time and harvest, your crops, after all your labour, are dependent on the weather. Would any help from science, which should teach you to foretell the probable weather 24 hours in advance, be a thing to despise? Two ploughs are offered you for sale — equally showy in appearance — would science be useless, if by means of the *dynamometer* she showed you which of the two would give your horses the less work? Two samples of manure—guano, superphosphate, or what not, are forwarded to you for choice: science can tell you the comparative value of each: will you spurn her aid? What is this *science* after all but a Latin word equivalent to our old English word *knowledge*. I don't know any modern trade that can get on without it. The builder can't, he may never have heard of the *parallelogram of forces*; but he must know all about levers, pumps, screws, and arches. The miller can't, he would not be able to adjust the diameter of his wheel to the cubic contents of the bed of his stream without it. The tanner does not refuse the aid of science in hastening the preparation of his leather, or in cheapening the materials used in his pits, and the dyes of the cloth manufacturer would be but strangely blended, were it not for the *mordants* which his chemist enjoins him to use.

Some time ago, a foundry-proprietor, weary of paying out money for coals, determined to utilise a fine water-power which lay about 2 miles from his establishment for the purpose of working his fan or blast. The pipes were laid, and the fan went to its duty with great energy—no effect though in the cupola! How so? There must be a hole through which the air escapes—pipes were taken up and cased in tarred cloth: still all the sound in the cupola was as of an asthmatic old man wheezing away at a tobacco-pipe that would not draw. At last, *science* was consulted, and replied, in effect, that the foundry-proprietor might have saved all his outlay had he consulted her at first: the friction against the sides of the pipes had devoured all the power of the blast.

The days are coming when, in these old cultivated lands, we shall have but a choice of two things: either to let the soil revert to its former state of *bush*, or to restore its fertility by means of artificial manures and stock feeding. If we prefer the former—well, we must depend on others for our food, and become a purely manufacturing community. If the latter, without we know something of science, we shall be robbed with impunity on all sides.

Now, science is to many a word of vague meaning and vastly terrific sound. It must not be allowed to frighten you, though. The more you know of science in general the better you will understand its principles. I mean its foundations, you need not be an engineer or an analytical chemist to be very usefully fitted for your agricultural career. A few weeks earnest application for 3 or 4 hours a day would give you such an insight into the practical working of those branches of science that concern you, that you would feel yourselves in a in a position to detect a fraud whenever you meet with it—and that, at all events, is more than 99 farmers out of 100 can do now. Of all impossible lies that are told in the world, commend me to those told by certain men who have trees, implements, or manures to sell. If you can learn, by a little study, how to avoid being robbed by those scoundrels, you will not have wasted your time.

I shall now proceed to consider that branch of science with which perhaps we have most concern—*Pneumatics*, we could not breathe without *pneuma*—the breath—but with us it has a wider signification. Pneumatics treats of the air, and the laws which govern its condensation, rarefaction, and gravity. The body of air surrounding the entire surface of our globe is supposed to be about 57 miles high. You can form no more idea of this than you can of what 200 million dollars are; but conceive a ball one foot in diameter having been left untouched in your drawing room, by a careless housemaid, until it has accumulated a coating of dust one-tenth of an inch in thickness. that is about, the relative proportion of the earth and the circumambient air.

Air has weight (gravity is just the same thing; the force of gravity is the force of weight): 100 cubic inches of air at 60° F. and with the Barometer at 30 inches, will weigh about 30 grains. So you see it has a considerable power of pressure—if taken at 50 miles high and at the above weight the force would be 15 lb. per square inch. This, in mechanics, is said to be one *atmosphere*—as you may see on the *steam gauge* of any engine: 5½ quatrillions of tons, or a ball of lead 60 miles in diameter, represents the total weight. Powerful stuff enough when bought wholesale isn't it, though it is such a thin, almost imperceptible concern, as we walk through it? If it is so heavy, why does it not, all round and above us as it is, crush us to death? A man of ordinary size contains on his surface about 2000 squares inches—the air presses upon him with a force of 2000 × 15 = 30,000 lbs. and yet he is not powdered! Fortunately, in obedience to the laws of equal and contrary pressure of the air *without* and *within* the body, the catastrophe is prevented. And of what is this wondrous atmosphere composed?

It contains in every 100 parts:

	by measure.	by weight.
Nitrogen.........	77.5	75.55
Oxygen.........	21.	23.32
Carbonic Acid.	0.08	0.10
Water in vapour	1.42	1.03
	100	100 (1)

Observe how the carb. ac. is proportionately heavier than bulky—how watery vapour *distends* the air.

There is no chemical combination here, merely mechanical mixture. Add the two papers of an ordinary Sedlitz powder to a glass of water, and you have chemical combination—Stir up a spoonful of sugar with a spoonful of mustard, and you have mechanical mixture.

Here we are at a standstill, for we don't know anything about N., O., or C., but let us say for the present that N., often called Azote, or *life depriving*, as no animal can live in it, has to be thinned by Ox. or *acid generator*, to make our air breathable—as in N. death comes from impossibility of breathing, so in O death ensues from rapidity of living: in N. a candle won't burn, in O. it burns out like fury.

These proportions in the air never vary. Animals and vegetables use the air in all places, and in using it *change* the proportions, but the sun's heat in the tropics, and their luxurious vegetation, evolve an abundant supply of oxygen, while, perhaps, the predominant existence of animals in the colder regions affords plenty of carbonic acid — this however is not certain, but at all events, whatever the source, the beneficent winds of heaven mix all the constituents of the air together, and make them fit for our inhalation.

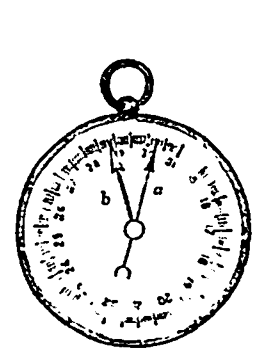
(1) I say nothing about the newly discovered element *Argon* (1895), because it is, as yet, unknown to the crowd.

There ought to be in every farmhouse in the country an instrument to measure the gravity of the atmosphere —the *Barometer* — I should recommend a well made *aneroid* as the more sensitive, tho' the upright mercurial barometer is, if large enough in the tube to overcome or lessen the friction, correct enough for all practical purposes.

Now, this instrument is founded upon a very simple theory: the column of mercury is 30 inches high, and of exactly the same weight as a column of air of the same diameter, 50 miles high, and of a column of water of the same diameter, 33 feet high. so that, as you may observe, the air pressing on the open end of the tube keeps the column of mercury in equilibrium. Let, however, the air become drier or more moist, and a change takes place. in the first case the Barometer rises, in the second it falls. How is this? Is dry air heavier than moist air? I answer the question by another—is a bushel of dry sand heavier or lighter than a bushel of wet sand—a bushel of dry wheat than a bushel of wet wheat? What did we find in the air besides Nitrogen, Oxygen, and Carbonic acid? a little vapour, which by weight formed 1.03 of the 100 parts; but in bulk 1.42. Moisture, then, from its excessive tenuity in the vaporous form we find it taking in the atmosphere, causes the air to occupy more space, so to speak, and therefore to become lighter—but, in dry weather, the air becomes dense, from the highly elastic vapours, and presses with increased force upon the exposed mercury. I may as well mention here that, in the *common pump* the same principle is called into play. The plunger, in rising when the handle is depressed, withdraws the air from the chamber of the pump; and the column of air pressing on the water of the well or tank, causes it to rise, and fills the chamber which has been exhausted of air. Theoretically, 33 ft. 9 in. is the limit of the action, but practically, pumps won't lift above 28 or 29 ft. The force-pump acts by both the elasticity and the pressure of the air. The ordinary force of the column of air raises the water to the 30 ft., or so, and the elastic force of the air in the condenser sends it thence 200 or 300 feet onwards: as in your fine fire-engines.

The *Siphon* is also dependent on the same principle. Here we have a bent tube with two unequal limbs, the greater the difference between the length of the limbs the more efficient the instrument. But to return to our Barometers. there is another form of these "weather glasses" as they are sometimes called. the aneroid from a *aeros, without moisture* (1). This handy, nay, elegant little instrument is the most portable of all barometers, and, if carefully constructed, the most correct; but it should, now and then, be compared with a mercurial barometer and, if in error, corrected. Take care in buying an ordinary barometer to see that the column is large enough: if small, the mercury won't work freely, it will stick to the sides of the tube.

(1) The *aneroid barometer* is an invention by M. Vidi, of Paris. Its action depends upon the effect produced by the pressure of the atmosphere on a metallic box, fr . which the air has been exhausted: the box is then hermetically sealed. As the weight of the atmosphere increases or diminishes, the surface of the corrugated elastic box is depressed or elevated, as is also at the same time the spiral spring upon which the principal lever rests; and this motion is communicated through the levers to the *arbour* of the hand. The tension of the box in its construction is equal to 44 lbs.



Aneroid Barometer.

We may as well take the Thermometer into consideration at once, and then we shall be free to attack with these weapons our great and interesting object *Meteorology*.

You all know what heat is, or rather what it does. A pint-pot will hold a pint of cold water—but by no means can you keep the liquid in the measure when it is nearly boiling; heat then expands objects: cold on the other hand, contracts them. Heat is the great opponent of gravity. If gravity acted alone, everything would be a dense solid; there could be no life. The property of heat is to part asunder the atoms of all bodies. it is invisible, and imponderable. I must harass you with a difficult phrase; "latent heat"; all bodies contain this quality or whatever you like to call it, it lies hid in them, and is brought into notice by friction. Rub two pieces of wood together and what happens? heat is evolved: whence did it come? it was there in the wood, and the friction drew this latent heat to the surface. Why? Because motion always is accompanied by heat, a law of nature, and the intensity of heat is always in a specific relation to the velocity of motion. You see then that no instrument can measure this latent heat: what does that which we call a *heat measurer* do? All that we require of it: it indicates the *relative* amount of heat in various bodies, or in the same bodies under different circumstances.

You are all familiar enough with the ordinary Thermometer. A simple glass tube, air exhausted, hermetically, sealed. Three sorts are in use—Réaumur's, the Centigrade or Celsius', and Fahrenheit's.

Now, the principle on which these are constructed is the same in each. It is only in their notation that they differ. Réaumur, a Frenchman, (1683) was the first to propose the use of mercury as the expansive medium in the thermometer. Alcohol had been used, but its expansion proved to be irregular. He took the melting point of ice as his *zero*, and each of the divisions he made equal to $\frac{1}{1000}$ part of the bulb capacity. Fahrenheit, a Dane (1686 to 1736), ingeniously fixed on another standard point—that of boiling water under the mean pressure of the atmosphere; in his scale 212°. He called the melting point of ice 32°, and fixed his *zero* at what he, erroneously, supposed to be the greatest cold, viz. a mixture of salt and snow. Celsius, a Swede, (1670 to 1755), starting from the same point as Réaumur, divided his scale into 100 parts; hence the name given to it:

The conversion of these notations is easy enough: