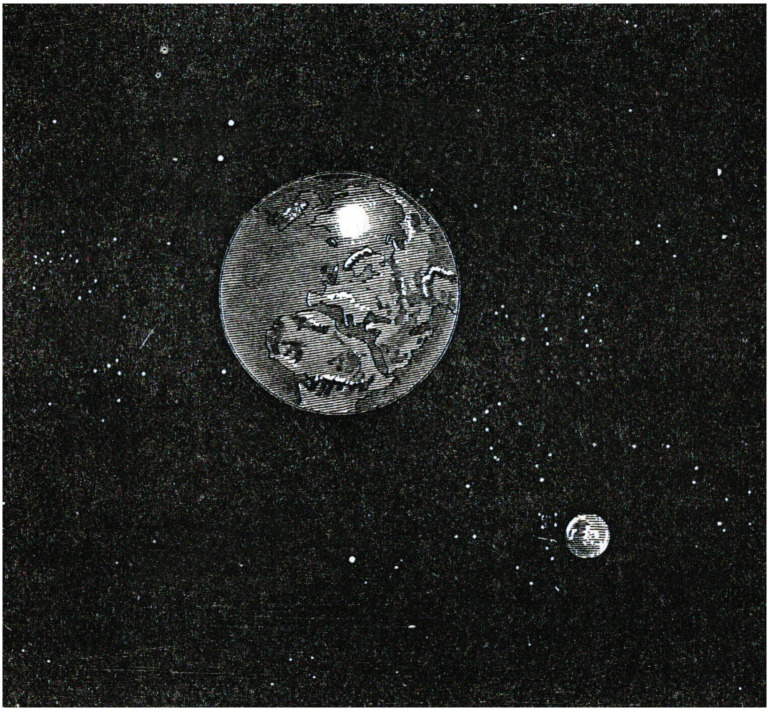

Figure 2 — The Earth and Moon as they would appear seen from the Sun

§34 You must not suppose that there is any actual rod passing through the earth to form the axis round which it turns. The axis is only an imaginary line, and the two opposite points where it reaches the surface, and where the ends of the rod would come out were the axis an actual visible thing, are called the **North Pole** and the **South Pole**. They are represented by the two little points by which the school-globe is fixed in its place.

§35 Round this axis the earth spins once in every twenty-four hours. All this time the sun is shining steadily and fixedly in the sky. But only those parts of the earth can catch his light which happen at any moment to be looking towards him. There must always be a bright side and a dark side, just as there was a bright side and a dark side when you placed the globe opposite to the candle. Now you can easily see that if there were no motion in the earth, half of its surface would never see the light at all, while the other half would never be in darkness. But since it rotates, every part is alternately illuminated and shaded. When we are catching the sun's light, we have **Day**; when we are on the dark side, we have **Night**.

§36 The sun seems to move from east to west. The real movement of the earth is necessarily just the reverse of this, viz. from west to east. In the morning we are carried round into the sunlight, which appears in the east. Gradually the sun seems to climb the sky until we are brought directly opposite to him at noon, and gradually he sinks again to set in the west, as the earth in its constant rotation bears us round once more into the dark. Even at night, however, we can still trace the movement of the earth by the way in which the stars one by one rise and set, until their lesser lights are quenched in the returning light of another day.

§37 All the time that the earth is rotating on its axis it is circling or **revolving** round the sun. This motion is called the **revolution** of the earth in its **orbit**. To go completely round the sun, the earth has to travel over so wide a circle or orbit, that it takes rather more than three hundred and sixty-five days to perform the journey, even though it is rushing along at an average speed of about nineteen miles in a second.

§38 By the motion of rotation, time is divided into days and nights, by that of revolution it is marked off into years. So that in this way the earth is our great time-keeper.

THE AIR

I. WHAT THE AIR IS MADE OF

§39 When we begin to look attentively at the world around us, one of the first things to set us thinking is the air. We do not see it, and yet it is present wherever we may go. At one time it blows upon us in a gentle breeze, at another it sweeps along in a fierce storm. What is this air?

§40 Although invisible, it is yet a real, material substance. When you swing your arm rapidly up and down you feel the air offering a resistance to the hand. The air is something which you can feel, though you cannot see it. You breathe it every moment. You cannot get away from it, for it completely surrounds the earth. To this outer envelope of air, the name of Atmosphere is given.

§41 From the experiments explained in the Chemistry Primer (§9) you learn that the air is not a simple substance, but a mixture of two invisible gases, called nitrogen and oxygen. But besides these chief ingredients, it contains also small quantities of other substances; some of which are visible, others invisible. If you close the shutters of a room, and let the sunlight stream through only one chink or hole into the room, you see some of the visible particles of the air. Hundreds of little motes or specks of dust cross the beam of light which makes them visible against the surrounding darkness, though they disappear in full daylight. But it is the invisible parts of the air which are of chief importance; and among them are two which you must especially remember—the **vapour of water** and **carbonic acid gas**. You will soon come to see why it is needful for you to distinguish these.

§42 Now what is this vapour of water? You will understand its nature if you watch what takes place when a kettle boils. From the mouth of the spout a stream of white cloud comes out into the air. It is in continual motion; its outer parts somehow or other disappear, but as fast as they do so they are supplied by fresh materials from the kettle. The water in the kettle is all the while growing less, until at last, if you do not replenish it, the whole will be boiled away, and the kettle left quite dry. What has become of all the water? You have changed it into vapour. It is not destroyed or lost in any way, it has only passed from one state into another, from the liquid into the gaseous form, and is now dissolved in the air.

§43 Now the air always contains more or less vapour of water, though you do not see it, so long as it remains in the state of vapour. It gives rise to clouds, mist, rain, and snow. If it were taken out of the air, everything would be dried up on the land, and life would be impossible. As you learn more and more of the changes which take place from day to day around you, you will come to see that this vapour of water plays a main part in them all.

§44 Carbonic acid gas is also one of the invisible substances of the atmosphere, of which, though it forms no more than four parts in every ten thousand, yet it constitutes an important ingredient. You will understand how important it is when you are told that, from this carbonic acid in the air, all the plants which you see growing upon the land extract nearly the whole of their solid substance (see Chemistry Primer, §11). When a plant dies and decays, the carbonic acid is restored to the air again. On the other hand, plants are largely eaten by animals, and help to form the framework of their bodies. Animals in breathing give out carbonic acid gas; and when they die, and their bodies decay, the same substance is again restored to the atmosphere. Hence the carbonic acid of the air is used to build up the structure both of plants and animals, and is given back again when these living things cease to live. There is a continual coming and going of this material between the air and the animal and vegetable kingdoms (see Chemistry Primer, §13).

II. THE WARMING AND COOLING OF THE AIR

§45 You know that though you cannot see the air you can feel it when it moves. A light breeze, or a strong gale, can be just as little seen by the eye as still air; and yet we readily feel their motion. But even when the air is still it can make itself sensible in another way, viz. by its **temperature** (see Physics Primer, §51). For air, like common visible things, can be warmed and cooled.

§46 This warming and cooling of the air is well illustrated by what takes place in a dwelling-house. If you pass out of a warm room, on a winter's day, into the open air when there is no wind, you feel a sensation of cold. Whence does this sensation come? Not from anything you can see, for your feet, though resting on the frozen ground, are protected by leather, and do not yet feel the cold. It is the air which is cold, and which encircles you on all sides, and robs you of your heat; while at the same time you are giving off or **radiating** heat from your skin into the air (see Physics Primer, §67). On the other hand, if, after standing a while in the chilly winter air you return into the room again, you feel a sensation of pleasant warmth. Here, again, the feeling does not come from any visible object, but from the invisible air which touches every part of your skin, and is thus robbed of its heat by you.

§47 Air, then, may sometimes be warm and sometimes cold, and yet still remain quite invisible. By means of the thermometer (which is explained in the Physics Primer, §51), we can measure slight changes of heat and cold, which even the most sensitive skin would fail to detect.

§48 Now, how is it that the atmosphere should sometimes be warm and sometimes cold? Where does the heat come from? and how does the air take it up?

§49 Let us return again to the illustration of the house. In winter, when the air is keen and frosty outside, it is warm and pleasant indoors, because fires are there kept burning. The burning of coal and wood produces heat, and the heat thus given out warms the air. Hence it is by the giving off or **radiation** of the heat from some burning substance that the air of our houses is made warmer than the air outside.

§50 Now, it is really by radiation from a heated body that the air outside gets its heat. In summer, this air is sometimes far hotter than is usual in dwelling-houses in winter. All this heat comes from the sun, which is an enormous hot mass, continually sending out heat in all directions.

§51 But, if the sun is always pouring down heat upon the earth, why is the air ever cold? Place a screen between you and a bright fire, and you will immediately feel that some of the heat from the fireplace has been cut off. When the sun is shining, expose your hand to its beams for a time, and then hold a book between the hand and the sun. At first, your skin was warmed; but the moment you put it in the shade, it is cooled again. The book has cut off the heat which was passing directly from the sun to your hand. When the atmosphere is felt to be cold, something has come in the way to keep the sun's heat from directly reaching us.

§52 Clouds cut off the direct heat of the sun. You must often have noticed the change of temperature, when, after the sun has been shining for a time, a cloud comes between it and the earth. Immediately a feeling of chilliness is experienced, which passes off as soon as the cloud has sailed on, and allowed the sun once more to come out.

§53 The air itself absorbs some of the sun's heat, and the greater the thickness of air through which that heat has to make its way, the more heat will be absorbed. Besides this, the more the rays of heat are slanted the weaker do they become. At noon, for example, the sun stands high in the sky. Its rays (as at B in Figure 3) are then nearest to the vertical, and have also the least thickness of air to pass through before they reach us. As it descends in the afternoon, its rays get more and more slanted, and must also make their way through a constantly increasing thickness of air (as at C in the diagram). Hence the middle of the day is much warmer than morning or evening.

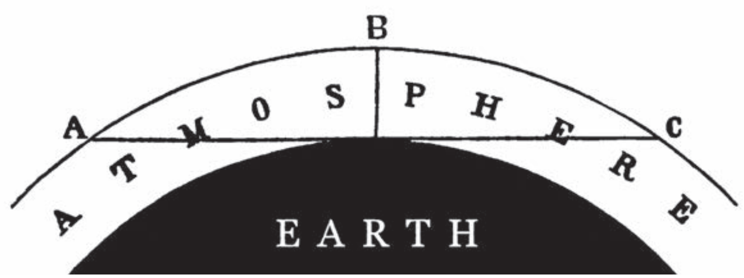

Figure 3 — Diagram showing the influence of the varying thickness of atmosphere in retarding the Sun's heat. A. Line of Sun's rays in the morning. B. Line of rays at noon. C. Line of the rays at sunset.

§54 At night, when the sun no longer shines, its heat does not directly warm the part of the earth in shadow. That part not only receives no heat from it, but even radiates its heat out into the cold sky (see §59). Hence night is much colder than day.

§55 Then, again, in summer the sun at noon shines much higher in the sky with us, or more directly overhead, than in winter. Its heat comes down less obliquely and has less depth of air to pass through, and hence is much more felt than in winter, when, as you know, the sun in our part of the world never rises high even at midday.

§56 From all this it is evident that we get our supplies of heat from the sun, and that anything coming between us and the sun serves to interrupt this heat and give us the sensation of cold.

§57 Still, if we were dependent for our warmth upon the direct heat of the sun alone, we should be warm only when the sun shines. A cloudy day would be an extremely cold one, and every night as intensely frosty as it ever is in winter. Yet such is not the case. Cloudy days are often quite warm; while we are all aware that the nights are by no means always very cold. There must be some way in which the sun's heat is stored up, so that it can be felt even when he is not shining.

§58 Let us again have recourse to our first illustration. If you place the back of a chair opposite to the fire, you will find that it gets so hot that you can hardly touch it. Remove the chair to a distant part of the room, and it quickly cools. Hence a part of the heat from the fire has been absorbed by the wood, and again given out.

§59 In like manner in summer the ground gets warmed; in some parts, indeed, becoming even so hot at times that we can hardly keep the hand upon it. In hot countries this is felt much more than in Britain. Soil and stones absorb heat readily, that is to say, soon get heated, and they soon cool again. When they have been warmed by the sun, the air gets warmed by contact with them, and keeps its heat longer than they do; so that even when at night the soil and stones have become ice-cold, the air a little above is not so chilly. On the other hand, when the surface of the ground is cold, it cools the air next it. The ground parts easily with its heat, and a vast amount of heat is in this way radiated at night from the earth outward into the cold starry space. Much more heat, however, would be lost from this cause did not the abundant aqueous vapour of the atmosphere (§43) absorb part of it, and act as a kind of screen to retard the radiation. This is the reason why in hot climates, where the air is very dry—that is, contains a small proportion of the vapour of water—the nights are relatively colder than they are in other countries where the air is moister. In like manner, clouds serve to keep heat from escaping; and hence it is that cloudy nights are not so cold as those which are clear and starry.

§60 The atmosphere, then, is heated or cooled according as it lies upon a warm or cold part of the earth's surface; and, by means of its aqueous vapour, it serves to store up and distribute this heat, keeping the earth from such extremes of climate as would otherwise prevail.