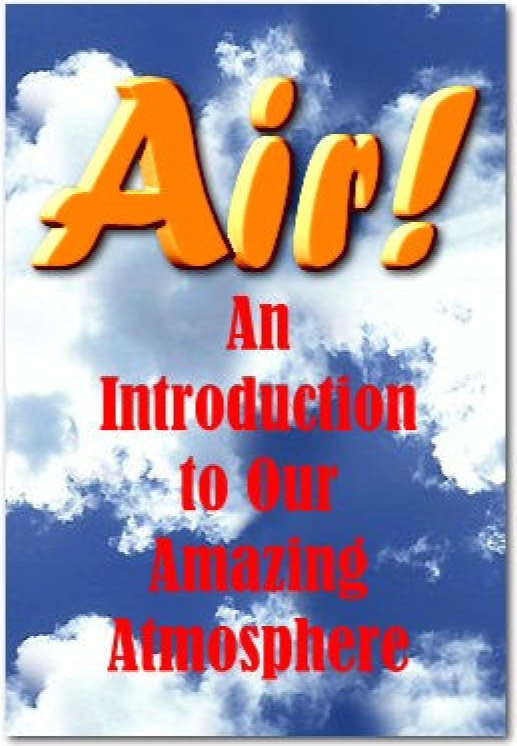

This collection is brought to you by
HomeschoolFreebieOfTheDay.com

Visit us daily for new homeschool, educational, and family fun resources!

Compilation copyright 2009, Jim Erskine, all rights reserved
Permission is granted to distribute this PDF file as long as you do so freely, with no charge to access this document, and that it remains unchanged in any way.

NOTE: This overview of Air and the atmosphere was originally published in 1917, so a few of the references included in this text will obviously be dated. However, there is much excellent material here well worth reviewing with your students. Glean and learn! - JE

The Instability of the Air

We are usually not conscious of the air around us, but sometimes we realize that the air is heavy, while at other times we feel the bracing effect of the atmosphere. We live in an ocean of air as truly as fish inhabit an ocean of water. If you have ever been at the seashore you know that the ocean is never still for a second; sometimes the waves surge back and forth in angry fury, at other times the waves glide gently in to the shore and the surface is as smooth as glass; but we know that there is perpetual motion of the water even when the ocean is in its gentlest moods. Generally our atmosphere is quiet, and we are utterly unconscious of it; at other times we are painfully aware of it, because of its furious winds. Then again we are oppressed by it because of the vast quantity of vapor which it holds in the form of fog, or mist. The atmosphere around us is as restless and varying as is the water of the sea. The air at the top of a high tower is very different from the air at the base of the tower. Not only does the atmosphere vary greatly at different altitudes, but it varies at the same place from time to time, at one period being heavy and raw, at another being fresh and invigorating.

Winds, temperature, and humidity all have a share in determining atmospheric conditions, and no one of these plays a small part.

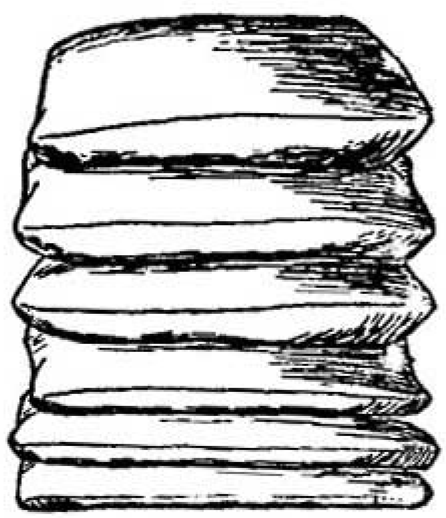

Figure 1 —To illustrate the decrease in pressure with height.

The Character of the Air

The atmosphere which envelops us at all times extends more than fifty miles above us, its height being far greater than the greatest depths of the sea. This atmosphere varies from place to place; at the sea level it is heavy, on the mountain top less heavy, and far above the earth it is so light that it does not contain enough oxygen to permit man to live. Figure 1 illustrates by a pile of pillows how the pressure of the air varies from level to level.

Sea level is a low portion of the earth's surface, hence at sea level there is a high column of air, and a heavy air pressure. As one passes from sea level to mountain top a gradual but steady decrease in the height of the air column occurs, and hence a gradual but definite lessening of the air pressure.

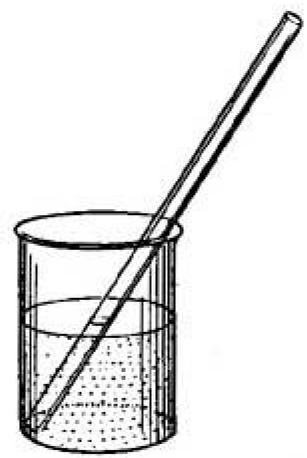

FIG. 2 —The water in the tube is at the same level as that in the glass.

Air Pressure

If an empty tube (Fig. 2) is placed upright in water, the water will not rise in the tube, but if the tube is put in water and the air is then drawn out of the tube by the mouth, the water will rise in the tube (Fig. 3). This is what happens when we take lemonade through a straw. When the air is withdrawn from the straw by the mouth, the pressure within the straw is reduced, and the liquid is forced up the straw by the air pressure on the surface of the liquid in the glass. Even the ancient Greeks and Romans knew that water would rise in a tube when the pressure within the tube was reduced, and hence they tried to obtain water from wells in this fashion, but the water could never be raised higher than 34 feet. Let us see why water could rise 34 feet and no more. If an empty pipe is placed in a cistern of water, the water in the pipe does not rise above the level of the water in the cistern. If, however, the pressure in the tube is removed, the water in the tube will rise to a height of 34 feet approximately. If now the air pressure in the tube is restored, the water in the tube sinks again to the level of that in the cistern. The air pressing on the liquid in the cistern tends to push some liquid up the tube, but the air pressing on the water in the tube pushes downwards, and tends to keep the liquid from rising, and these two pressures balance each other. When, however, the pressure within the tube is reduced, the liquid rises because of the unbalanced pressure which acts on the water in the cistern.

FIG. 3 —Water rises in the tube when the air is withdrawn.

The column of water which can be raised this way is approximately 34 feet, sometimes a trifle more, sometimes a trifle less. If water were twice as heavy, just half as high a column could be supported by the atmosphere. Mercury is about thirteen times as heavy as water and, therefore, the column of mercury supported by the atmosphere is about one thirteenth as high as the column of water supported by the atmosphere. This can easily be demonstrated. Fill a glass tube about a yard long with mercury, close the open end with a finger, and quickly insert the end of the inverted tube in a dish of mercury (Fig. 4). When the finger is removed, the mercury falls somewhat, leaving an empty space in the top of the tube. If we measure the column in the tube, we find its height is about one thirteenth of 34 feet or 30 inches, exactly what we should expect. Since there is no air pressure within the tube, the atmospheric pressure on the mercury in the dish is balanced solely by the mercury within the tube, that is, by a column of mercury 30 inches high. The shortness of the mercury column as compared with that of water makes the mercury more convenient for both experimental and practical purposes.

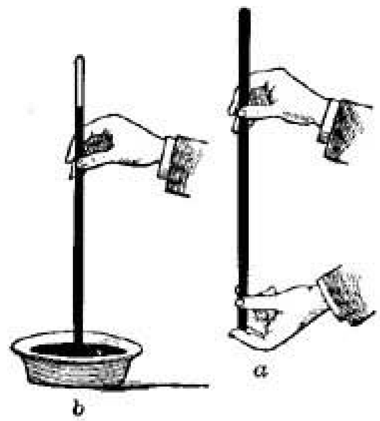

FIG. 4 —The air supports a column of mercury 30 inches high.

The Barometer

Since the pressure of the air changes from time to time, the height of the mercury will change from day to day, and hour to hour. When the air pressure is heavy, the mercury will tend to be high; when the air pressure is low, the mercury will show a shorter column; and by reading the level of the mercury one can learn the pressure of the atmosphere. If a glass tube and dish of mercury are attached to a board and the dish of mercury is enclosed in a case for protection from moisture and dirt, and further if a scale of inches or centimeters is made on the upper portion of the board, we have a mercurial barometer (Fig. 5).

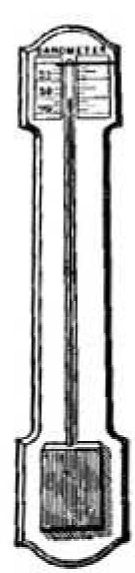

FIG. 5 —A simple barometer.

If the barometer is taken to the mountain top, the column of mercury falls gradually during the ascent, showing that as one ascends, the pressure decreases. Observations similar to these were made by Torricelli as early as the sixteenth century. Taking a barometric reading consists in measuring the height of the mercury column.

A Portable Barometer

The mercury barometer is large and inconvenient to carry from place to place, and a more portable form has been devised, known as the aneroid barometer (Fig. 6). This form of barometer is extremely sensitive; indeed, it is so delicate that it shows the slight difference between the pressure at the table top and the pressure at the floor level, whereas the mercury barometer would indicate only a much greater variation in atmospheric pressure. The aneroid barometers are frequently made no larger than a watch and can be carried conveniently in the pocket, but they get out of order easily and must be frequently readjusted. The aneroid barometer is an air-tight box whose top is made of a thin metallic disk which bends inward or outward according to the pressure of the atmosphere. If the atmospheric pressure increases, the thin disk is pushed slightly inward; if, on the other hand, the atmospheric pressure decreases, the pressure on the metallic disk decreases and the disk is not pressed so far inward. The motion of the disk is small, and it would be impossible to calculate changes in atmospheric pressure from the motion of the disk, without some mechanical device to make the slight changes in motion perceptible.

FIG. 6 —Aneroid barometer.

In order to magnify the slight changes in the position of the disk, the thin face is connected with a system of levers, or wheels, which multiplies the changes in motion and communicates them to a pointer which moves around a graduated circular face. In Figure 6 the real barometer is scarcely visible, being securely enclosed in a metal case for protection; the principle, however, can be understood by reference to Figure 7.

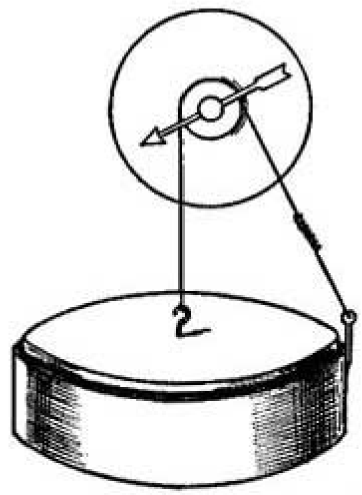

FIG. 7 — Principle of the aneroid barometer.

The Weight of the Air

We have seen that the pressure of the atmosphere at any point is due to the weight of the air column which stretches from that point far up into the sky above. This weight varies slightly from time to time and from place to place, but it is equal to about 15 pounds to the square inch as shown by actual measurement. It comes to us as a surprise sometimes that air actually has weight; for example, a mass of 12 cubic feet of air at average pressure weighs 1 pound, and the air in a large assembly hall weighs more than 1 ton.

We are practically never conscious of this really enormous pressure of the atmosphere, which is exerted over every inch of our bodies, because the pressure is exerted equally over the outside and the inside of our bodies; the cells and tissues of our bodies containing gases under atmospheric pressure. If, however, the finger is placed over the open end of a tube and the air is sucked out of the tube by the mouth, the flesh of the finger bulges into the tube because the pressure within the finger is no longer equalized by the usual atmospheric pressure (Fig. 8).

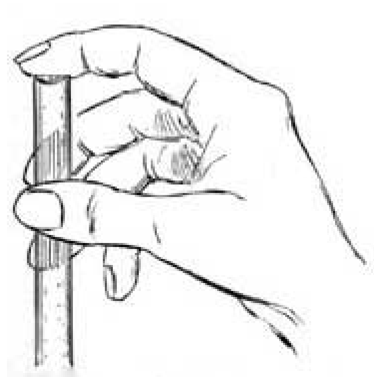

FIG. 8 —The flesh bulges out.

Aëronauts have never ascended much higher than 7 miles; at that height the barometer stands at 7 inches instead of at 30 inches, and the internal pressure in cells and tissues is not balanced by an equal external pressure. The unequalized internal pressure forces the blood to the surface of the body and causes rupture of blood vessels and other physical difficulties.

Use of the Barometer

Changes in air pressure are very closely connected with changes in the weather. The barometer does not directly foretell the weather, but a low or falling pressure, accompanied by a simultaneous fall of the mercury, usually precedes foul weather, while a rising pressure, accompanied by a simultaneous rise in the mercury, usually precedes fair weather. The barometer is not an infallible prophet, but it is of great assistance in predicting the general trend of the weather. There are certain changes in the barometer which follow no known laws, and which allow of no safe predictions, but on the other hand, general future conditions for a few days ahead can be fairly accurately determined. Figure 9 shows a barograph or self-registering barometer which automatically registers air pressure.

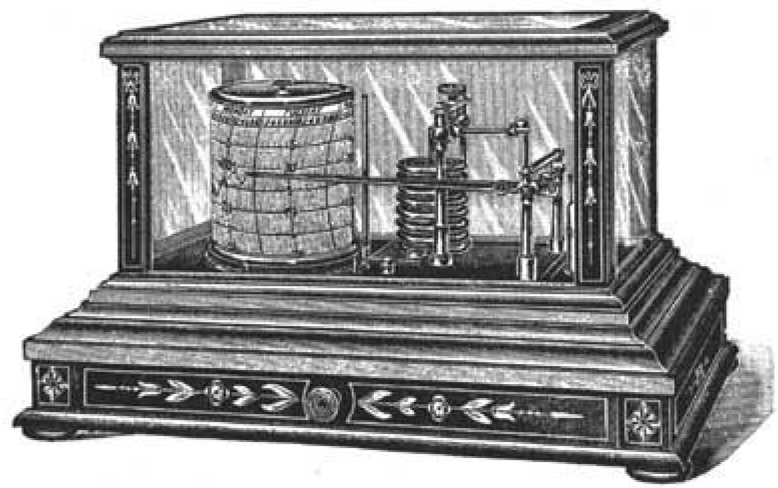

FIG. 9 —Barograph.

Seaport towns in particular, but all cities, large or small, and villages too, are on request notified by the United States Weather Bureau ten hours or more in advance, of probable weather conditions, and in this way precautions are taken which annually save millions of dollars and hundreds of lives.

I recollect a summer spent on a New Hampshire farm, and know that an old farmer started his farm hands haying by moonlight at two o'clock in the morning, because the Special Farmer's Weather Forecast of the preceding evening had predicted rain for the following day. His reliance on the weather report was not misplaced, since the storm came with full force at noon. Sailing vessels, yachts, and fishing dories remain within reach of port if the barometer foretells storms.

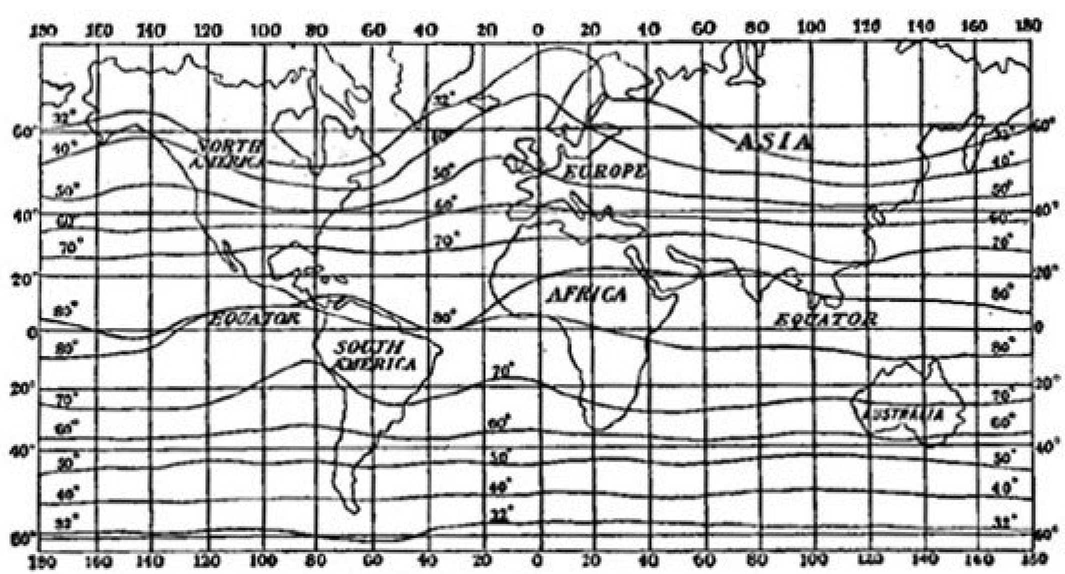

FIG. 10 —Isotherms.

Isobaric and Isothermal Lines

If a line were drawn through all points on the surface of the earth having an equal barometric pressure at the same time, such a line would be called an isobar. For example, if the height of barometers in different localities is observed at exactly the same time, and if all the cities and towns which have the same pressure are connected by a line, the curved lines will be called isobars. By the aid of these lines the barometric conditions over a large area can be studied. The Weather Bureau at Washington relies greatly on these isobars for statements concerning local and distant weather forecasts, any shift in isobaric lines showing change in atmospheric pressure.

If a line is drawn through all points on the surface of the earth having the same *temperature* at the same instant, such a line is called an isotherm (Fig. 10).

Weather Maps

Scattered over the United States are about 125 Government Weather Stations, at each of which three times a day, at the same instant, accurate observations of the weather are made. These observations, which consist of the reading of barometer and thermometer, the determination of the velocity and direction of the wind, the determination of the humidity and of the amount of rain or snow, are telegraphed to the chief weather official at Washington. From the reports of wind storms, excessive rainfall, hot waves, clearing weather, etc., and their rate of travel, the chief officials predict where the storms, etc., will be at a definite future time. In the United States, the *general* movement of weather conditions, as indicated by the barometer, is from west to east, and if a certain weather condition prevails in the west, it is probable that it will advance eastward, although with decided modifications. So many influences modify atmospheric conditions that unfailing predictions are impossible, but the Weather Bureau predictions prove true in about eight cases out of ten.

The reports made out at Washington are telegraphed on request to cities in this country, and are frequently published in the daily papers, along with the forecast of the local office. A careful study of these reports enables one to forecast to some extent the probable weather conditions of the day.

The first impression of a weather map (Fig. 11) with its various lines and signals is apt to be one of confusion, and the temptation comes to abandon the task of finding an underlying plan of the weather.

If one will bear in mind a few simple rules, the complexity of the weather map will disappear and a glance at the map will give one information concerning general weather conditions just as a glance at the thermometer in the morning will give some indication of the probable temperature of the day.

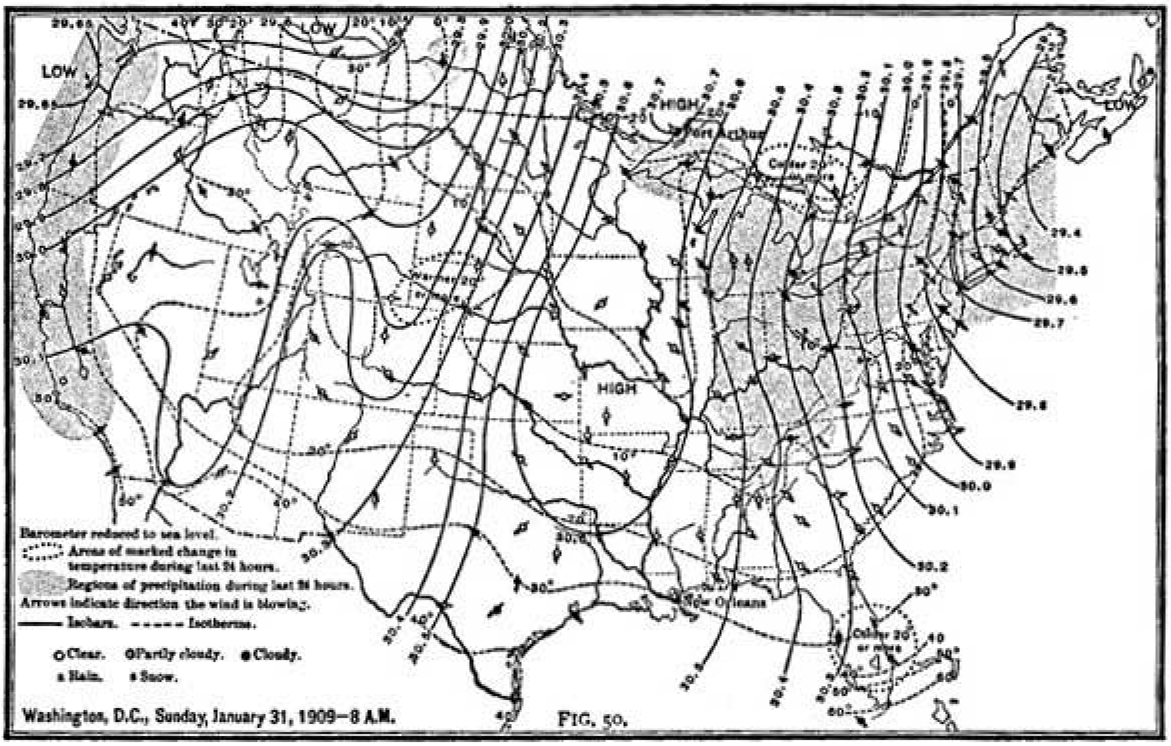

FIG. 11. Weather Map

On the weather map solid lines represent isobars and dotted lines represent isotherms. The direction of the wind at any point is indicated by an arrow which flies with the wind; and the state of the weather—clear, partly cloudy, cloudy, rain, snow, etc.—is indicated by symbols.

Components of the Air

The best known constituent of the air is oxygen, already familiar to us as the feeder of the fire without and within the body. Almost one fifth of the air which envelops us is made up of the life-giving oxygen. This supply of oxygen in the air is constantly being used up by breathing animals and glowing fires, and unless there were some constant source of additional supply, the quantity of oxygen in the air would soon become insufficient to support animal life. The unfailing constant source of atmospheric oxygen is plant life. The leaves of plants absorb carbon dioxide from the air, and break it up into oxygen and carbon. The plant makes use of the carbon but it rejects the oxygen, which passes back into the atmosphere through the pores of the leaves.

Although oxygen constitutes only one fifth of the atmosphere, it is one of the most abundant and widely scattered of all substances. Almost the whole earth, whether it be rich loam, barren clay, or granite boulder, contains oxygen in some form or other; that is, in combination with other substances. But nowhere, except in the air around us, do we find oxygen free and uncombined with other substances.

A less familiar but more abundant constituent of the atmosphere is the nitrogen. Almost four fifths of the air around us is made up of nitrogen. If the atmosphere were composed of oxygen alone, the merest flicker of a match would set the whole world ablaze. The fact that the oxygen of the air is diluted as it were with so large a proportion of nitrogen, prevents fires from sweeping over the world and destroying everything in their path. Nitrogen does not support combustion, and a burning match placed in a corked bottle goes out as soon as it has used up the oxygen in the bottle. The nitrogen in the bottle, not only does not assist the burning of the match, but it acts as a damper to the burning.

Free nitrogen, like oxygen, is a colorless, odorless gas. It is not poisonous; but one would die if surrounded by nitrogen alone, just as one would die if surrounded by water. The vast supply of nitrogen in the atmosphere would be useless if the smaller amount of oxygen were not present to keep the body alive. Nitrogen is so important a factor in daily life that an entire chapter will be devoted to it later.

Another constituent of the air with which we are familiar is carbon dioxide. In pure air, carbon dioxide is present in very small proportion, being continually taken from the air by plants in the manufacture of their food.

Various other substances are present in the air in very minute proportions, but of all the substances in the air, oxygen, nitrogen, and carbon dioxide are the most important.

THE END

This collection is brought to you by
HomeschoolFreebieOfTheDay.com

Visit us daily for new homeschool, educational, and family fun resources!

Collection copyright 2009, Jim Erskine
Permission is granted to distribute this PDF file as long as you do so freely, with no charge to access this document, and that it remains unchanged in any way.