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SUGAR PRODUCING PLANTS.[1]

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I have to speak of the manufacture of sugar and the plants from which it is extracted. Of all the chemical industries properly so called, this is probably the oldest, and it is now the greatest, both as regards the capital involved and the general importance to all classes of mankind. It is said that the march of civilisation in a country is marked by an increase in the consumption of sugar and of soap, and this is certainly supported by present statistics. The world seems to have got on very well with little or no sugar until the 16th century of our era, when the introduction of tea and coffee into Europe increased the demand an hundred-fold and more, and refineries were established in Holland and England.

The origin of the sugar industry is naturally shrouded in the darkness of a time very far past. We consider the word sugar to be derived from the Persian *shukkar* which, with the Arabic name of the same pronunciation, comes from the Sanskit *sarkara*. It is, however, impossible to tell from ancient writers whether the substance frequently

[1] Sommerville Lecture delivered April, 1889.

alluded to as resembling honey and used in medicine was sugar or not. Most probably it was, but in the form of syrup and not at first in crystals.

Galen and Pliny, in the beginning of our era, spoke of a substance called *saccharum* found in Arabia Felix, and only used in medicine, and in the Bible we all know of the mention of sweet calamus and cinnamon in Solomon's song, and of sweet cane in Isaiah and Jeremiah. Herodotus speaks of manufactured honey, and Nearchus, one of Alexander's admirals, tells of a reed which gave honey without bees.

Moses Chorenensis, however, is the first writer to mention the boiling of plants, in this case sugar-canes, for the extraction of sugar, and the first European home of the sugar industry was in Sicily where Frederick Barbarossa found many factories when he invaded Italy in 1121. From Sicily the culture of the cane gradually spread into Spain, and from thence was carried by the Spaniards into the West Indian Islands and Brazil. Here it found a congenial climate similar to the Indian one, from whence it came, and soon it became a source of great wealth, there being no less than twenty-eight sugar factories in San Domingo in 1518. It became apparent that the cane was meant to flourish in tropical countries and the cultivation in Europe died out, so that for over 300 years sugar came to Europe over the sea from equatorial countries and was produced almost entirely from the sugar-cane, which had come to be looked upon as the only practical source of sugar.

In the year 1747, however, a German chemist named Markgraf announced the discovery of 6 per cent. of sugar in certain sorts of roots which grew in northern Europe. This was looked upon as a botanical fact of small value to the world at large, until another German named Achard erected a little factory on his farm at Cunern near Breslau, and began actually to produce fine white sugar from Markgraf's roots. Furthermore, he made money at the same time, which was vastly more important, and drew the attention of all thinking men to the fact that a new source of wealth had arisen in Europe. From that moment, in fact, a mighty rival to the veteran sugar cane appeared. It might have been long, however, before it could have coped successfully with foreign sugar, had not the first Napoleon, whose eye was as keen in peace as it was in war, lent his mighty help to the struggling industry in France, where Crespel Delisse and a few others, recognizing the value of Achard's results, were striving to establish the new industry on a firm footing. The result was in accordance with the Emperor's favorite maxim that God favours the heaviest battalions, other things being equal, and beet sugar rose steadily in France. Germany followed the good example, and then Holland, Belgium, Austria and Russia took it up. To-day out of five million tons of sugar consumed in the world per annum, more than half is made from the sugar beet. The rest is made from the sugar-cane principally, and some from the date-palm, the sugar-maple with which we are familiar, and the sorghum or bastard sugar-cane. The only plants which deserve any extended notice are the cane and the beet, for they alone are of commercial importance. The sorghum is capable doubtless of great things, although, up to now the costly and valuable experiments of the United States Government with it, have not resulted in much progress among the growers of the plant.

I will speak first of the sugar-beet, as it now occupies first place as a sugar-producing plant in the world, and bids fair to hold its own against all comers.

The sugar beet is a hardy biennial plant, indigenous to the south of Europe. We are all familiar with the shape of the ordinary mangel wurzel, and it resembles this more than any other, being white in the flesh and not *red* as many suppose. It is smaller than the mangel and much heavier in proportion. When from good seed and properly cultivated, it grows entirely beneath the ground, only the collar, from which the leaves spring, showing. Extensive experiments and cultivation have produced an immense number of varieties, but the origin of the rich sugar beet is the old root known to botanists as the *Beta alba*. Only the part which grows below the ground is valuable to the sugar-maker, but the leaves and collars make first rate cattle food. Sugar beets are propagated from seed entirely, which is produced by the plant in the second year of its growth. The seed is sown early in the spring, in long drills, and now almost entirely by machinery. The drills are usually about eighteen inches apart and every year efforts are made to sow them closer, for the farmer as well as the manufacturer likes small and heavy beets rather than large and porous ones.

In about a week's time the small plants show themselves above the ground and all attention is paid to the thinning out. This is a delicate process which must be done by hand and on the proper performance of it everything depends. The plants are taken out so as to leave only one by itself, every eight or nine inches in the row, and children are found to be best adapted for the work. In the beet districts there is a continual struggle between the school authorities and the farmers as to who shall have the children in the spring time, and the school inspector usually has a hard time, for he has to contend with the parents and the children themselves, as well. I have seen as many as fifty boys and girls working slowly across the fields in a long row, and in Bohemia often three times as many, all of whom ought by law to have been in school. And often have I seen a sudden stampede from the fields, led by the overseer himself, at the sight of a gendarme in the distance. In fact in my apprenticeship days, I have several times found it very advisable to depart from the fields with more rapidity than dignity and to let the youngsters take care of themselves, which Bohemian children are well qualified to do. After the beets are thinned out the fields are left alone for a few days to allow the young plants to gather strength, and then the weeding and hoeing begin. This is done now almost entirely with machines drawn by horses, which keep turning up the ground and destroying the weeds between the rows, until the leaves of the beets get to be large and begin to cover the ground completely. Then they are left to themselves till the fall, when in the latter end of September they are taken out. At this time the leaves are yellowish and the root firm and heavy, the growth being ended for the first year, while in the root is a store of sugar, which it has accumulated for further use, as bees do honey. But before it can get a chance to use the sugar in the second year's growth, the manufacturer takes it out of the ground and carries it off to the factory. The harvesting is done either by hand, loosening the roots with a narrow spade and then pulling them out, or by special plows for the purpose. The leaves and heads are cut off on the field and the roots transported to the factory for immediate use, or put into what are called *silos*. These are large piles of beets covered over with eight or ten inches of earth to keep out the frost. It is a simple and good way of keeping any roots, and now universally adopted instead of the costly buildings or cellars of former years. In these the beets may be kept safely until they begin to grow again, which time depends much on the weather and the country. In France it is difficult to keep them after New Year's day, while in Germany they may still be in good condition in February. In Russia and Canada they are perfectly inactive as late as the end of April, owing to the continuous cold. Once the sprouting begins, a series of chemical changes takes place in the root, the principal one being the transformation of the crystallizable sugar into another form which is useless to the manufacturer. On the other hand the beets may be frozen without damage, always supposing that they are worked up while still frozen, for, inasmuch as the freezing kills them, they rot as soon as they thaw, and the process of putrefaction partially destroys the sugar as well as makes the work in the factory well nigh impossible.

In the culture of the sugar beet, the two primary considerations are, first the seed and then the soil. On the kind of seed depends, entirely, the richness of the beet and, the soils being the same, the size of the beet. Small beets are usually rich, large ones poor in sugar, and the great object of the manufacturer is to get as much sugar as possible per acre. The different kinds of beets are crossed and re-crossed until finally the proper beet for the particular country is got at. It is remarkable, indeed, to note how the roots have increased in richness in the past twenty years. Then six to eight per cent. was common in Germany, but now they will not have anything under 15 per cent. with an ordinary crop, and plant seed beets which contain over 20 per cent. The man to whom the honour of this improvement is due is Vilmorin, of Paris. He took the old Silesian beet and by long and careful cultivation produced a small beet containing a great deal of sugar, and also very pure. Every year the German, Austrian and Russian seed growers buy from him at whatever price he likes to ask, and keep improving their stock until now they export seed back to France, for all this time the Frenchman could not appreciate their countryman's efforts, and continued to grow the old cattle beet until the Germans got so far ahead that they exported sugar into France. In 1884 came a terrible crisis, and all turned their eyes to Germany to find that they were far behind, and all on account of bad seed.

The nature of the soil has a double effect on the beet. It affects the size of the crop and also its quality. Beets may be considered as consisting of five to six per cent. of what is called mark or insoluble fibrous matter, and 94 to 95 per cent. of juice. In this juice the sugar is dissolved and also, unfortunately, a number of other substances, which are salts of lime and potash joined to organic acids, and various complicated gummy matters. The presence of these is the cause of molasses. That is to say, the more of them, the more molasses, and the less pure sugar results from the process of manufacture. It is, therefore, of great importance that there be as little as possible of them, and their presence is determined greatly by the nature of the soil and the manure which is used. It is practically true that the only substances a plant derives from the soil, are phosphoric acid, nitrogen, and potash, and, therefore, manures are only of value inasmuch as they contain these substances. Of these, the one we wish most to avoid is potash, and it is a fact that this is a substance for which a beet has a most unreasonable fondness. It will absorb potash just as a child will eat candy, and grow large and coarse, yielding an impure salty juice of small value. Wherefore potash is used very sparingly, only in fact, where the absence of it in the original soil is so marked as to render an addition absolutely necessary for the life of the plant. Again nitrogen is an element to be avoided in excess, for its use results in large spongy beets, which will not keep and yield impure juices which are very difficult to handle. The chemically inclined readers of this paper will be interested in hearing that a strong odour of nitrogen peroxide is frequently observed in the factory where the beets are obtained from dark rich soils, or those on which a Chili saltpetre is used in excess. And when such beets are decomposed by heating in the silos, they give out in the process of manufacture, inflammable gases which often cause violent explosions.

The remaining element of nutrition which the plant requires, phosphoric acid, is the greatest friend the sugarmaker has. It counteracts the alkalies in the juice, forming a harmless combination, and has also a ripening action which is most valuable in backward seasons. Therefore, when manuring, we add to the soil plenty of phosphoric acid and a little nitrogen, while potash is generally forbidden; and in selecting a soil we avoid very rich ones, or alkaline ones, and select a light, warm one if possible. But really, the only way to tell whether a certain soil is fitted for the culture of the beet as a general rule, is to sow some seed and see what will come of it. Chemical and physical considerations are wonderfully helpful in agriculture and have revolutionised that science, but up to now no chemist can tell what a given soil is best adapted for by analysing it, unless of course there be certain very marked characteristics. As a rule, however, beets will grow almost anywhere, and will stand more rough usage from the weather than any other crop. Their greatest enemy is water in the subsoil, which kills the young roots as soon as they reach it. Deep and thorough cultivation with plow and grubber is absolutely necessary, and this fact, and the one that nothing repays care so well as a beet, have caused a revolution in the state of agriculture wherever beets are grown in any quantity. It is the only crop grown by man on whose quality everything depends, and the only one which is subject to severe scrutiny. It is true that barley is also carefully examined by the maltsters, but we do not hear of careful chemical analysis of barley, or hundreds of thousands of dollars spent in the mere propagation of the seed. When a farmer grows a crop of beets, and knows that the more sugar they contain the better for him, he takes care to find out the best way to manage his soil. And this care produces a great effect on all other crops. Instead of ploughing three or four inches deep, he goes down to fourteen inches, and he keeps his land clean. He also begins to understand about manures. In this country, for instance, the farmer will buy anything that looks black and smells bad, or will take any artificial manure you may offer him on trust. But the beet grower calmly offers so much per pound for potash or nitrogen or phosphoric acid, and cares not a bit whether these elements are in guano, or Chili saltpetre, or sulphate of ammonia, or anything else. Of course there are enlightened farmers in all countries, but in beet districts such accurate knowledge is universal.

Beets are most extensively cultivated now in the tract of land extending from Paris and Prague on the south, to the Baltic Sea on the north, and between the German Ocean on the west and the Russian boundary on the east. In Russia, the beet fields extend from Kiew to Moscow principally. Several attempts have been made in Italy without success, and in Spain as well; the ignorance and backwardness of the farmers in these countries was the greatest difficulty. In California, beets are now grown extensively, but experts seem agreed that, of all countries, Canada is the best adapted to this industry. Let us hope that this opinion will be justified in times to come.

So much for the beet. Now let us turn to the sugar-cane, the other great source of sugar to the world. It is still, I may say, looked upon by many as the only source, so little do we often know about the commonest things in life. The cane has now been cultivated for nearly a thousand years, but almost entirely in tropical countries, and, therefore, under the management of tropical peoples. Genius, we are told, lights her lamps in northern latitudes, and the way in which northern nations have succeeded in competing in the sugar markets of the world, through the sugar-beet with the sugar-cane, is certainly a most pointed instance of the truth of the old proverb. For it is only in the last few years that intelligent work is being done in the cane sugar countries, and that under the stimulus of German and English engineers. But even yet, the waste on a cane sugar estate is appalling to the scientific sugarmaker of Europe, and things are altogether in a backward and inefficient state. In consequence, we have not the same accurate knowledge concerning the cane as a plant that we have about the beet.

The sugar-cane is a sort of enormous grass belonging to the genus *Saccharum*, and known as the *Saccharum officinarum*. There are an immense number of kinds, but probably all are from a single species of which they are varieties, the differences being induced by cultivation in different soils and countries, and, indeed, consisting often in only a different name. The vast area over which the cane is grown has resulted, indeed, in a greater number of names. We have, for instance, the Bourbon cane, the Otaheite cane, the Batavian cane, the large red cane of Assam, the black and yellow Nepaul cane, the Chinese cane, the Seelangore cane, the last named being, perhaps, the finest kind known. The South Pacific islands, probably the original home of the cane, produce many varieties with unpronounceable names.

The principal differences are in the colors of the leaves and stalks, which range from black or purple to green or red. The yield per acre and the percentage of sugar is also most variable, and has hitherto been a matter more of accident than anything else, owing to the backward state of the whole industry which I have mentioned above.

In appearance, the cane is a plant with a knotty stalk surmounted by a bunch of leaves, and from six to ten feet high. At each joint or knot, there is a leaf and an inner joint. The number of joints in the stalk varies from forty to eighty, and these joints are peculiar structures which it is difficult to describe clearly without proper diagrams. They are the parts in which the juice is perfected, and each encloses the germ of a new cane. The cane is propagated in the same way as potatoes, by means of these eyes or joints, as up to now no sugar cane has been known to perfect its own seed. The cuttings are taken from the most healthy canes and usually from near the top. They are planted very carefully in straight rows some two or three feet apart, and begin to sprout in about a fortnight. They are then carefully banked with earth from time to time as they grow, until there is a little hill all round the cane very much like the way our own Indian corn is treated. At the same time weeding and trashing is carried on, the latter operation being the removal of all dead leaves and suckers—a most important point.

There is another method of propagation which ought to be mentioned, namely *rattooning*. This is merely allowing the new cane to sprout up from the old root or stool as it is called. It is remarkable that in some countries as in Bengal, good rattoons are never seen, while in Jamaica all canes are re-produced in this way. It entails a smaller yield but a surer crop. In harvesting, the canes are cut as close to the stool as possible, the leaves and tops discarded, the rat-eaten canes put aside, and the sound ones transported to the mill. This is done, usually, by horses or mules but often wire tramways stretch across the plantations, or navigable trenches are laid out on which flat boats are propelled and the cane conveyed on them.

The yield per acre of cane, varies a good deal in different countries. About 25 tons in Louisiana is a good crop, while in Barbadoes 30 tons is common.

Canes contain all the way from six to twenty-four per cent. of sugar and may be said to be richer as a rule than sugar beets.

What has been said concerning the effect of soil and manure on the sugar beet applies, in a general way, to the cane. Plenty of phosphoric acid and as little nitrogen and potash as possible is the general law to be guided by, although the number of empirical rules about the best manures for canes, is large and confusing. The kind of climate is a more important consideration with the cane than the beet. It is not a hardy plant and needs great heat and considerable moisture. Thus it is that canes grow best on tropical islands or on the coast. Warm inland countries, even where irrigation can be practiced, are not nearly so well suited. As in the beet, the development of the sugar in the cane is greatly helped by warmth towards the end of its period of growth, and altogether it may be said that the cane wants just what the beet does, to manufacture its sugar, but wants the conditions intensified. The fight between the cane and the beet is now a bitter one. It will probably continue for all time, but the beet will get the upper hand gradually, inasmuch as it is of great benefit to the country at large, indirectly, that is to say, otherwise than as a sugar producing plant. The refuse of a beet factory ranks among the finest cattle foods in the world, while that from the cane is good only as fuel. The culture of the beet raises the general state of agriculture to the highest pitch of perfection, while that of the cane excludes other crops.

Let us now see what becomes of the ripe cane and beet after it arrives at the factory. These are very large buildings nowadays, filled with expensive machinery and not insignificant little places as many people suppose. To be sure there are still a few which are not extensive, and the most primitive and curious one is probably that now working on the banks of the Ganges. It consists of the stump of a tree with a hole in it, in which is a conical crusher driven by an ox at the end of a long beam. Two or three canes are squeezed in it at a time and the resulting liquor boiled in an iron pot alongside.

Then in China and Manilla the cane is grown in small patches and by poor people, and the canes crushed anyhow and the liquor boiled down to a thick mass without any purification. Much of this sugar is refined in Montreal to-day, and it resembles earth in appearance. Sugar is also made, as we know, from the maple by simple concentration of the sap, which, however, is so pure that the product is very fine. That made from the date palm and called jaggery, is also merely juice boiled down in any kind of a pot, but n countries where a great deal of sugar is produced, as in Cuba or Java or Germany and France, things are carried on in a different way, factories work all the way from 200 to 2,000 tons of raw material in twenty-four hours, and are worth anywhere from $200,000 to $500,000 a piece.

I will give a general description of a beet sugar factory, inasmuch as it is much the more perfect and extensive and will include nearly all that may be said about a cane sugar one.

On approaching the factory, the beets are seen in great heaps outside in process of delivery by the growers. From these heaps they are carried by various appliances to the first step in the process of manufacture, that is the washing

The conveyance of these beets was long a puzzle to manufacturers until a German named Riedinger, a few years ago hit upon water sluices as the best means, and now they are everywhere adopted. The beets are tossed into the sluice which carries them along to an elevator. This lifts them up a certain distance and throws them into the first washer, which is a drum revolving in a tank of water. They are next thrown into a second washer which consists of a water tank in which great arms revolve and throw the roots about, carrying them forward at the same time and throwing them on to an elevator which lifts them up to the top of the building. If the washing has been properly done, the beets are now quite clean and ready to be cut up.

The form into which the roots are now reduced depends entirely on the method of extraction to be subsequently followed. In former times they were rasped up into an almost impalpable pulp and afterwards the liquor was pressed out by hydraulic presses of great power, or by roller presses of various kinds and shapes. This was always a most unsatisfactory way, and has been entirely superseded by what is called diffusion. Wherefore, instead of being rasped, the roots are sliced up into long, narrow slices and run by suitable means into an apparatus called a diffusion battery. This consists of a number of cylindrical iron vessels, holding each about one ton of cut beets and communicating with each other by means of valves and piping. In it the slices are, so to speak, soaked out with hot water, passing from one to the other. It is not, however, a mere solution that takes place but a curious phenomenon known to chemists as osmosis.

This may be described as follows: If you have a vessel divided into two parts by a porous membrane such as parchment, and in one part water, while in the other there is a solution of crystallizable and uncrystallizable salts together, the crystallizable ones will pass through the membrane into the water on the other side, while the others, or colloid ones, as they are called, will not. This is what takes place in the battery. The long, thin slices of beet are placed in water of a particular temperature, and the cell walls of the root act as the membrane, allowing the sugar, which is crystallizable, to pass through into the water while other matters remain behind. Unfortunately there are other crystallizable matters besides sugar, and these go through also, and the broken cells of course give up all their contents to the water. So the resulting solution is still impure enough, but it is much purer than the liquor obtained in the old way, and the process is more rapid. The process is a continuous one, the liquor being passed from one cell to another until it has passed through ten or eleven, when it is drawn off. One end of the battery is continually discharging the liquor and the other the exhausted slices, which latter are pressed and sold for cattle food, while the liquor is further treated. It is very thin, black in color, and quite opaque. It would be quite possible to boil it down now to a thick syrup and let it crystallize out, but the result would be black sugar, and very little of it, so it must be first clarified. This is done in what are called defecation tanks, and by means of a peculiar application of lime and carbonic acid. As both these substances are used in large quantities, there is a lime-kiln always attached to the factory, in which lime-stone or carbonate of lime is burnt and the resulting gas and quicklime collected.

The defecating pans are wrought-iron tanks holding about 700 gallons each, and provided with steam coils for heating, and perforated coils for the injection of the gas, which is sucked from the kiln by means of a large pump, and forced into them and up through the liquor.

The operation is as follows:—The tank is filled about three-quarters full of the black liquor from the battery, which has previously been heated to boiling point, and a certain quantity of lime is added (usually about 2 per cent. on the weight of the beets) in the form of lime milk. This causes an immediate partial clarification, and the whole is a gummy mixture, light in color. Then the gas is pumped through until, by a simple test, we know that it has precipitated very nearly all the lime that was put in. This precipitation completes the clarification begun by the lime, as it seems to drag down small suspended particles and coloring matters with it, to the bottom of the tank. The action is not very well understood, but the result is a very bright, clear liquor of increased purity.

We now have the defecator filled with a nearly boiling mixture of lime and sugar-liquor, and the question is to separate the one from the other. This is done in what are called filter-presses, which are machines so constructed that the mass is forced into spaces between coarse cloths held in iron frames, so that the liquor runs out clear through the cloths, and leaves a thick, nearly dry, cake behind. The cake is thrown outside, to be used as manure, and the liquor passes into the next stage, which is a simple repetition of the defecation, in which a little lime only is added and the gas passed through until there is but a trace of lime left. It is necessary to repeat the operation in this way to get a really good clarification. It is again filtered, and is now very thin still, but perfectly bright and clear, and is ready for concentration. This is done in two stages: first, it is thickened to a syrup, containing 50 per-cent. of sugar, in what is known as a double or triple effect. This is a peculiar and ingenious apparatus constructed first by a Frenchman named Rillieux, and consists of two or three cylinders about ten feet in height and six feet in diameter. They each contain a series of vertical or horizontal steam pipes for boiling the liquor, and communicate with each other, so that the vapor from the boiling liquor in the first boils the liquor in the second, and that from the second boils the liquor in the third. In this way we greatly economise the heat.

There is a further peculiarity about the machine, and that is, that to the third cylinder is attached an air pump, which sucks all the hot vapor from it as the sugar boils, and draws it through a stream of cold water, thus producing a vacuum. The object of this is to evaporate the water in the liquor at a low temperature, for, by the well-known law of physics, the less the pressure on the surface of a liquid the less heat it takes to cause it to boil—that is, to evaporate. We do not do this to save fuel, for we have to use more than we gain in driving the pump, but we do it to save the sugar, for if sugar-liquor is boiled at the pressure of the atmosphere, it becomes partially destroyed by the heat and gets quite dark in color. The boiling of liquor in a vacuum is the greatest advance made yet in sugar-making, and was known long before the principle of the multiple evaporator. In fact, the vacuum pan, which is the next piece of apparatus we have to consider, was long the great centre of the sugar factory, and the most difficult and important process was the boiling of sugar, We do not look on the matter now with the same awe that our progenitors did, but consider it still a most important station.

The syrup on leaving the evaporator is now quite thick and is dark brown in color. It is customary now, in the best factories, to boil it up at once in the vacuum pan, but many still adhere to an older process, that of bleaching by animal charcoal or by sulphurous acid gas. This will produce brighter sugar, but we do not value this much, as the refiner, to whom the raw product is sold, buys it by its analysis and does not care much about a small difference in color.

The pan is an iron or copper cylinder, furnished with a great number of steam coils and an air pump and condenser. It may be any size almost, but usually is about nine feet in diameter and ten feet high.

It is not an easy matter to boil sugar well if it be of a low grade, and long experience is valuable. In refineries, good boilers get high wages, for the yield depends much on them; but they are commoner now than they used to be. The general operation is this. The pan is partially filled with liquor, and the steam turned on the lower coils so that the liquor is gradually boiled down till quite thick. Then the boiler opens the valve suddenly and takes in a small charge, shutting again quickly. The result is usually that crystals began to form in the pan, and after a little he takes in another charge. Sometimes, however, there is great trouble in forming the grain as we say, and charge after charge is taken in, and the amount carefully varied until at last we do get some grain. Then the panman proceeds cautiously to nourish the grain which is at first very small, by carefully regulated charges. This done, the operation proceeds more rapidly and all the panman has to do, usually, is to watch his vacuum guage and thermometer, and keep taking regular charges till the pan is sufficiently full. Then it is concentrated a little more and the work is done. The liquor has now become a thick sticky mass of syrup and sugar crystals of the consistency of putty, and brown in color. Had the syrup been boiled in the open air, it would have been nearly black, but by reason of the vacuum, the temperature has been kept down to 150°, and may be kept as low as 110°, and it has merely got browned a little. The panman tests his pan by taking out little samples, and examining them on a piece of glass, or by feeling them and as soon as he is satisfied, he shuts off the steam, lets in the air to destroy the vacuum and opens the pan below, dropping the contents into a long receiver, which is placed over the centrifugal machines.

Centrifugals are vertical drums whose periphery is made of perforated brass plate or brass wire gauze. A portion of the masse cuite, as it is termed, is let into them from the receiver, and they are then set in rapid motion, making 1,500 turns per minute. The masse cuite is thrown violently against the perforated plate, and the syrup finds its way through the holes and into the outer casing from which it runs to tanks below. In the centrifugal, the sugar is left in a nearly dry state. It is light yellow in color, of a well-defined grain and has a salty taste. It is quite easy now to make it white by throwing a little water on it, while the centrifugal is in motion, or sending a jet of steam through it, but as this melts so much of it, and besides has only a partial whitening effect, it is now abandoned in most places, and yellow aw sugar is produced.

This is called the first product and amounts to from six to thirteen or more per cent. on the weight of the beets according to their quality.

The syrup which runs off, is still of considerable value, as it contains fully two per cent. of sugar on the weight of the beets. It is utilised by boiling it up again and then letting it stand in a hot room until the sugar gradually settles out of itself. Then it is again put into the centrifugals and a second product is the result, which is darker and less pure than the first product.

The resulting syrup now will hardly crystallise any more, by reason of its impurity, and so special means are taken to get rid of the impurities, which have gradually increased in proportion as the sugar has been extracted, until they now form a great percentage. It is found by practical experiment that if the sugar in a liquor does not represent more that 60 per cent. of the total solids dissolved in that liquor, some special purification is needed. When the liquor left the clarifiers it had 85 per cent. of the total solids, as sugar now there is only 60 per cent. This has been a fruitful field of investigation for chemists for many years, and all efforts have been made to combine the sugar with some substance and so separate from its impurities.

This can be done by forming what are called saccharates of lime, or barium, or strontium, which are decomposed afterwards by means of carbonic acid or of heat.

The factories erected for the strontium process are much larger and more complicated than the original sugar factories and would entail too long a description. The lime processes are simple ones, but scarcely of general interest, so I will dismiss them at once.

There is another and peculiar process which is older than the others, and still a good deal used, depending on the principle of osmosis which I mentioned before in connection with the diffusion. It is cheap but slow. Any one of these processes may be used to get at the last of the sugar in the molasses, but also the molasses may be distilled and the sugar turned into alcohol. This used to be the universal custom, but now it is found to pay better to extract the sugar.

This ends the manufacture of the raw beet sugar. It is put into bags and sold to refiners. Very few factories turn out refined sugar, that is, combine the two processes, for, as a rule, it does not pay.

I will now briefly point out the differences between a cane and a beet sugar factory. The processes are either very similar or identical. The liquor is, however, extracted almost universally by crushing under immense rollers instead of diffusing, which latter process is but of doubtful value where cane is concerned. The clarification is made by means of lime alone without carbonic acid, and in a crude way enough as a rule. The evaporation and concentration in the multiple effect and vacuum pan are the same, but these are only to be seen in the more advanced districts.

Centrifugals are also used now in many places and, in fact, the cane sugar men are copying closely beet sugar methods. The products of a cane sugar factory are divided into several classes like that from a beet sugar one, the chief difference being that the molasses is either sold for direct consumption or distilled, the saccharate processes not being applicable for the extraction of sugar.

Crude or raw sugar from a factory is now almost always sold to a refiner to be turned into white or yellow sugar. Refineries resemble raw sugar factories in a few points only. They are very large places containing storehouses and cooperages as well as the machinery. A fair sized refinery will work 200 tons of raw sugar in twenty-four hours and the general process, I will briefly describe. On arriving, the raw sugar is melted in a large cistern of hot water in which arms revolve. Sugar is put into the water until the contents of the cistern are half water and half sugar. This liquor is then pumped up to the top of the building and heated boiling hot. Next it is filtered through cloth bags, from which it runs very clear and limpid. After this it goes to the char tanks. These are immense cylindrical iron vessels containing about 25 tons of charred bones or animal charcoal as it is called.

This substance has the peculiar property of decolorising liquor. A dark brown syrup often being in contact with it for a short time will become as clear as water. After passing through these it is collected in cisterns, concentrated in vacuum pans and the masse cuite worked off in centrifugals. Owing to the action of the char, the sugar is white or light yellow according to how much charcoal has been used in proportion to sugar melted. The syrups that run from the centrifugals are boiled up again and allowed to crystallise out, or are sold for consumption according to their strength. On the whole, the process is much simpler than that used in a raw sugar factory, but everything is on a much greater scale. A very important part of a refinery is the char house, this is a place where the char is reburnt after having been used in order to serve again, which it is made to do many times, until finally being exhausted it is sold for artificial manure.

Concerning the chemistry of sugar, I can say but little, as it is too extensive and complicated a subject to be dealt with in a paper of this sort, however, I may say that the sugars belong to the great chemical division called the hydrocarbons and are divided into two great groups, called the glucose group whose formula is $C_6 H_{12} O_6$, and the cane sugar group whose formula is $C_{12} H_{22} O_{11}$. Of the first named group, the principal member is common glucose, a widely distributed substance in nature, which is usually artificially prepared by treating starch with sulphuric acid. It is often considered as a deleterious substance and used to adulterate sugar, but, although it is my natural enemy, as a sugar maker, I must admit that it is just as harmless and wholesome as the best of sugar, and its only fault is that it is not over one-third as sweet. It may be produced in many curious ways, for instance in the human body by the irritation of the medulla oblongata, or from this very desk by means of sulphuric acid. To this group belong also levulose, inverted sugar, sorbin, inosit, and many rarer kinds.

The chief member of the second group is cane sugar or saccharose, which we have been discussing. It is called cane sugar, but occurs in many plants as the sugar beet, the maple, etc., as we have seen. To this group belong milk-sugar, maltose, and many others.

Strange as it may seem, no chemist has ever been able to make sugar from a foreign substance. The plants know how to do it, but we cannot. Nor has anybody ever been able to turn glucose into cane sugar, although the difference in their formulæ is but a molecule of water. Could this be done easily, no more sugar-canes nor beets would be grown, but we would use up old rags, sawdust, and all sorts of detritus. Every year somebody reports success in this quarter, but no results are forthcoming. The sugar world is used to such scares, but it got a bad one a little while ago when Prof. Remsen, of Johns Hopkins' University, made from one of the derivatives of coal-tar, toluene, a substance called benzoyl sulphonic amide, or as it is now termed, saccharine. This is one of the chemical curiosities of the present day. It is a white powder, slightly soluble in water, and 280 times as sweet as sugar, that is, one pound of saccharine will sweeten as much water as a barrel of sugar.

All sugar makers felt very uneasy when this came to light, but now it is known that it is harmful in its properties and valuable only as a medicine, those who own the five hundred million dollars invested in sugar in this world breathe again.

How is the Cambrian Divided?—A Plea for the Classification of Salter and Hicks.[1]

By G. F. Matthew, M.A.; F.R.S.C.

A new classification of the Cambrian system has lately been proposed by Mr. C. D. Walcott, the well-known palæontologist of the United States Geological Survey and has received the assent of Prof. Chas. Lapworth. The most prominent feature of this classification is the basal position given to the Olenellus fauna which no doubt is in accordance with facts. Another point in this classification is the placing of the rocks containing the Paradoxides fauna as Middle Cambrian; with this the knowledge at present before the writer does not seem to agree. A while ago it seemed as though the Cambrian system was divided palæontologically into three sections, the Paradoxides beds, the Lingula flags and the Tremadoc or Ceratopyge beds, which would thus be the Lower, Middle and Upper Cambrian. But this "Upper" Cambrian was not only weak in bulk of measures, but in the genera it contained it exhibited a strong palæontological affinity to the Ordovician forms, so strong, indeed, that by many European geologists it was classed as a part of the "Lower Silurian" system.

The discovery by Mr. Walcott of many of these so-called Ordovician forms, low down in the Cambrian strata of the Rocky mountain region, shows that a different interpreta-

[1] From the American Geologist, September, 1889.

tion may now be given to these forms, for they do not by their presence exclude the Ceratopyge or Tremadoc beds from the Cambrian. Nevertheless, under the classification proposed by Messrs. Salter and Hicks some twenty years ago, the Cambrian is divided into two great divisions only. The purpose of the present article is to review some of the evidence touching the faunas and the sedimentation of this system, and to compare the proposed division with that presented by Dr. Hicks.[1]

Late discoveries in America and Europe, and especially the *enlargement of the fauna with Olenellus and the discovery*, or rather the determination of its proper place in the Cambrian succession, has led to this proposal for a new allotment of the parts of the Cambrian system.

If the object in view were merely the arrangement of the members of this system which may occur in any particular country, the sedimentation, or division into series, in that country could be utilized for the purpose, but as the object is a classification that will apply generally, other criteria must be sought. Among those which have been used are the succession of the several faunas and the relationship of the genera in each; and the comparative bulk of measures n the several parts of the system. These form the basis of the following remarks.

The Cambrian rocks as originally described by Prof Sedgwick no doubt contained the Ordovician or Lower Silurian as well as the strata to which the name has since been restricted. These (the Lingula flags, etc.) were also claimed by Sir R. Murchison as a part of his Silurian system. In later times the conflicting claims of these discoverers have been compromised by assigning to each his own special domain, and erecting the disputed territory into a separate system, the Ordovician.

The development of the Cambrian system from its original basis in the Lingula flags, etc., received a great impulse from the discoveries of Dr. Henry Hicks and the late Mr. J. W. Salter, in Wales; and especially in the find-

[1] Pop. Sci. Review, N.S. Vol. 5.

ing of the Menevian fauna in South Wales by Dr. Hicks.

In the process of elaborating the Cambrian faunas, the first step was the discrimination of the two faunas in the Lingula flags in 1853.

1865. In this year Messrs. Salter and Hicks made known the Menevian fauna, and showed the position of the Paradoxides beds in Britain.

1866. In this year the Tremadoc fauna was distinguished in South Wales, and fully confirmed in 1872.

1869. In 1869 Messrs. Hicks and Harkness described the great series of red, green and grey slates below the Menevian in South Wales, and showed the existence of a fauna older than that of the Paradoxides beds but with no trilobites.

Subsequently Dr. Hicks elaborated the Cambrian system into seven groups, but showing only four trilobite faunas, the first or oldest not having been found by him in Britain. The groups of sediments containing these faunas he classified as follows:

Lower Cambrian. Three groups.—Caerfai, Solva and Menevian.

Upper Cambrian. Four groups.—Maentwrog, Ffestiniog, Dolgelly and Tremadoc.

It may be well to inquire what there is to support this classification of the Cambrian system, before adopting a new one.

Two principal criteria for determining a question of this kind would be the facies and succession of the faunas and the bulk of the measures. In applying these tests, we turn our attention first to Scandinavia, for in no part of the world is there known such a clear, continuous and complete succession of Cambrian faunas as in that country.

Connection, etc., of the Cambrian faunas.

Of the several classes of organisms of these faunas, the trilobites may be taken as the group which will best show the relationship subsisting between the several faunas, for they are the most varied, and were more sensitive to the changing conditions of environment than the others.

In Brögger's admirable work on the Stages 2 and 3 of the Palæozoic rocks of Norway, a table is given which shows the succession and range of the species in the Cambrian faunas of that country. Then as regards the neighboring kingdom of Sweden, Dr. G. Lindström's list (1888) of the fossil faunas of the Cambrian and Lower Silurian rocks is complete for the several zones of the Cambrian in that country. Combining the genera from these sources a full representation of Cambrian life in Scandinavia is obtained, so far as relates to the genera of the trilobites.

The first or oldest fauna presents the following genera:

OLENELLUS (by its sub-genus MESONACIS†)	* *Arionellus* (=*Agraulos.*)
* *Ellipsocephalus.*	* *Agnostus.*

Of these genera one is peculiar and three (marked by an asterisk) pass to the next fauna.

In the second fauna are the genera.

* *Harpides.*	*Solenopleura.*
PARADOXIDES (including *Centropleura.*)	*Arionellus.*
Ellipsocephalus.	*Anomocare.*
* *Liostracus* (includes *Ptychcoparia.*)	*Dolichometopus.*
Conocoryphe.	*Aneucanthus* (c. f. *Centropleura ?*)
Elyx (=*Ctenocephalus.*)	*Corynexochus.*
	Microdiscus.
	* *Agnostus.*

Here are fourteen genera of which three are found at higher horizons in the Cambrian system. Under *Liostracus* the Swedish palæontologists include *Ptychoparia* which with *Agnostus* has a wide range in the Cambrian system, so that with the exception of these genera the break is almost complete, between this fauna and that which follows. *Conocoryphe* as understood in Sweden does not extend beyond this fauna.

† The name of the leading genus (or genera) of each fauna is given in Roman capitals.

The third fauna contains the following genera:

Liostracus ?	*Leptoplastus.*
OLENUS †	*Eurycare* (s. gen. of Leptoplastus†
Parabolina (s. gen. of Olenus†).	**Agnostus.*

Here all the genera and subgenera are peculiar to this fauna except the ubiquitous *Agnostus* and Liostracus?

But the connection with the next fauna is closer than appears from the names, as some of the genera are closely related to those of the succeeding fauna. *Eurycare* especially is intermediate between *Leptoplastus* and *Ctenopyge.*

The fourth fauna has the following genera:

**Cyclognathus* (sub-gen. of Peltura†)	*Ctenopyge* (s. gen. of Leptoplastus†)
PELTURA.	*Sphærophthalmus* (s. gen. of Leptoplastus†)
Protopeltura (sub-gen. of Peltura†)	*Boeckia* (sub. gen. of Leptoplastus.)
Acerocare (sub-gen. of Peltura†)	
**Agnostus.*	

Cyclognathus is found also in a fauna above, but *Peltura* and *Ctenopyge*, with their related forms, especially mark this horizon.

The fifth fauna, which has a strong Ordovician facies, exhibits the following genera:

Cheirurus.	*Nileus.*
Pliomera.	*Symphysurus* (s. gen. of Nileus†)
° *Harpides.*	*Niobe.*
Remopleurides.	° *Holometopus.*
° *Triarthrus.*	*Conophrys.*
° DICELLOCEPHALUS	° *Parabolinella* (s. gen. of Olenus.†)
° CERATOPYGE.	*Amphion.*
° *Euloma*	*Ampyx.*
Megalaspis	° *Agnostus.*

Among these eighteen genera there are only about eight (marked by "°") which by their aspect recall the European types of the Cambrian trilobites, and probably for this

† See Brögger's Etagen 2 und 3.

reason the Swedish palæontologists regard this fauna as belonging to the Lower Silurian. But it evidently corresponds to the Tremadoc fauna, which by English palæontologists is reckoned to the Cambrian; and late discoveries in America show that *Nileus*, *Niobe*, &c., also are truly Cambrian.

In Wales, which has given its name to the Cambrian system, the succession of the faunas, their unity and their relative importance are much the same as in Sweden and Norway, but these features are obscured by the use of different names for some of the genera.

Mr. Robert Etheridge's catalogues in the Geology of North Wales are the basis for the comparisons made here. In them the genus *Conocoryphe* (as used by Mr. Salter) is made to serve for a number of Scandinavian and other genera. The figures of many of the species in this work are very imperfect, but for the purposes of this comparison the species in *Conocoryphe* may be distributed to *Conocoryphe*, *Ctenocephalus*, *Liostracus*, *Ptychoparia*, *Solenopleura*, *Euloma*, *Parabolina*, *Parabolinella* (?) *Conocephalites* and *Dicellocephalus*.

In Wales the first fauna has produced no trilobites unless *Conocoryphe viola* belongs here. The second Cambrian fauna has a full representation as follows:—

PARADOXIDES.	*Ctenocephalus.*
Plutonia (sub gen. of *Paradoxides.*)	
Anopolinus (c.f. *Centropleura.*)	*Carausia.*
Solenopleura.	*Conocoryphe.*
**Liostracus* (or *Ptychoparia.*)	*Erinnys* (c.f. *Harpides.*)
Holocephalina.	*Microdiscus.*
Arionellus.	**Agnostus.*

Here there are twelve genera of which two only extend upward to higher horizons.

The third fauna (Lower Lingula flags) has the following genera:

OLENUS.	**Euloma.*
**Parabolina.*	**Agnostus.*

Of these three extend upward to the higher zone, leaving only Olenus as peculiar to this fauna.

In the fourth fauna (Dolgelly group) are the following genera:

**Euloma.*	PELTURA.
**Parabolina*	*Sphærophthalmus.*
**Parabolinella* (?)	*Ctenopyge.*
**Conocephalites*	**Agnostus.*

Five of these genera extend upward into the next zone. The *Conocephalites* have been called *Dicellocephali*, but they are not the typical forms of *Dicellocephalus* with spined pygidium, which occur higher; they are related to *Conocephalites* (sens. strict) and *Conocephalina*,† which has short spines found by Brögger in the Paradoxides zone. The genus is not reported from the equivalent beds in Sweden, where the genera of the second column held possession, but it is found in the fauna of Hof in Bavaria.

The fifth Cambrian fauna (Tremadoc group) exhibits the following genera:

Psilocephalus	°*Euloma.*
Asaphus	°*Parabolina.* (?)
Cheirurus.	°*Parabolinella.* (?)
°*Angelina.*	°*Dicellocephalus.*
Nesuretus.	*Conophrys.*
Niobe.	*Ampyx.*
Ogygia.	°*Agnostus.*
Dionide.	

In this assemblage of fourteen genera only six represent "Cambrian forms" of trilobites, but in the lower half of the first column are a number of genera which, once thought to have appeared first at this period, are now found to be present in the West of America by representative forms at a lower horizon. Hence these, although hitherto regarded as Ordovician, as already remarked, are essentially Cambrian types.

It will be observed that in the Welsh area the four Cambrian faunas, which have trilobites, show a correspondence

† Om paradoxidesskifrene ved Krekling.

of genera with those of Scandinavia, and here as there, exhibit a very decided palæontological break at the summit of the Paradoxides beds. Hence Dr. Hicks was justified in dividing the Cambrian groups of strata into Upper and Lower, accordingly as they were above or below this horizon.

Having seen how the Cambrian faunas are related to each other in Europe, we may now examine their succession in the eastern half of North America.

To Mr. C. D. Walcott is due the credit of having determined the relation of the Olenellus fauna in this region to the rest of the Cambrian system.

The clearest succession of the lower members carrying unmistakable forms of this fauna is that which he has lately examined in Newfoundland. Combining the genera found there with those of the Champlain and Hudson valleys we find the following:—

OLENELLUS.	* *Zacanthoides.*
MESONACIS.	* *Olenoides.*
* *Paradoxides* (Shaler)	*Bathynotus.*
Avalonia (n. gen. not yet described.)	
* *Ptychoparia.*	* *Protypus.*
* *Agraulos.*	* *Microdiscus.*
* *Solenopleura.*	* *Agnostus.*

Of these thirteen genera it will be observed that two-thirds pass to the Paradoxides beds, and of the remainder, *Avalonia* is not described, and *Mesonacis* is by Scandinavian palæontologists regarded as congeneric with *Olenellus*. There is thus a much closer connection between this fauna and that which follows it, than there is between the latter and the faunas of the Upper Cambrian. Moreover, the embryonic and larval stages of Paradoxides and Olenellus show that these genera are closely related.

We have very little knowledge as yet of the way in which the Paradoxides fauna was related to that which follows it, since both in Newfoundland and Acadia the next zone has yielded very scanty remains of trilobites. Perhaps the Mt. Stevens section where the genus Paradoxides has been found[1] will yield the required information. In New-

[1] See this journal, vol. III, No. 1. (Jan. '89.)

foundland Mr. Walcott has found *Olenus*, and in the St. John area (Acadia) *Leptoplastus* occurs. In the latter area also the fourth Cambrian fauna has been found, being indicated by the presence of *Ctenopyge flagillifer*, *C. spectabilis* and *Orthis lenticularis*.

A fuller presentation of Upper Cambrian forms is that which is found in the Mississippi valley in the states of Wisconsin and Iowa, where there is a succession of 600 feet of sandstones whose fauna has been described and figured by Dr. D. D. Owen and Prof. Jas. Hall. The latter divides this series into three parts, the lowest of which contains forms similar to those at the base of the Olenus zone in Europe.

In the middle division, which is most prolific of the remains of trilobites, are species which may be compared to those of the genera *Olenus*, *Parabolina*, *Leptoplastus?* *Euloma* and *Conocephalites*. Dr. Dames compares others to *Anomocare*. It is only in the highest Potsdam division and in the beds above it, according to Prof. Hall, that the typical Dicellocephali appear, and these in Europe are found in the Tremadoc or fifth Cambrian fauna. *Triarthrella* occurring in Wisconsin with these Dicellocephali is compared by Brögger to *Cyclognathus*, a genus of the fourth fauna and of the base of the Ordovician. The whole series of 600 feet in Wisconsin seems to belong to the Upper Cambrian. But the phase of the fourth Cambrian fauna represented in Europe and Acadia by *Ctenopyge* and its allies is absent, probably from the want of favorable habitat.

Comparative bulk of measures holding the faunas.

The relative age and position of the Paradoxides beds in the Cambrian system may be shown by the bulk of the measures in the different parts of the system. With our present knowledge, this can be only imperfectly done, but the following is a comparison of the mass of deposits in three different countries. When the system has been more carefully studied in different parts of the world a more exact proportion in the sedimentation will be had.

In Norway the Cambrian system has the following thickness[1] :—

			Ratio.
Stage	3*a*=Tremadoc or Ceratopyge fauna..........	45 feet..	1.2
"	2*d-e*=Dolgelly or Peltura fauna..............	40 " ..	1.0
"	2*a-c*=Lower Lingula flags, Olenus fauna	110 " ..	3.2
"	1*c-d*=Menevian and Solva, Paradoxides fauna.	80 " ..	2.3
"	1*a-b*=Harlech (?) or Olenellus fauna.........	80 " ..	2.3
		355 feet.	10.0

In Wales there are the following groups of Cambrian strata :—

			Ratio.
Upper Cambrian.	Tremadoc	1000 feet,	1.
	Dolgelly	600 "	.5
	Ffestiniog	2000 "	4.5 (Ffestiniog and Maentwrog)
	Maentwrog	2500 "	
Lower Cambrian.	Menevian	700 "	2.5 (Menevian and Solva)
	Solva	1800 "	
	Caerfai	1500 "	1.5
		10,100 "	10.0

In Acadia the Cambrian sediments are intermediate in thickness between those of Wales and Norway. The average of two sections in the city of St. John gives the following proportions :—

			Ratio.
Division	3=Dolgelly (and Tremadoc).......	600 feet[2].......	2.5
"	2=Ffestiniog and Maentwrog.......	1050 "	4.0
"	1=Menevian and Solva.............	350 "	1.5
Series	A =Caerfai (?)......	500 "	2.0
		2500	10.0

In Newfoundland Mr. Walcott has found the Olenellus beds to be about 600 feet thick and the Paradoxides beds 370 feet, which agrees nearly with the thickness of these portions of the Cambrian system at St. John (New Brunswick).

The Olenus fauna is found in Newfoundland, but apparently Mr. Walcott has not discovered there the fourth

[1] Die Silurischen Etagen 2 und 3.

[2] Above this is a thin body of slates with Arenig graptolites.

fauna (Peltura) or the fifth fauna. We, therefore, are still confined to the three countries of Scandinavia, Wales and Acadia as giving the most complete presentation of the sedimentation and life of the Cambrian period. Combining the ratios for these three countries we get the following result:—

		Norway.	*Wales.*	*Acadia.*	*General Ratio.*	
Fifth fauna	Stage 3*a*	1.2	1.	1.[1]	1.1	6. Upper Cambrian.
Fourth "	" 2*d-e*	1.0	.5	1.5	1.0	
Third "	" 2*a-c*	3.2	4.5	4.	3.9	
Second "	" 1*c-d*	2.3	2.5	1.5	2.1	4. Lower Cambrian.
First "	" 1*a-b*	2.3	1.5	2.	1.9	
		10.0	10.0	10.0	10.0	

These facts do not favor the separation of the Paradoxides beds from the Lower Cambrian, or their erection into a separate division as Middle Cambrian. If there is to be a Middle Cambrian it would rather seem that the Olenus fauna holds this position. But as has been shown the faunal relationship of the Olenus beds to those which follow them forbids their separation, just as in the Lower Cambrian a similarity in the forms correspondingly connects the Olenellus with the Paradoxides fauna.

On the Occurrence of Leptoplastus in the Acadian Cambrian Rocks.

By G. F. Matthew, M.A., F.R.S.C.

It is somewhat singular that while species of Olenus have been found in Britain and elsewhere, the genus Leptoplastus, of which Angelin describes several species, appears to have been observed thus far only in Scandinavia.[2] Angelin seems to have thought this genus so important that he made it the type of a family, Leptoplastidæ, in which he included Olenus, Parabolina, Peltura, Acerocare, Eurycare and Sphærophthalmus. Leptoplastus may, perhaps, have been

[1] The general average is taken for this portion.

[2] I observe that Zittel (Traité de Palæontologie 1887, page 593,) mentions the occurrence of this genus in Great Britain, but does not give the source of his information.

regarded by him as a link between the first four of these genera and the two last, and thus most suitable for the family type. Within the genus there are species which ally it to Olenus and Peltura (*L. stenotus, &c.*), and also one (*L. raphidophorus*) which by its peculiar cheek-spines shows a relationship to Sphærophthalmus and Ctenopyge.

The most obvious distinction between Leptoplastus and Olenus is the position of the eyes, which in the latter genus are in advance of their normal position in trilobites; this difference is expressed by Angelin as "oculi subapicales" in Olenus, "oculi centrales" in Leptoplastus. In the latter genus the head is more strongly vaulted transversely, and the genal spines spread outward in a more decided manner than in Olenus. There are other differences, as the number of segments in the thorax, form of the pygidium, &c., which are not so easy to determine.

By the form of the head, &c., the Acadian species belong to Leptoplastus, and though we have not sufficiently perfect specimens to reproduce all the characters as given by Angelin, those known are sufficient for a description of the species.

LEPTOPLASTUS STENOTOIDES. N. Sp.

Head. Broadly semi-circular; crust, smooth. *Centre piece* of the head-shield sub-trapezoidal; strongly arched transversely, depressed in front of the glabella; marginal fold distinct, elevated. Glabella ovate-cylindrical, indented on each side by a pair of furrows which are moderately inclined backward. Occipital furrow distinct, impressed all across. Eyelobes prominent, ocular fillet faint. Occipital ring rounded backward.

Cheeks arched upward in the middle, depressed at the posterior furrow. Movable cheek broad, with a rather wide marginal furrow and sharp flaring genal spine about as long as the inner area of the cheek. Posterior furrow distinct.

Pygidium nearly semi-circular (longer than half the width), with a broad, flat margin. Rachis distinct, extending to the marginal furrow, divided into three distinct and two or more faint rings; lateral lobes with three furrows.

Hypostome (found loose with this species), sub-rectangular, rounded in front, truncated at the posterior corners; arched upward across the middle, depressed at the end and having there a narrow upturned fold.

Sculpture. Crust smooth.

Size. Length of middle piece of head 6 mm., width 10 mm. Length of movable cheek 11 mm., width 4 mm. Length of pygid. 4 mm., width 7 mm. Length of hypostome (?) 3 mm., width 2 mm.

Horizon and Locality. Calcareous layers in fine dark olive grey shales. Div. 3, Band *a*. St. John Group on Long Island, Kennebecasis River, N.B., in company with *Agnostus pisiformis, &c.*

This species is very near to *L. stenotus*, but differs from it (as figured by Angelin) in its conical glabella, more flaring cheek and spine and wider border to the pygidium.

Leptoplastus Spiniger. N. Sp.

Head. Only the centre piece known. This is trapezoidal in outline, with a spinous projection in front and another behind. It is strongly vaulted transversely and has a distinct anterior marginal fold produced at the axial line into a sharp spine. The spine projects forward, and is about three-quarters of the length of the glabella. Glabella ovate-conical, with two pairs of short, slightly oblique furrows. Occipital furrow distinct, crossing the axis; occipital ring, broad in the middle, bearing a spine directed backward. Fixed cheeks strongly arched. Eyelobes prominent. Posterior furrow and fold distinct.

Sculpture. Crust smooth.

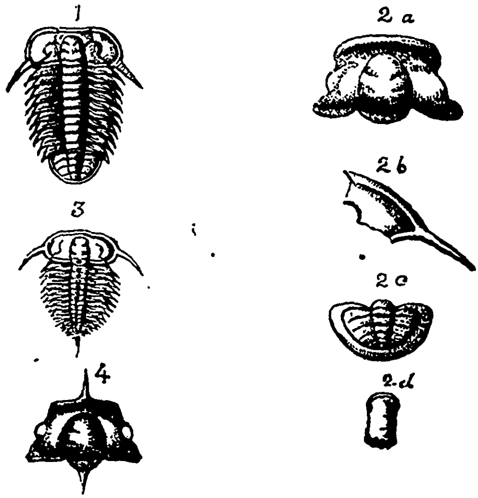
Size. Length, excluding spines, 2½ mm., with spines, 4 mm.: width, 4 mm.

Horizon and Locality. Occurring with the last species.

Among the Swedish Leptoplasti, *L. raphidophorus* is the one which in size compares to this, but it differs in many details. It also is a spinous species, but is not shown to possess the peculiar spine at the apex of the shield, which

3

gives to our species somewhat the appearance of an Ampyx. In Ampyx, however, the spine springs from the front of the glabella, and in some species is much longer than that of *L. spiniger*.



REFERENCE TO FIGURES.

Fig. 1. *Leptoplastus stenotus.* Ang. After Angelin.
" 2. *Leptoplastus stenotoides.* N. sp. Mag. 2/1. 2*a* Middle piece of head shield. 2*b* Movable cheek. 2*c* Pygidium. 2*d* Hypostome found with this species. From Div. 3*a*, Long Island, Kennebecasis River.
" 3. *Leptoplastus raphidophorus.* Ang. After Angelin.
" 4. *Leptoplastus spiniger.* N. sp. Mag. 4/1. Middle piece of the head shield. From Div. 3*a*, Long Island, Kennebecasis River.

In Sweden the beds with Leptoplastus are regarded as the upper number of the Olenus beds, as distinguished from those which carry Peltura and Sphærophthalmus. In New Brunswick, however, the physical conditions during the time when this genus lived were such as to associate it more closely with the later fauna. The two species of

Leptoplastus occur in the lowest of the fine slates which succeeded to the flags and slate of Div. 2, and lithologically the beds fall into Division 3.[1]

In the Acadian area no trilobites are yet known in the great mass of sediments intermediate between the shales carrying Leptoplastus and those which hold Paradoxides.

Derivatives of Tolidin.

R. F. Ruttan, B.A., M.D.

In 1845 a Russian chemist named Zinin,[2] by reducing Azobenzol with hydrogen sulphide obtained a substance which, when further treated with sulphuric aicd, gave rise to a base called Benzidin. The intermediate product of the reduction of azobenzol was subsequently examined by Hofmann[3] and found to be Hydrazobenzol, and the nature of the reaction giving rise to Benzidin was made clear.

From a homologue of hydrazobenzol, viz.: hydrazotoluol by Hofmann's method, Petriew[4] prepared the homologue of Benzidin, viz., Tolidin, and studied some of its characteristics. The constitution of both Benzidin and Tolidin was afterwards established by Gustav Schultz.[5] These two bases were shown by him to be double molecules of anilin and toluidin, respectively, connected by their benzol neuclei, and having their amidogen groups in the para position. Their formulae being:—

$$\text{Benzidin}\left\{\begin{array}{l} C_6\ H_4\ NH_2 \\ \mid \\ C_6\ H_3\ NH_2 \end{array}\right. \qquad \text{Tolidin}\left\{\begin{array}{l} C_6\ H_3\ (CH_3)\ NH_2 \\ \mid \\ C_6\ H_3\ (CH_3)\ NH_2 \end{array}\right.$$

Benzidin has received some attention from chemists and many of its reactions have been investigated. Tolidin, on the other hand, owing to the difficulty with which it was

[1] In a former communication to this journal, they were referred to as probably at the top of Div. 2. (See July, 1889.)

[2] Journal für practische Chemie, xxxvi., 93.

[3] Jahrsbuicht der Chemie, 1863, 424.

[4] Berichte, vi., 557.

[5] Liebig's Annalen, 174, 227. Berichte, xvii., 467.

obtained, and its apparent unimportance, has received until lately no attention whatever. These two bases were long regarded merely as chemical curiosities whose chemical relations were of importance only so far as their existence threw light on other reactions, and thus aided generalization. A few years ago, however, Greiss[1] announced that benzidin, like anilin, formed a diazo compound on treatment with nitrous acid. From this Gustav Schultz, of Berlin, in 1879, prepared the first of the now important class of dyes called Azo-dyes from Benzidin, but the first economic dye of this class was patented in 1884 and named Congo red. These dyes, now very numerous, owe their importance in the arts to the fact that they dye wood and cotton fibre directly, *i.e.*, without the use of a mordant.

The success of the Congo red and other dyes of this class lead to the preparation of these rare bases, Benzidin and Tolidin, in available quantity. Through the kindness of Prof. Hofmann I was enabled to obtain from Gustav Schultz, of the Berlin anilin factory, a kilogramme of crude Tolidin, and began the study of its derivatives in Berlin three years ago. Some of these compounds have already been described by me, and formed part of a paper read before the British Association in 1886,[2] but others have been obtained since. This paper deals chiefly with those derivatives obtained directly from the base Tolidin, and includes only those secondary derivatives necesary to illustrate completely a particularly reaction of the base itself. The subject is, however, by no means worked out as in a direction indicated at the end of this paper, it gives promise of interesting results yet to be obtained.

The crude base obtained from the factory proved to be the ortho-tolidin, and on purification crystallized in glistening scales of a pale violet hue, melting at 128° C—not at 112°, as was originally stated by Petriew.[3] It turns intensely blue when treated with oxidizing agents, gives a

[1] Journal für practische Chemie, 101, 92.

[2] Proc. Brit. Ass'n., 1886.

[3] Loc cit.

blue color with ferric chloride when concentrated, and green when dilute, when boiled this turns red and gives a precipitate of ferric hydrate. The sulphate is very insoluble; the hydro-chlorate is soluble in water and in alcohol; it forms with Platinum chloride beautiful yellow acicular crystals, usually in rosettes, insoluble in water and dilute alcohol. These decompose on exposure to moist air, but if dried after precipitation by washing with alcohol and ether, they may be further dried at 100° and analysed. The following results confirm the formula:—

$$\left.\begin{matrix} C_6\ H_3\ (CH_3)\ NH_2 \\ | \\ C_6\ H_3\ (CH_3)\ NH_2 \end{matrix}\right\} 2HCl,\ PtCl_4$$

	Calculated.	Found. I.	Found. II.
Platinum =	31.07 per cent.	30.81.	30.90.

Cyanide of Tolidin.

Cyanogen gas, evolved by heating mercuric cyanide, was slowly passed through a cold saturated alcoholic solution of Tolidin, till a distinct precipitate occurred, the solution was tightly corked and allowed to stand for forty-eight hours.

A voluminous, brown, amorphous precipitate resulted which, when filtered and washed with alcohol, ether and benzol, was dried and examined. This product was found to be a reddish brown amorphous body, insoluble in water, alcohol, ether or benzol, very slightly soluble in phenol, ligroin and nito benzol. It did not melt at 320°, and burned with difficulty when heated on platinum. It decomposed into tolidin and oxalic acid when heated with acids.

In making the combustion of this substance it was found necessary to add lead chromate to the copper oxide to ensure complete oxidation, and even then the combustion was very tedious. The following figures established the formula:—

$$C_{16}\ H_{16}\ N_4 \quad 2 \left\{ C_6\ H_3\ (CH_3)\ NH_2 \right\} CN$$

Theory.	Found. I.	Found. II.	Found. III.
C = 72.72	71.96	71.8	....
H = 6.06	6.11	6.21	....
N = 21.21	....	....	21.43

The Thio-urea.

Twenty grammes of Tolidin in alcohol were boiled with an equal weight of carbon bisulphide in a flask with reversed condenser for six hours. The result was the formation of a white crystalline powder, melting at 185° and insoluble in most media, but soluble in strong sulphuric acid, from which it was precipitated on dilution. Hydrogen sulphide was evolved during the reaction. The resulting compound had the formula: $C_{14} H_{14} N_2 CS$, and the reaction which occurred may be represented thus:

$$\begin{matrix} C_7 H_6 NH_2 \\ | \\ C_7 H_6 NH_2 \end{matrix} + CS_2 = \left.\begin{matrix} C_7 H_6 NH \\ | \\ C_7 H_6 NH \end{matrix}\right\} CS \times H_2 S$$

The following are the analytical results:—

Theory.		Found. I.	Found. II.	Found. III.
$C = 70.86$	per cent.	71.11	71.06	....
$H = 5.50$	"	6.03	5.81	....
$N = 11.02$	"	....	....	....
$S = 12.01$	"	....	....	12.14

All attempts to convert this into an iso-sulpho-cyanide by the usual methods were ineffectual.

Diacetyl Tolidin.

Tolidin, when boiled for a few hours with 7-8 times its weight of glacial acetic acid, in a flask with reversed condenser, readily forms the diacetyl tolidin. The same substance is at once formed in the cold when acetic anhydride is added to a solution of the base. It is a white crystalline powder, melting above 320° and insoluble in the usual solvents. It is deposited, however, in snow white needles on cooling its solution in boiling nitro-benzol; when thus purified and dried at 130° it yielded the following analytical data:—

Calculated for $C_{18} H_{20} N_2 O_2$

Theory.	Found. I.	Found. II.	Found. III.
$C = 72.97$	72.62	72.29	....
$H = 6.75$	6.88	6.59	....
$N = 9.46$	....	....	9.75
$O = 10.81$	....	....	....

Tetra-acetyl Tolidin.

This is probably the most interesting of all the derivations of Tolidin, inasmuch as it is, with one exception, the only example of a primary base in which both of the hydrogen atoms in the amidogen group (NH_2) have been replaced by the acetyl radicle. The only other compound of this class is Diacetanilid.* $C_6 H_5 N (C_2 H_3 O)_2$. Hoffmann prepared this by the action of glacial acetic acid on phenyl mustard oil in a sealed tube at 130°—140 *C.*

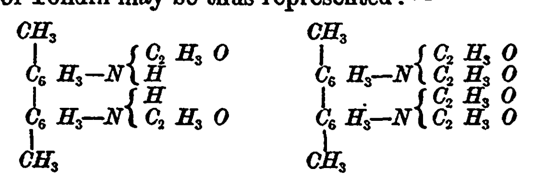
$$C_6 H_5 NCS + 2 C_2 H_4 O_2 = C_6 H_5 N (C_2 H_3 O)_2 + CO_2 + H_2 S.$$

From the readiness with which the acetyl radicle united with the tolidin it was supposed that a similar compound might be obtained directly by treating diacetyl tolidin with acetic anhydride. Accordingly diacetyl tolidin was, with 6-7 times its weight of acetic anhydride sealed in tubes and submitted to a temperature of 180° *C* for six hours. The tubes were then found to contain in a dark fluid acicular crystals, which were soluble in alcohol, ether, benzol and and acetic acid, but insoluble in water. After purification, the substance was found to crystallize in long, silky, snow white needles, melting at 210° and on analysis gave the following results :—

Calculated for $C_{22} H_{24} N_2 O_4$

Theory.	Found. I.	Found. II.
$C = 69.47$	69.28	....
$H = 6.32$	6.61	....
$N = 7.37$	....	7.65
$O = 16.84$	....	....

When treated with dilute alkalies it at once broke down into diacetyl tolidin and acetic acid. The two acetyl derivations of Tolidin may be thus represented :—



DIACETYL-TOLIDIN. TETRA-ACETYL TOLIDIN.

Dinitio-diactyl-tolidin.

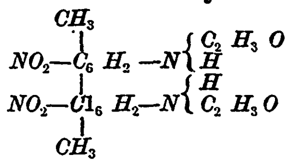
Diacetyl tolidin is easily nitrated when added in small quantities to fuming nitric acid, and the violence of the reaction moderated by surrounding the flask with ice cold water and maintaining a large excess of nitric acid. The mixture is then poured into a long beaker filled with snow and the precipitated nitro body filtered and washed. It is insoluble in alcohol, water and the usual media, but may be, like diactyl tolidin, purified by precipitation from solution in boiling nitro benzol. This compound, at first of a brown tint, can be obtained almost white by repeated recrystallization. It does not melt, and when an attempt was made to purify by sublimation it exploded violently.

On combustion it yielded the following data:—

Calculated for $C_{18}\ H_{18}\ N_4\ O_6$

Theory.	*Found.*	
$C = 55.96$	55.73	....
$H = 4.66$	4 82	....
$N = 14.51$	....	15.10
$O = 24.87$	....	....

These results are in conformity with the formula:—



Dinitro-tolidin.

When the body above described is saponified by prolonged boiling with strong caustic potash a red compound results, which from a large volume of boiling dilute alcohol may be obtained in garnet red tabular crystals which melt at 265° and explode on heating to a higher temperature. It is with difficulty dissolved in any ordinary solvent.

It yielded on analysis the following results:—

Calculated for $C_{14}\ H_{14}\ N_4\ O_4$

Theory.	*Found.* I.	II.
$C = 55.63$	55.87	....
$H = 4.65$	4.91	....
$N = 18.54$	....	18.10
$O = 21.16$	....	....

This points to the following as the probable formula:—

$$\begin{array}{c}
\quad CH_3 \\
\quad | \\
NO_2—C_6\ H_2—NH_2 \\
\quad | \\
NO_2—C_6\ H_2—NH_2 \\
\quad | \\
\quad CH_3
\end{array}$$

It was thought probable that this compound like other nitro derivatives of the aromatic series might be reduced and a tetra-amido derivative thus obtained, but this reduction could not be affected. When dinito tolidin is submitted to the reducing action of nascent hydrogen, evolved either from tin and hydrochloric acid or from sodium amalgam, it breaks down into tolidin, and by no means employed could the nitro groups be reduced to amidogen.

(Continued.)

Chemical Laboratory,
McGill Univ., Med. Faculty.
October, 1889.

L'Abbé Louis Ovide Brunet.[1]

Louis Ovide Brunet, priest in the Archdiocese of Quebec, and Professor of Botany in the University of Laval, was the second son of Jean Olivier Brunet and of Dame Cecile Lagueux, who kept an honorable commercial house in Quebec. He was born in the Lower Town the tenth day of March, 1826. After having pursued a brilliant course of study in the Petite Seminaire, he consecrated himself to the priesthood and was ordained on the first of October, 1848. He was successively Vicar at Notre Dame de Quebec, of St. Joseph de Levis, Missionary at the station of Grosse Isle, and priest at Valcartier. In 1854 he passed to the rectory of St. Lambert, where he remained until his entrance to the Seminary of Quebec.

[1] From L'Annuaire de L'Université Laval, pour L'Année Academique 1877-78.

His very decided taste for communal life, and his rare aptitude for science, caused him for a long time to wish to be admitted into that institution. His desires were at last fulfilled: in 1858 he entered the Seminary as an auxiliary priest, and was immediately charged with the teaching of Botany. There he occupied himself with the organization of a museum, but the difficulties he met with, and the numerous cares of such an undertaking, caused him, at the outset, to wish to visit Europe, in order the better to prepare himself for the teaching of his favorite science. He departed for Europe in 1861. The preparation he made for that purpose, during the two preceding years, rendered his visit most advantageous and productive of good results. After his return, M. Brunet was appointed ordinary professor in the Faculty of Arts, a title which he kept until his death; although sickness obliged him to give up his work in 1870 and leave the Seminary in 1871. He then retired to the privacy of his family, where he enjoyed the society and devoted care of a beloved mother and sister. Madame Brunet died before her son, but Madame Giroux never ceased to surround her brother with the most attentive care until the last.

During his career as professor in the Faculty of Arts, M. Brunet rendered important services to Laval University, which that institution cannot forget. He must, in fact, be regarded as the founder of the Museum of Botany. The Canadian plants which the herbarium now contains, were gathered, for the most part, by himself, and are the fruit of twelve years of earnest work. All were studied and classified by himself. He profited by his voyage to Europe, to give all possible authenticity to his determinations, and in carefully comparing those plants which presented difficulties of determination with original specimens in the herbarium of Michaux at Paris, and of Sir W. Hooker at Kew. After his return from Europe, the new or doubtful plants were submitted to examination by the most distinguished American botanists, such as Dr. Asa Gray, Dr. Engelmann, and others.

For the plants of America outside of Canada, as well as for the general herbarium containing species from all other parts of the world, M. Brunet, always careful to give to his museum an indisputable authority, secured specimens from the most celebrated collectors, as we may see from the following partial enumeration:—

Plants from the Rocky Mountains, from the collections of Hall, Parry and Harbour, named by Asa Gray and Dr. Engelmann

Plants of Illinois and Missouri, from the collections of Reid arranged by Stendel. Also from the collections of Geyer.

Flora of New York from the collection of Leidenberg, named by N. Sonder.

Flora of Texas and vicinity, from collection of Mr. Vincent.

American mosses, from the collections of Sullivant and Lesquereux.

It would also be necessary to mention a large number of plants furnished to M. Brunet by his correspondents as exchanges; among others, by Mosser, Smith and Durand, of Philadelphia. As for the specimens of the general herbarium, it will suffice to name Messrs. Puel, Maille, Borderey, Le Jolis, Verlot, E. Bourgeau, J. Carruel, Balansa, Mougeot and Nestler, to make one realize the value of an herbarium containing collections from so many well known botanists.

An idea of the amount of labor accomplished by the lamented professor, outside of his teaching and other duties, may be gained from the statement that the herbarium of Laval University—thanks to the intelligent care of M. Brunet—contains more than 10,000 specimens, all properly named and classified. In addition to this work, M. Brunet occupied himself in collecting for the benefit of his students a complete series of our Canadian woods. He caused the specimens to be cut in such a manner as to present all the parts of the wood from the bark to the pith. To the collection thus made by himself, he added a number of exotic woods which he obtained from the friends he had made in

France and elsewhere. Being designed wholly for purposes of study, and therefore of small dimensions, these specimens were little calculated to be remarked in a museum and draw attention to the resources offered to commerce and industry by the magnificent species of wood in our forests. Having been charged to prepare collections of Canadian woods for the Universal European Exposition, M. Brunet profited by observations made during the preceding exhibition, and succeeded so well, that he obtained the medal of honour at Dublin in 1865, and again at Paris in 1867. These were the only two occasions on which he had been called upon to compete. Such results, in causing the resources of Canada to be appreciated in Europe, show the high esteem in which he was held. It is hardly necessary to say that the collection for which he received the medal in 1867 was similar to the one which still excites the admiration of all those who visit the museum of Laval University.

M. Brunet was honorably known in Europe and the United States; a member of several learned societies, he counted among his friends men of the highest scientific attainments. He published several botanical articles of merit. They are as follows:—

1. Notes upon the Plants collected in 1859, by L'Abbé Ferland, upon the Coasts of Labrador.
2. Journey of André Michaux to Canada. (Translation by Dr. T. Sterry Hunt in Can. Nat. N. S., p. 325.)
3. Enumeration of the Species of Plants of the Canadian Flora.
4. Catalogue of Canadian Plants contained in the Herbanium of Laval University.[1]
5. History of the Picea found within the limits of Canada.
6. Catalogue of the Ligneous Plants of Canada.
7. Elements of Botany and Vegetable Physiology, with a small flora.

[1] It is to be regretted that M. Brunet was not able to continue this detailed catalogue, which has remained unfinished.

This last work was particularly intended for the use of young ladies in religious institutions. Notwithstanding some incorrectness of style, it has fully answered the purpose of its author, and is yet highly esteemed, because in a small compass, it comprehends all that can interest those for whom it was written.

During his connection with the Seminary, M. Brunet united to his duties as professor of the University, works of a much more modest character, but in which he was equally interested. Gifted with various aptitudes, he willingly occupied himself with everything that might contribute to develop intelligence and taste in children. He taught drawing at the Seminary for several years. During his visit to Europe he had perfected a talent already remarkable, by studying different styles of drawing, and he found many occasions to verify the fact that in an educational institution, one cannot have too much knowledge on different subjects.

Whether in charge of the literary societies, or engaged in the more important duties of his sacred office, he gave to each and all an attention which extended to the minutest details. It was at his suggestion that two divisions of the yearly *retraite* of the Petite Seminaire were made,—the exercises being conducted simultaneously, but separately. The *grande retraite* includes all the classes from the sixth; the *petite retraite*, though it includes only the two lowest classes, numbers, however, 120 to 150 *retraitants.* By this division it became possible to deal with subjects in a manner particularly suited to the members of each division.

Amiable and full of wit, the conversation of M. Brunet was pleasant and cheerful—qualities which caused his colleagues to seek his society. The long illness which brought his life to a close, altered this feature of his disposition, and in the latter part of his life he lived in almost complete seclusion—his best friends having much difficulty in seeing him.

The illness which slowly took his life away assumed a serious character only a few days before his death, which became known even before the aggravation of his illness was realized. M. Brunet enjoyed lucidity of mind almost to the last. The end came without pain, on the second of October, 1876, at eight o'clock in the evening. He was fifty years of age, exactly twenty-eight of which he passed in the priesthood. His remains rest in the chapel of the Seminary.

AN ANCIENT BLAZE.

By D. P. PENHALLOW.

Somewhat more than four years since, I described[1] an interesting blaze of considerable antiquity, found in the interior of a beech tree when in process of being cut up for firewood. In a more recent publication[2], additional notes were offered, and the statement then made, that the possible date when the blaze was made—assuming the 160 rings of growth to represent exactly as many years, and also assuming that none of the external layers had been removed by decay and other causes—corresponded exactly with the date when the parish of Two Mountains was established, viz., 1721.

It was therefore thought possible that it represented an old boundary blaze, of which there might be others preserved in some of the old trees of the vicinity. This explanation, however, was never a satisfactory one to me, inasmuch as surveyors would hardly undertake so elaborate a figure for such a purpose, nor would they be liable to make the lines of the figure so narrow as to render their early obliteration, within a few months at the farthest, a matter of certainty.

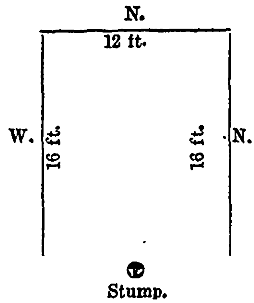
At our request, therefore, Mr. Oswald, who originally discovered the specimen, kindly undertook to make a

[1] Science III., 356.

[2] Trans. R. Soc. Can., V., iv. 50.

thorough examination of the locality. His report is substantially as follows:—

"From the appearance of the ground at the base of the tree, I think there must have been a hut there at one time. There are three mounds of earth forming as many sides of a square. Those forming the two sides, east and west, are about sixteen feet long, while the mound at the north end is about twelve feet long. They are all about two feet high. At the southern end of the square there is no mound, the



earth being at natural level, while at four feet from the probable line of this end, is the stump of the tree from which the blaze was taken. The land to the south rises gradually for one hundred yards, while to the north, for about the same distance, it slopes down towards a small stream where there is every indication of an old beaver dam. The land around it is in heavy bush, and no doubt a century and a half ago, it was in that condition for miles around. I made inquiries of old inhabitants if there were ever any boundary lines near here, and I found there were none. At present, the location is a full mile from the boundary line dividing the parishes of St. Augustin and St. Scholastique, and the Seigniory boundary of the Seminary of St. Sulpice and the Globensky Seigniory, while it is just about the center of the County of Two Mountains." He also dug on the site to a depth of two feet without any result beyond the fact that the earth appeared to be in a natural condition.

These facts must certainly dispose of any possible connection between the blaze and a boundary line, while they also strongly point to the probable fact that a log hut once stood at the foot of the tree, and in decay produced the mounds observed. It is also of interest in this connection to note what we have elsewhere[1] stated, that the Franciscan Hennepin, who was with La Salle from 1679–1682, was traversing this very region of Two Mountains during the years when this blaze was cut, and he speaks of frequently making blazes on trees, as was then customary, the figures taking the form of a cross.

It would appear probable, therefore, from the facts now in our possession, that the blaze was made as a sort of shrine by a trapper or a monk whose hut stood at the foot of the tree, and that it was made by a Franciscan monk would appear most probable from the character of the blaze itself.

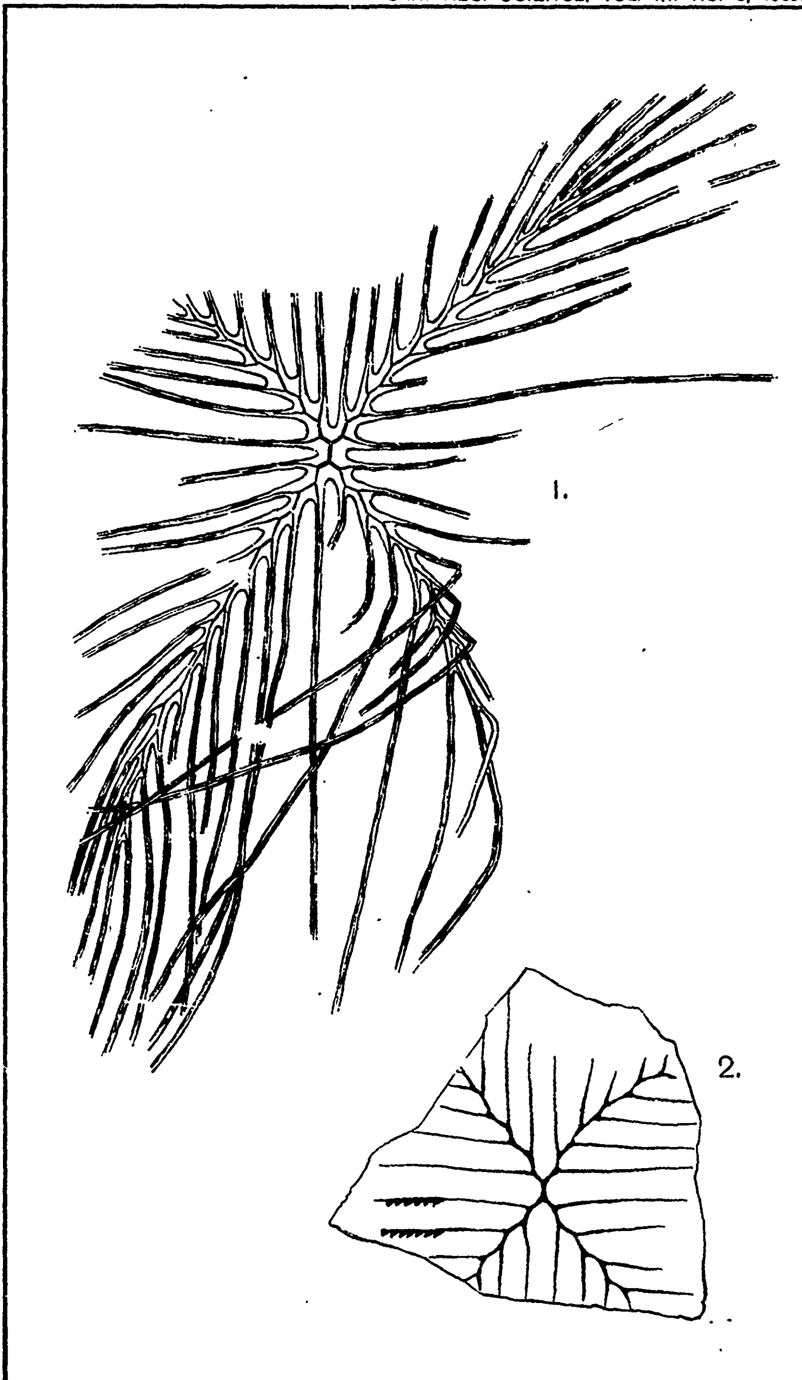
Additional Notes on Goniograptus Thureani, McCoy, from the Levis Formation, Canada.

By Henri M. Ami.

In Vol. III., No. VII., p. 422 of the *Record*, the writer presented a brief paper "on a species of Goniograptus from the Levis formation, Levis, Quebec," in which there was recorded for the first time on this continent the discovery of this interesting genus of siculate graptolites. It was intended to have a *plate* illustrating the Canadian individuals accompanying that paper, but it was unavoidably omitted.

The plate accompanying this note was prepared by Mr. Lawrence Lambe, artist to the Canadian Survey, and illustrates well, two of the best specimens collected by Mr. Weston and Mr. Lambe, in 1886 and 1887, respectively. There are a number of obvious typographical errors, of

[1] Trans. R. Soc. Can., V., v. 50.



AMI ON GONIOGRAPTUS FROM LEVIS, QUEBEC.

little import, in that paper (*loc. cit. supræ,*) whilst one or two less obvious corrections are hereby submitted.[1]

On page 426 and line 12 from the bottom the text reads: "The angle which these celluliferous stipes make with the general direction of the arm is generally 450°" The angle here meant is 45° not 450°.

On the same page, in the preceding paragraph, it is stated of the arms that "all four are sub-equal, disposed regularly and symmetrically, so as to form a large + shaped figure." This statement might be modified so as to indicate the exact angles made by the arms; that they are disposed so as to form a polypary with two series of arms and areas included within or between the arms, one set of which contains an angle of seventy-five degrees, and the other or larger angle, one hundred and five degrees.

The excellent figures by Mr. Lambe are exact reproductions of the specimens in the national collections of the Geological Survey Museum, Ottawa, and indicate admirably the mode of growth of the polypary. Only in fig. 2, the smaller specimen, are there any hydrothecæ visible.

Although the material very kindly placed at the disposal of the writer by Dr. Selwyn and Mr. Whiteaves is excellent, and presents new features respecting the morphology and development of *Goniograptus,* it is nevertheless hoped that additional material will be forthcoming whereby all the generic and other relations of this interesting member of the disc-bearing group of graptolites can be studied and ascertained.

It might be interesting here to add that the following species occur in the same measures with *Goniograptus Thureani,* McCoy var. Selwyni, *nobis,* viz:—

Tetragraptus quadri-brachiatus, Hall; *T. approximatus,* Nicholson; *T. fruticosus,* Hall; *T. serra,* Brongniart; (=*T. bryonoides,* Hall); *Dichograptus octo-brachiatus,* Hall; D. (?) *ramulus,* Hall; *Drityograptus* sp., and *Lingula Trene,* Billings.

[1] The paper in question was published during the author's absence in Europe, so that he had not opportunity of correcting the proof.

Book Notices.

Text-Book of Botany.[1]—This most recent of American Text-Books of Botany is dedicated to the illustrious memory of Antoine L. De Jussieu, upon whose inductive method the course of study is based. The first part deals with instructural and systematic botany, touching briefly upon some of the more important physiological processes. Part II., Phytology, opens with a pretty full list of abbreviations used, a most useful list of etymons, and a very full list of proper names. The remainder of the work—169 pages—is taken up by a "Manual of Plants, including all the known orders with their representative genera."

There is little evidence of advance beyond what has been stated in previous text-books. We note, however, as announced in the preface, that the sequence of the leading divisions of the Phanerogams—Class I. Gymnosperms and Class II. Augiosperms—is more in accord with present views than what is usually found in our unrevised text-books. The figures are good, and for the most part fresh—a few being original.

The treatment is clear and concise, but in the use of similes is often inclined to be trivial—a style quite out of place in a scientific treatise. The attempt to cover too much ground within a very limited space has resulted—as must be expected under such circumstances—in a breviety of statement which must often leave the student without any clear conception of the particular subject. So far as the systematic and structural portion is concerned, this difficulty would be overcome by a competent teacher, but for the student under the ordinary circumstances of academic instruction, the fault is a serious one. It becomes more marked in the Manual, where brevity and condensation is carried to such an extreme as to render this part of the work of little or no value for the determination of species by those who have not already gained a considerable experience in the analysis of plants.

When a new work such as this appears, one naturally looks to it as giving recognized facts of fairly recent date, and it is disappointing to find, page 46, that the leaves of Welwitschia are spoken of as persistent cotyledons; page 70, and in the chart, page 69, the term Azoic is retained instead of Eozoic, while the statement is made, notwithstanding the known presence of *Eozoon Canadense* and graphite in the Laurentian formation, that no life appeared until the Palæozoic; the cells of Diatoms are rich in starch, p. 25;

[1]Botany for Academies and Colleges, with a Manual of Plants. By Annie Chambers-Ketchum, A.M. J. B. Lippincott & Co., 1889. 8vo, pp. 190 and 169.

the term radicle is still applied to the caulicle of the embryo; the obsolete term spongioles, is given a definite value; while on p. 163 we are left to infer that soda is present only in marine plants. No doubt these mistakes will be eliminated from the next edition. Though hardly adapted to the requirements of a college, the book will doubtless serve a very useful purpose, and we are certainly disposed to give it a welcome, as promising evidence of zealous work by a lady.

P.

GRAY'S SCIENTIFIC PAPERS.[1]—The most important of recent botanical publications, and one which will be received with the greatest favor wherever botanical research is prosecuted, is the collection of scientific papers by Dr. Gray, recently issued in a most attractive form, under the editorship of Prof. Sargent. The present issue embraces two volumes, a third to follow, as we may infer from a statement in the preface.

The voluminous character of Dr. Gray's writings is well known to botanical students, but, as the editor correctly deserves, "The number of his contributions to science and their variety is remarkable, and astonishes his associates even, familiar as they were with his remarkable intellectual activity, his various attainments, and that surprising industry which neither assured position, the weariness of advancing years, nor the hopelessness of the task he had imposed upon himself ever diminished." There will, therefore, be a well nigh universal feeling of regret for the necessity which compelled exclusion of "a number of papers of nearly as great interest and value as those which are chosen."

The writings are grouped in four divisions, according to the particular subjects dealt with. "The first in importance contains his contributions to descriptive botany. These, with few exceptions were devoted to the flora of North America, and although it did not fall to his lot, as it did to that of some of his contemporaries, to elaborate any one of the great families of plants, the extent and character of his contributions to sympathetic botany will place his name among that of the masters of the science.

"His works, of a purely educational character, are only second in importance to his writings on the flora of North America; and their influence upon the development of botanical knowledge in this country, during the half century which elapsed between the publication of the first and the last of the series, has been great and must long be felt. No text-books of science surpass them in the

[1]Scientific papers of Asa Gray, selected by Charles Sprague Sargent; Houghton, Mifflin & Co., 1889. 2 vols. 8vo., pp. 397 and 498.

philosophical treatment of the subjects they embrace, or in the beauty and clearness of their style.

A series of critical reviews of important scientific publications, and of historical accounts of the lives and labors of botanical worthies, may be conveniently grouped in the third division of Professor Gray's writings; while in the fourth fall a number of papers which owe their existence to the discussions which followed the publication of Mr. Darwin's 'Origin of Species'—discussions in which Professor Gray took, in this country, the foremost position."

For the re-publication of the first and second divisions, there is no present necessity. The most important of the philosophical essays "which grew out of the discussion of the Darwinian theory, have already been re-published by their author," and are, therefore, available. The two volumes now before us, therefore, embrace many of the most important scientific articles, reviews and biographical sketches which Dr. Gray wrote during that long period of an unusually active and brilliant career, extending from 1834 to 1887. As many of the valuable papers now left are beyond the reach of most botanical students of the present day, it is to be hoped means may be provided for their re-publication at a later date as a fourth volume of the present series.

The writings of Dr. Gray possess a peculiar interest, not only from the fact that they cover a period of somewhat more than fifty years, but because we also have in them a history of botanical science during a period pregnant with the most important developments—a period which has given birth to an entirely new school, of which Dr. Gray was himself one of the most brilliant leaders.

As a critic, "his reviews represented the opinion of a just and discriminating mind, thoroughly familiar with all sides of the question before it, critical rather than laudatory, loving the truth and its investigators, but the truth above everything else. No other naturalist of his reputation and attainments ever devoted so much time to literary work of this sort, or continued it so uninterruptedly for so many years; and in our time, the criticism and advice of no other botanist has been so eagerly sought or so highly valued by his contemporaries."

The thanks of botanists everywhere are due Professor Sargent for the service he has rendered them and science, in this compilation.

P.

INDEX.

ABSTRACT FOR THE MONTH OF JULY, 1889.

Meteorological Observations, McGill College Observatory, Montreal, Canada, Height above sea level, 187 feet C. H. McLEOD, *Superintendent.*

DAY.	THERMOMETER. Mean.	Max.	Min.	Range	BAROMETER. *Mean.	§Max.	§Min.	§Range.	† Mean pressure of vapour.	‡ Mean relative humidity.	Dew point.	WIND. General direction.	Mean velocity in miles perhour	SKY CLOUDED IN TENTHS. Mean.	Max.	Min.	Per cent of possible sunshine.	Rainfall in inches.	Snowfall in inches.	Rain and snow melted.	DAY.
1	76 75	87.5	66.0	21.5	30.1672	30.200	30.124	076	.6135	67.7	64.7	S.	9 0	2.0	5	0	89	....	....	....	1
2	75 42	82.3	68.2	14.1	30.1308	30.194	30.059	.135	.6422	73.8	66.2	S.	14.2	5.5	10	1	65	Inapp.	....		2
3	75.05	82.0	69.2	12.8	29.8837	30.045	29.727	.318	.7308	84 2	69 8	S.E	12.3	8.5	10	4	00	0.10	....	...	3
4	70.07	77.0	59.3	17 7	29.7755	29.979	29.638	.341	.5918	79.7	63.2	S.W.	20.9	6.2	10	2	41	1.03	....		4
5	64.52	75.0	54.4	20.6	30 1163	30.146	30.060	.086	.3748	62.0	51.0	N.W.	10.8	0.8	5	0	100	....	.	....	5
6	68.25	77.5	57.3	20.2	30.1762	30.247	30.111	.136	.4035	59.7	53 0	S.W.	8.6	2.5	10	0	89	....	....	...	6
SUNDAY........ 7	.....	74.8	63.1	11.7	....	......	......	....	...	....	....	S.W.	22.1	....	..		04	0.3	....	....	7 ....SUNDAY
8	74.00	82.0	67.0	15 0	29.9125	29.926	29.899	027	.6155	74 0	64.8	W.	8.6	9.5	10	3	31	0.02	...	...	8
9	62.72	71.6	58 9	12.7	29.9975	30.024	29.978	.046	.4968	87.0	58.7	N.E.	13 0	10.0	10	10	00	0.11	....	..	9
10	67.92	76.1	59 3	16.8	29.9673	39 001	29.933	.068	.5472	80.2	61.5	N.E.	10.9	6.8	10	1	34	...	...	..	10
11	66.10	72 6	61 3	11.3	29.8870	29 957	29.856	.101	.5805	90 5	63 0	N.E.	7 9	10.0	10	10	25	0.52	....	....	11
12	65.00	72.5	58.8	13 7	29 9992	30.026	29.963	.063	.4965	80.8	58.8	N.E.	7.9	8.2	10	0	34	...	....	....	12
13	67.65	78.0	59.3	18.7	29.8140	29 929	29.710	.219	.5703	84.7	62.5	S.E.	8.7	8.0	10	1	28	0.42	...	....	13
SUNDAY. 14	.....	71.0	58.3	12.7	....	. ...	.	....	.....	....	....	N.W.	10.7	...	.	..	67	. .	....	...	14 ....SUNDAY
15	61.65	69 9	53.4	16.5	29 8465	29 885	29.813	.072	.3683	67.0	50.3	N.	10.7	6.7	10	0	48	0.03	...	..	15
16	66.02	77 1	57 3	19 8	29.7987	29 840	29.746	.094	.4695	74.3	57 0	W.	19.0	7.2	10	3	48	0 36	....	....	16
17	64.67	72.5	59.0	13 5	29 8918	29 932	29.813	.119	.4430	73.0	55.7	W.	13 9	3.8	9	0.	72	Inapp.	....	....	17
18	68.75	77.0	58.3	18 7	29.8763	29.940	29.791	.149	.4802	68.7	57.8	S.	11.4	2.2	10	0.	98	...		......	18
19	71.13	80.8	64.2	16 6	29 7223	29.785	29 644	.141	.5997	79.0	63.8	S.	9.3	10.0	10	9	18	0.23	....		19
20	68.63	74.9	64 5	10.4	29.7025	29.831	29.582	.249	.5625	80.8	62.3	N.	15.5	10.0	10	10	19	2.00	....	....	20
SUNDAY........21	.....	80.0	61.5	18.5	..	......		....	.....	...	....	N.W.	11.2	....	..	.	99	....	..	....	21 ....SUNDAY
22	71.25	80.9	61.2	19 7	29.8633	29 939	29 775	.164	.5285	69.3	60.2	S.W.	7 1	3 3	10	0	92	....	...	....	22
23	65.48	74.9	58.5	16.4	29 7227	29.798	29.653	.145	.4788	76.2	57.7	S.W.	19 0	4 5	10	0	61	0.10	---	...	23
24	59.78	69.9	56.0	13.9	29 8777	29.953	29.822	.131	.3518	68.7	49.0	W.	14.7	6.7	10	0	36	0 04	.	....	24
25	61.98	70.0	52.3	17.7	30 0190	30 062	29.982	.080	.3402	61.5	48.0	W.	13.7	3.0	8	0	85	Inapp.	. .	....	25
26	65.67	73.9	52.4	21.5	30.1002	30.144	30.064	080	.3323	53.8	47.7	E.	6.2	2 0	7	0	100		. .	....	26
27	63.33	72 0	57.9	14.1	29.9635	30.038	29 876	.162	.4635	80.7	56.8	S. E.	12 0	8.8	10	3	02	0 78		....	27
SUNDAY.. 28	.....	77 9	59.2	18.7	....	29 884	29.750	...	....	..	....	S. E.	16.3	....	..	..	66	0.28		....	28 ....SUNDAY
29	71.68	79 6	66.2	13.4	29.8023	30 037	29.923	.134	.6388	82.3	65.7	S.	17 9	9.3	10	7	17	0.97		....	29
30	69 28	75.5	65.3	10.2	29.9570	30.138	30.064	.114	.6125	85.7	65.0	S.W.	13.2	8 0	10	1	27	0 14	.	....	30
31	72.57	81.0	65.3	15.7	30.1005	......	......	.074	6135	77.8	64.7	S.W.	9 8	8.2	10	0	64	....	.	....	31
....Means	67.97	76.38	60 42	15.96	29.9286	......	.....	131	.5165	74.9	59.2	....	12 47	6 36	..	..	50.3	7.16	....	..	Sums ....
15 yrs. means for & including this mo.	69 02	77.34	60.02	16.32	29 8815	.....	....	.1396	5011	70 9	...	..	..	5.42	..		¶59.2	4 25	....	..	15 years means for and including this month.

ANALYSIS OF WIND RECORD.

Direction.......	N.	N.E.	E.	S.E.	S.	S.W.	W.	N.W.	Calm.
Miles..	998	518	234	1126	1529	2481	1394	998	
Duration in hrs..	95	51	32	103	121	164	94	84	
Mean velocity...	10.51	10.16	7.31	10.93	12 64	15.13	14.83	11.88	

Greatest mileage in one hour was 33 on the 4th and 20th.

Resultant mileage, 3,170

Resultant direction, S 51° W.

Total mileage, 9,279.

*Barometer readings reduced to sea-level and temperature of 32° Fahr.

§ Observed.

† Pressure of vapour in inches of mercury.

‡ Humidity relative, saturation being 100.

¶ Eight years only.

The greatest heat was 87.5 on the 1st; the greatest cold was 52.3 on the 25th, giving a range of temperature of 35.2 degrees. Warmest day was the 1st. Coldest day was the 24th. Highest barometer reading was 30,247 on the 6th; lowest barometer was 29.582 on the 20th; giving a range of 0.665 inches. Maximum relative humidity was 97 on two days. Minimum relative humidity was 38 on the 26th.

Rain fell on 20 days.

Hail fell on 1 day.

Auroras were observed on 3 nights.

Thunderstorms on 5 days.

NOTE.—The rainfall is the greatest recorded in July, in 15 years; and is the greatest for any one month during that time, except the month of August, 1888 (rainfall 7.89) and October, 1885; (rainfall 7.17).

ABSTRACT FOR THE MONTH OF AUGUST, 1889.

Meteorological Observations, McGill College Observatory, Montreal, Canada, Height above sea level, 187 feet. C. H. McLEOD, *Superintendent.*

DAY.	THERMOMETER. Mean.	Max.	Min.	Range	BAROMETER. *Mean.	§Max.	§Min.	§Range.	† Mean pressure of vapour.	‡ Mean relative humidity.	Dew point.	WIND. General direction.	Mean velocity in miles perhour	SKY CLOUDED IN TENTHS. Mean.	Max.	Min.	Per cent of possible sunshine.	Rainfall in inches.	Snowfall in inches.	Rain and snow melted.	DAY.
1	66.72	72.5	63.4	9.1	30.0460	30.148	29.965	.183	.6162	94.2	65.0	S.	6 3	8.3	10	0	00	0.68	....	....	1
2	70.53	79.1	63.2	15.9	29.9000	29.976	29.841	.135	.6185	84.2	65.0	S.	10.6	8.5	10	1	42	0.11	....	..	2
3	68.97	78.6	61.1	17.5	29.8603	29.918	29.816	.102	.5633	79.8	62.3	S.W.	16.5	6.3	10	0	50	0.04	....	....	3
SUNDAY........ 4	.....	73.5	57.4	16.1	....	......	......	....	.....	....	....	S.W.	14.9	....	..		[illegible]	0.13	....	....	4 ....SUNDAY
5	61.57	70.0	58.3	11.7	30.0587	30.113	30.035	.078	.4290	78..	54.5	W.	7.6	6.8	10	0	28	0.02	.. .	....	5
6	64.40	73.0	55.4	17 6	30.1103	30.161	30.060	.101	.3930	66.5	52.2	S.W.	15.9	2.8	10	0	98	....	....	....	6
7	62.67	70.9	54.9	16 0	30.1428	30.194	30.108	.086	.3657	65.2	50.2	W.	8.4	2.2	9	0	86	....	....	....	7
8	62.37	73.0	51.9	21.1	30.1227	30.215	30.014	.201	.3903	67.7	52.0	S.W.	6.3	7.0	10	0	85	....	....	....	8
9	66.52	74.0	59.2	14.8	29.8567	29.976	29.787	.189	.5498	84.5	61.5	S.W.	15.8	9 8	10	9	02	0.04	....	...	9
10	64.90	70.4	59.1	11.3	29.8165	29.848	29.788	.060	.4638	75.7	56.8	W.	11.6	8.5	10	1	45	0.26	....	....	10
SUNDAY........11	.....	63.7	52.4	11.3	....	......	....	....	.....	...	....	W.	14.7	...	.	..	46	....	....	....	11 ....SUNDAY
12	58.42	67.3	50.4	16.9	30.0043	39 043	29.959	.084	.3615	75.0	50.0	S.W.	15 3	5.7	10	0	77	Inapp.	....	....	12
13	60.05	68.3	52.4	15.9	30.0845	30.102	30.041	.061	.3423	67.0	48.5	W.	6 9	7.2	10	0	83	. .	....	....	13
14	59.98	64.7	55.0	9.7	29.9015	30.049	29.738	.311	.3952	76.3	52.0	E.	16.5	10 0	10	10	00	0.63	....	....	14
15	61.13	66.5	56.4	10.1	29.7532	29.828	29.677	.151	4507	84.2	55.8	S.W.	14.1	9.7	10	3	21	0.51	....	....	15
16	61.30	68.1	54.3	13.8	29.8400	29.857	29.824	.033	.4130	76.8	53.3	S.W.	9 5	6 7	10	0	65	0.06	....	....	16
17	63.38	71.0	56.4	14.6	29.9198	29.973	29.854	.119	.4558	79.2	56.3	W.	14.4	9.0	10	7	66	....	....	....	17
SUNDAY........18	.....	71.7	57.8	13.9	....	......	......	....	.....	..	....	S.W.	15.7	....	..	..	60	....	...	......	18 ....SUNDAY
19	64.10	68.6	58.4	10.2	29.9437	29.974	29.915	.059	.4978	83.2	58.5	S.W.	18.2	9.5	10	7	03	....	....		19
20	68.28	74.9	63.6	11.3	29.9353	29.960	29.916	.044	.5353	78.0	60.8	W.	9.5	5.7	10	0	75	....	....	....	20
21	68.93	76.3	63.0	13.3	29.7658	29.882	29.668	.214	.6122	86.5	64.7	S.W.	14.8	8.8	10	3	01	0.23	...	....	21
22	65.90	72.0	61.4	10.6	29.8083	29.855	29.730	.125	.4643	73.5	57.0	S.W.	17.7	3.5	10	0	76	....	....	....	22
23	65.48	75.2	58.8	16.4	29.9660	30.051	29.888	.163	.4593	74.5	56.7	S.W.	15.2	4 7	10	0	93	0.02	....	....	23
24	61.47	68.6	53.9	14.7	30.1452	30.190	30.102	.088	.3938	72.3	52.2	N.E.	12.3	5 0	10	0	69	....	....	....	24
SUNDAY........25	.....	70.0	52.0	18.0	....	......	......	....	.....	....	....	N.E.	7.6	....	..	..	99	....	....	....	25 ....SUNDAY
26	61.47	71.5	50.1	21.4	30.2852	30.319	30.250	.069	.4125	74.8	53.5	N.E.	9.5	2 2	9	0	93	....	....	....	26
27	66.58	76.0	59.1	16.9	30.2552	30.329	30 192	.137	.4863	75.5	58.2	S.W.	12.0	2.5	10	0	70	....	....	....	27
28	69.67	79.3	59.2	20.1	30.1938	30.248	30.147	.101	.5295	74.3	60.7	S.W.	4.4	0.5	2	0	94	....	....	....	28
29	71.32	81.1	60.3	20.8	30.0965	30.153	30.041	.112	.5568	73.5	62.2	S.W.	9.2	3 0	10	0	84	....	....	....	29
30	71.70	79.0	66.3	12.7	30.0608	30.125	50 032	.093	.5068	64.8	59.2	S.W.	19.3	4.8	8	0	77	.	....	....	30
31	65.38	73.9	59.3	14.6	30.2595	30.293	30.187	.106	.3755	60.8	51.0	N.E.	13.8	2.2	8	0	90	...	...	....	31
....Means.	64.97	72.35	57.56	14.78	30.0049	......	......	.118	.4681	75.8	56 7	S. 54° W.	12 40	5 96	.		59.0	2.73	....	....	Sums ....
15 yrs. means for & including this mo.	67.10	75.38	58.96	16.42	29.9397	......	......	.129	.4840	72.5	....	....	....	5.36	..	..	60 4	2 83	..	....	15 years means for and including this month ..

ANALYSIS OF WIND RECORD.

Direction........	N.	N.E.	E.	S.E.	S.	S.W.	W.	N. W.	Calm.
Miles...........	661	686	460	177	927	4344	1725	257	
Duration in hrs..	59	66	45	22	86	298	134	34	
Mean velocity...	11.2	10.4	10.2	8.0	10.8	14.6	12.9	7.6	

Greatest mileage in one hour was 27 on the 30th.
Resultant mileage, 4,805.

Resultant direction, S 54° W.
Total mileage, 9,237.

*Barometer readings reduced to sea-level and temperature of 32° Fahr.

§ Observed.

† Pressure of vapour in inches of mercury.

‡ Humidity relative, saturation being 100.

¶ Eight years only.

The greatest heat was 81.1 on the 29th; the greatest cold was 50.1 on the 26th, giving a range of temperature of 31.0 degrees. Warmest day was the 30th. Coldest day was the 11th. Highest barometer reading was 30.329 on the 27th; lowest barometer was 29.668 on the 21st; giving a range of 0.661 inches. Maximum relative humidity was 98 on the 1st and 15th. Minimum relative humidity was 42 on the 6th.

Rain fell on 13 days.

Auroras were observed on 1 night.

Fog on 4 days.

Thunderstorms on 6 days.

ABSTRACT FOR THE MONTH OF SEPTEMBER, 1889.

Meteorological Observations, McGill College Observatory, Montreal, Canada, Height above sea level, 187 feet. C. H. McLEOD, *Superintendent.*

DAY.	THERMOMETER. Mean.	Max.	Min.	Range	BAROMETER. *Mean.	§Max.	§Min.	§Range.	† Mean pressure of vapour.	‡ Mean relative humidity.	Dew point.	WIND. General direction.	Mean velocity in miles per hour	SKY CLOUDED IN TENTHS. Mean.	Max.	Min.	Per cent of possible sunshine.	Rainfall in inches.	Snowfall in inches.	Rain and snow melted.	DAY.
SUNDAY....... 1	. ...	75.9	55.1	20.8	....	.....	......	....	.....	....	....	N.E.	6.6	....	..		91	....	....	....	1 ....SUNDAY
2	67 92	77.5	55.1	22.4	30.1868	30.258	30.113	.145	.5007	74.2	58.8	S.	9.3	6.8	10	0	75	....	....		2
3	69.32	79.2	59.5	19 7	30.0803	30.126	30.040	.086	.5373	76.7	61.0	S.	9.5	6.5	10	0	75	....	....	....	3
4	70.70	82.1	60.4	21.7	30.0582	30.113	30.022	.091	.5732	77.0	62.8	S.E.	5.5	3.7	10	0	79	....	....		4
5	70.32	77.0	62.9	14.1	29.9788	30.037	29.930	.107	.5493	75.0	61.5	S.	14.1	5 0	9	0	54	....	. .	....	5
6	64.35	72.0	57.1	14 9	30 0150	30.170	29.903	.267	.5142	85.0	59.7	S.W.	16.9	7.8	10	0	03	0.12	....	....	6
7	61.53	65.9	54.0	12.9	30.1903	30.253	30.123	.130	.4537	83.5	56.0	E.	6.3	8.3	10	0	07	....	....	....	7
SUNDAY. 8	.....	73.4	58.1	15.3	....	......	......	....	.....	....	....	....	1.9	....	.	..	77	....	...	....	8 ....SUNDAY
9	67.70	77.1	57.5	19.6	30.2428	30.284	30.208	.076	.4777	72.0	57.7	N.E.	9.3	0.0	0	0	98	....	....	...	9
10	68.03	78.8	00.1	18.7	30.2333	30.264	30.217	.047	.5310	78.7	60.7	N.E.	11.2	6.8	10	0	56	....	...	...	10
11	69.12	80.1	59.9	20.2	30.2030	30 260	30.164	.096	.5055	73.5	59.2	N.E.	13.1	0.8	5	0	88	....	....	....	11
12	68.97	80.4	58.4	22.0	30 1997	30.224	30.171	.053	.5168	74.0	59.7	N.E.	10.5	3.7	10	0	88	....	....	....	12
13	67.05	75.5	62.1	13.4	30.2153	30.273	30.151	.122	.4710	71.8	57.0	S.E.	8.8	8.7	10	0	05		...	....	13
14	69.83	78.7	60.3	18.4	30.1845	30.232	30.147	.085	.5680	76.8	62.2	S.E.	15.4	7.0	10	0	39	Inapp.	....	....	14
SUNDAY.......15	. ...	81.0	63.8	17.2	....	......	......	...	.....	....	....	S.	15.7	..	..	.	75	...	....	....	15 ....SUNDAY
16	62 82	72.9	54.1	18.8	29.9733	30.069	29.910	.159	.5240	89.3	59.8	N.	14.0	8.3	10	0	00	0.74	....	....	16
17	53.75	56 1	50.2	5.9	29.9817	30.061	29.867	.194	.3880	93.7	52 0	N.E.	7 7	10.0	10	10	00	0 85	....	....	17
18	54 95	59.2	51.4	7 8	29.7963	29.811	29.776	.035	.3763	86.5	50 8	S.W.	12.2	7.0	10	0	10	1.06		......	18
19	49.17	52.3	47 0	5.3	29 5155	29.782	29.376	.406	.3137	89.7	46.2	W.	18.2	8.8	10	5(?)	00	0.54	....		19
20	51.32	54.0	47.5	6.5	29.3262	29.362	29.292	.070	.3473	91.7	49.0	S.	15.9	10 0	10	10	00	0.40	....	....	20
21	49.02	53.0	45.5	7.5	29.4458	29.649	29.281	.368	.3068	87.5	45.3	W.	16.0	8.3	10	0	00	0.40	.	....	21
SUNDAY.. 22	.....	52.0	39.6	12.4	......	......	.....	....	... .	..	....	W.	22.9	....	10	.	40	Inapp.	...	....	22 ....SUNDAY
23	48.80	57.1	38.6	18.5	30.0125	30.070	29.943	.127	.2113	62.3	35.8	W.	20.3	1.8	10	0	95	.	....	....	23
24	56.22	65.0	48.2	16 8	30.0550	30 096	30.025	.071	.2925	65 8	44.0	S.	9 0	2 0	10	0	53	....	. .	....	24
25	59.40	71.2	45 7	25.5	30.0005	30.081	29.928	.153	.3418	70.3	48.2	S.	11.1	1.7	10	0	92	...	.	....	25
26	55.78	62 5	47.5	15.0	29.8337	29.882	29.792	.090	.3875	85.3	51 5	S.W.	20.0	9.3	10	6	00	0.23		....	26
27	47.08	55.0	43.5	11.5	29.9225	29.993	29.857	.136	.2487	77.2	40 0	W.	14.7	8.0	10	0	49	0.05		....	27
28	43.50	50.9	38.7	12.2	30.0630	30.133	30.028	.105	.2052	72.7	35.0	W.	14.3	5.2	10	0	30	0 07		....	28
SUNDAY........29	.....	48.5	37 7	10.8	....	......	.....	....	.....	...	..	W.	11.3	....		..	62	0.09		....	29 ...... SUNDAY
30	51.70	62 0	40.6	21.4	29.8747	30.010	29.668	.342	.3517	90.0	48.5	S.	11.3	9.8	10	9	10	0.08	...	....	30
....Means.	59.93	67.58	52.00	15.57	29.9835	......	.....	.142	.4197	79.21	52 9	....	12 43	6.21	.		45.0	4.63	....	....	Sums ....
15 yrs. means for & including this mo.	58.56	66.60	50.83	15.77	30.0065	......	.....	.179	.3804	74.94	....	.. ..	....	5 69		.	¶54.4	3.33			15 years means for and including this month

ANALYSIS OF WIND RECORD.

Direction........	N.	N.E.	E.	S.E.	S.	S.W.	W.	N.W.	Calm.
Miles...........	527	940	252	1301	1911	1751	2037	231	
Duration in hrs..	51	97	42	118	147	105	129	20	11
Mean velocity...	10.3	9.7	6.0	11.0	13.0	16.7	15.8	11.6	

Greatest mileage in one hour was 32 on the 9th.

Resultant mileage, 3,155.

Resultant direction, S 30° W.

Total mileage, 8,950.

*Barometer readings reduced to sea-level and temperature of 32° Fahr

§ Observed.

† Pressure of vapour in inches of mercury.

‡ Humidity relative, saturation being 100

¶ Eight years only.

The greatest heat was 82.1 on the 4th; the greatest cold was 37.7 on the 29th, giving a range of temperature of 44.4 degrees. Warmest day was the 15th. Coldest day was the 29th. Highest barometer reading was 30.370 on the 1st; lowest barometer was 29.281 on the 21st; giving a range of 1.089 inches. Maximum relative humidity was 99 on the 17th. Minimum relative humidity was 39 on the 25th.

Rain fell on 14 days.

Aurora on 1 night.

Fog on 6 days.