Now I would like to suggest that in drawing up a syllabus the first consideration should be the child and the average child at that, due emphasis being placed on all aspects of Science teaching and not on any one in particular, and bearing in mind that the average child is being trained for life and not for a university course. This would involve the cutting down of the present syllabus, to enable the treatment of each subject to be really scientific. Honours courses should be deleted for, with few exceptions, honours work in one subject means failure or poor work in another. It is much better that a child should have a balanced schooling.

Science teachers should strive earnestly for at least twelve periods per week for Science, in all secondary schools, so that Science could be given its due place in the curriculum. This would enable three sciences to be taken to the present standard. It is unfortunate that girls and boys should spend five years on any Science course without at any time using a microscope. Students always evince great interest on viewing such things as the fossil remains of foraminifera, or the aquatic feats of an amœba. Will anyone say that such interest is of less value than the mental coma induced in large numbers of non-mathematically minded students on hearing of the oxidizing actions of potassium bichromate, or of the relation of the thermal coefficients of gases?

Why should so much interesting matter be omitted and so much of little interest and value to the average student be included?

ATMOSPHERIC ELECTRICITY.

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It is very difficult to tell even a little about electricity in our atmosphere without telling a lot, because many pieces of information fit in together to form a complete picture of what is taking place. A few definitions and explanations will help.

Lightning is an electrical spark—an electric discharge—between two portions of a thunder cloud, between two clouds, or between cloud and earth. When we talk about "earth", we mean not only the ground itself, but all things connected with the ground, such as houses, trees, animals, people, and even the blades of grass; the electric charge reaches the actual earth in all cases where it strikes objects connected with the earth. Electric charges are of two kinds, positive and negative; a body which has equal quantities of positive and negative electricity is said to be neutral; one which has more positive than negative is said to be positively charged, and one which has more negative than positive is said to be negatively charged. The earth is *negatively* charged, and other *positively* charged bodies or positive charges of electricity are attracted to it. Unlike charges attract one another, like charges repel one another. The unit of quantity of electricity, or electrical charge, to which I will refer in this article, is called a coulomb, and represents a certain arbitrarily fixed amount of electricity; if I pull it away from where it wants to go, I have to do work; the further I move it against the force, the more work I have to do.

The earth is negatively charged, so that positive charges are attracted towards it, and work would have to be done to pull them away up into a cloud overhead; and if they were allowed to come bounding back to earth again, they could do that same amount of work on their journey, or on arrival. We say that there is an "electric field" round the earth, and measure it vertically in terms of the work we would have to do in moving a unit positive charge of a coulomb every one centimetre up from the earth. When we move the coulomb up through a centimetre, and have to expend one joule of work in the effort, we say that the "potential difference" between the two places is one volt, and that this is a vertical electric field of one volt per centimetre. (The difference in potential is one volt, if we do one joule work in transferring one coulomb.) This electric field is fairly uniform, even in its periodic fluctuations, in fine weather. It has an average value of the order of 100 volts per metre, which is 1 volt per centimetre; so that is easy to remember. A thundercloud 15 miles off makes practically no difference to this; but as the cloud approaches, the field increases in strength, till when the cloud is five miles off the field may have risen to 50 times as much over level ground, and be 5,000 volts per metre. When a thundercloud is overhead, the field is found to rise to as much as 20,000 volts per metre. That means that every coulomb charge of electricity moving down through a single metre has energy of 20,000 joules to expend.

Lightning is seldom the actual transfer of this electricity to earth, most discharges being within a cloud, or between clouds. The quantity of electricity that passes in each discharge ranges up to 100 coulombs, with an average value of 20 coulombs per "flash". In the land of thunderstorms, South Africa, it is estimated that nine-tenths of the lightning flashes are within the clouds, not to earth; but the percentage of discharges to earth over the world is far greater, estimates of one-fourth of the total having been made.

You know what a Kilowatt is; it is energy expended at the rate of 1000 joules a second. Consider this, then—an average "life" of a thunderstorm is about an hour, and the lightning represents the development and expenditure of energy at the rate of some three million Kilowatts continuously. So that the energy expended during an average thunderstorm is $3 \times 10^6 \times 10^3 \times 3600$ joules, which is about 10^{13} (ten million million) joules. Using another unit with which you are familiar, the Kilowatt-hour: 3 million Kilowatts for an hour is energy of 3 million Kilowatt-hours. The City Council commences by charging me 5d. for supplying a Kilowatt hour of energy, so that the thunderstorm represents at that rate 15 million pence, or some £60,000. Is it any wonder that it makes a noise?

It is estimated that throughout the year, over the world, there are some 16 million such storms; I will leave you to multiply £60,000 by 16 million, and get a possible sales value for the lightning displays.

Sixteen million storms per annum is 44,000 per day. Taking the average duration of an hour, there are 1800 such storms going on at once; and they represent over 100 lightning flashes every second, or 360,000 every hour amongst them. These movements of electricity represent energy being turned into heat (without the destruction of the electricity itself) at the continuous rate of 4×10^9 Kilowatts—a roaring and a crackling going on continuously, dissipating energy at the same rate as an ever-running engine of five thousand million horse power; if you find it hard to think of such a powerful engine, contemplate instead an engine working at 50 horse power: it is equivalent to one hundred million of those 50 H.P. engines for ever exerting their full power.

The energy for all this comes from the sun, which causes the upward movements of air and water vapour to separate out the electric charges. This work being available, there are two views as to how the electric charges are separated out so that thunderclouds become differently charged in different parts, and differently charged from the earth. Professor C. T. R. Wilson has a theory by which large droplets on forming become negatively charged, and tiny droplets positively charged. The large droplets fall rapidly towards the bottom of a cloud, carrying their small negative charges, so that the bottom of a cloud becomes negatively charged with electricity. The tiny droplets fall very slowly, so that the top part remains positively charged by the electricity on them; this separation continues till the difference in the charges produces such a strong electric field, and such a big difference in potential, *i.e.*, difference in voltage, that the air column in between breaks down, and the spark passes. Naturally, also, the effect of this big separation of charges in the clouds makes such big changes in the electric field between the earth and parts of the cloud that sometimes the air below breaks down, and the "lightning strikes to earth"—in other words, a negative electric charge rushes down to the ground.

The theory of G. C. Simpson is that the electric charges are caused by up-currents of air. Water drops falling faster than about 20 miles per hour are all broken up—no drop can fall faster than that. So that a vertical wind (or the vertical component of a wind) of more than that would carry up all drops with it, and break them up. Breaking up water drops causes them to become electrified, the broken drops becoming positively charged, and an equal but negative charge remaining on the air. The drops are carried up till the wind, spreading out, loses velocity; this leaves a cloud, the upper part of which is positively charged, which is the phenomenon to be explained.

On either theory, the portion carrying a particular charge is supposed to be of the order of ¾ mile across; one may imagine a distorted sphere of diameter ¾ mile carrying one charge.

The difference in potential between two portions, such as these, carrying unlike charges, is of the order of *a thousand million volts.* To give you a comparison, the difference in potential between the two sides of your electric light terminals at home is 240 volts (meaning that you can get 240 joules energy by letting one coulomb of electricity pass between the terminals). A single flash generally completely discharges the cloud for the moment, reducing the field from it to zero; and an average active cloud charges and discharges itself by a flash every 20 seconds, as a mean time value. Each flash represents the passage of some 20 coulombs, at an average potential difference of 10^9 (a thousand million) volts. So that the work done is 2×10^{10} joules. Most of this is converted into heat due to the resistance offered to the passage of the electricity along the flash, and so represents the production of 5×10^9 (five thousand million) calories per flash. The average length of a flash within the clouds is 2 miles. So that heat is spread through the air and water droplets over that distance. The five thousand million calories would be sufficient to raise the temperature of 50 tons of pure water from freezing point to boiling point, or some 200 tons of air through the same temperature change. The enormous air expansion, and subsequent contraction, along the heated path of the flash, causes the thunder which is heard. In a flash several miles long, different parts of the path are at different distances from the observer, and the sound travels to him at only 1,100ft. per second; so that there may be relatively big intervals between his hearing the sound from the nearest part of the flash and from that farthest remote. This causes the rumble.

The time taken for a single flash seems to be of the order of 0·001 second. It is apparently a unidirectional pulse which rises to a maximum and falls to zero. On this are superposed ripples or oscillations of frequency round 10 Kilocycles—that is, oscillations corresponding to radio wave lengths of some 30,000 metres. From this point of view a lightning flash can be looked upon as a transmitting aerial some 2 miles long, earthed at its base; this would only give a radio wave length (for your sets to pick up as atmospherics) of 12,000 metres; but the flashes have many branches.

Some flashes appear to last for as long as a second; photographs taken with a camera moving laterally so as to get a number of photographs side by side on the plate during the second show that it is a number of different flashes, taking much the same path, but with sufficient difference and branching to give the "jumping" effect observed.

You will be interested in the values of the electric currents, which are the average time rates of transfer of the quantities of electricity. The quantity transferred in a flash we will consider as 20 coulombs; the time of such transfer as ·001 second. A coulomb transferred per second is said to be a current of 1 ampere, so that the average "current" in our flash would be 20,000 amperes. This *average* value is much less than known maxima, for we have evidence in flashes to earth (by observing the crushing of lightning conductors, for instance) of currents as high as 500,000 amperes.

What of the "thickness" of a flash, or the actual cross section of the current stream? It is calculated as being about six inches in diameter. This is supported also by the measurements of "fulgurites", rods of rock formed in sand where lightning strikes it. They are some 2 inches in diameter, and we know from experiments that the diameter of a flash in the air is some three times that on entering the conductor. Lightning flashes to earth nearly all convey negative electricity to earth. Whether positive electricity is drawn up to the intense negative charge under the cloud, or negative electricity goes down to the *relatively* positive earth, is not definitely known. Extremely rapid photographs by Boys show a flash beginning in a zone 500 metres above the earth, and spreading up and down simultaneously.

The electric field in the vicinity of the earth is very much disturbed by irregularities in the surface, so that the current may stream away from points or knobs as a thundercloud passes by. The discharge is often so great that a glow is seen, as in the case of the so-called "St. Elmo's fire" on masts of ships. The function of lightning arresters, metal points connected to earth, is thus to discharge approaching clouds and lower the value of the electric field between them and earth, so that the charge will not pass as a destructive flash to high objects, such as the houses thus protected. Sometimes the flash does pass as a sudden discharge to the "conductor", which should therefore be of big surface area, low resistance, and pass to earth without any sharp bends; it should be buried in wet coke in the earth, there to dissipate the energy over a big area. Houses struck are ripped to the foundations by the dissipation of energy in the bad conducting walls; trees are torn open, and denuded of bark down the path of the electricity to earth; men and animals are killed.

In the absence of buildings, trees, bushes, even the blades of grass provide "discharge points" for passing thunderclouds. As an example, Schonland, in South Africa, took a small tree 13 feet high, cut it off at the base, and mounted it on insulators, so that current would pass between it and earth through a current-measuring instrument (a galvanometer). When the field reached 16,000 volts per metre, for example, the silent discharge was 4 microamperes (4×10^{-6} amps.). He calculated that the combined effect of all exposed natural conductors in the area within the influence of the cloud would be quietly discharging it at the rate of 2 amperes, in an upward direction.

This article will serve to give you some idea of the mechanism of thunderstorms, and of lightning; and should also suggest to you the magnitude of the energy involved. Nothing was known of it prior to the time of Franklin; he in 1737 believed it to be caused by "the inflammable breath of the pyrites, which is a subtle sulphur and takes fire of itself"—but advanced to the correct ideas, associating it with electricity, by 1749.

We have yet a lot to learn about atmospheric electricity.

THE INDO-MALAYAN (INCLUDING PAPUAN) ELEMENT IN AUSTRALIAN FLORA.

By Thistle Y. Harris, B.Sc.

Over a vast continent such as Australia one expects to find a great variety of plant life, since the climatic conditions and geological formations differ so markedly in different regions. Broadly speaking, however, the flora of the whole of Australia may be classified into two great groups :

(*a*) Endemic types, which are predominant and which, according to Bentham, either originated in Australia or were differentiated here in direct response to the