The next question which is dealt with is the existence of an optimum intensity of light for the decomposition of carbonic acid. Prof. Pringsheim does not consider that this is the intensity which effects the greatest evolution of oxygen, for, from his point of view, the amount of oxygen given off at any time is the resultant of the action of two distinct processes, respiration and assimilation, both of which are affected by the intensity of the light. He concludes that, so far as an actual gain of carbon is concerned, there is no general optimum intensity. He applies this mode of reasoning also to the question of the relative activity of the different rays of the spectrum in the process of assimilation. The green and yellow rays have been found to be more active than the blue, because, as he points out, they are not absorbed to the same extent by the chlorophyll, and not because they are endowed with any special reducing power. Finally, he proceeds to the discussion of the fact that the volume of an atmosphere in which green plants are exposed to light remains constant. This fact has led to the conclusion that, since the volume of carbonic acid decomposed and of oxygen exhaled is the same, the substance formed in the process is a carbohydrate. Prof. Pringsheim's inference from this fact is very different. He argues that since oxidation and reduction are going on simultaneously, the substance formed contains a smaller quantity of oxygen than a carbohydrate—in fact a quantity which is smaller by just that amount of oxygen which has been used up in respiration.

Stated in the briefest possible manner, Prof. Pringsheim's principal results are as follows:

1. That the presence of chlorophyll favors the assimilatory activity of the chlorophyll-corpuscle in consequence of the absorption, by the chlorophyll, of light, which would promote the respiratory activity.
2. That hypochlorin is the substance which is the first visible product of this assimilatory activity, and that the other substances (starch, glucose, oil, tannin) which are found in chlorophyll-corpuscles are derived from hypochlorin by oxidation. This conclusion is based upon the general occurrence of hypochlorin in chlorophyll-corpuscles, upon the fact that the amount of hypochlorin in a corpuscle varies inversely as the quantity of starch which is present, and upon the observation that hypochlorin cannot be detected in seedlings until they have been exposed to light of such an intensity as to enable them to assimilate.

It is of interest to note that hypochlorin makes its appearance at the later stages of germination in seedlings of various species of *Pinus* which have grown in the dark, inasmuch as it has long been known that these plants become green in darkness.

This paper cannot be regarded as other than a most important contribution to our knowledge of the physiology of plants, and it will be readily admitted that Prof. Pringsheim's theory of the function of chlorophyll is at least as satisfactory as any which are now current. But although the number of facts upon which the theory is based is large, yet the evidence in favor of it can hardly be considered to be complete at present; there are certain points which require further elucidation. For instance, Prof. Pringsheim regards the chlorophyll of a corpuscle as undergoing no change under ordinary circumstances, but it is difficult to reconcile this view with the fact that an alcoholic solution of chlorophyll loses its color under the same circumstances. Then again, as to the source of the reducing energy in the process of assimilation, if the rays absorbed by the chlorophyll are not directly concerned in it, it is most desirable that more information should be obtained as to the nature of the rays which are active, and as to the particular cell-contents which absorb them. Further, the correctness of the principle that an increase in the intensity of light to which a cell is exposed produces an increase of its respiratory activity, needs more direct and general experimental confirmation than is given here. In his views as to the respiratory function, he appears to insist too strongly that the chlorophyll-corpuscles are to be regarded not only as assimilatory, but also as respiratory organs.

It is not easy to see that any of the observations which he gives in this paper directly suggest such a view; on the contrary, they tend rather to show that exposure to intense light increases oxidation in the whole of the protoplasmic cell-contents. Prof. Pringsheim evidently desires to bring out that hypochlorin is the substance which undergoes oxidation in the cell, and since it is present exclusively or nearly exclusively in the chlorophyll-corpuscles, he considers that these bodies are the especial seats of the respiratory process. His observations, however, do not warrant this conclusion; what they prove is that the hypochlorin in the chlorophyll-corpuscles is oxidized when they are exposed to intense light in an atmosphere containing oxygen, and that certain changes (including a loss of substance) take place in the rest of the protoplasm, in consequence, doubtless, of the excessive oxidation of some substance or substances which it contains. His view may be fairly met with the *a priori* objection that it is highly improbable that the same organ should be the seat of two such opposite functions as respiration and assimilation. The true physiological significance of the chlorophyll-corpuscles becomes apparent when it is borne in mind that assimilation does not take place in cells which do not possess them, whereas respiration proceeds actively, perhaps most actively, in such cells.

And, finally, as to hypochlorin, it is to be hoped that a method will be devised for the extraction of this substance in such quantities as to allow its properties to be studied and its chemical composition to be ascertained. The curious fact that hypochlorin cannot be detected in plants which are not distinctly green (*Diatomaceæ*, *Fucaceæ*, etc.), is worthy of further investigation.

These desiderata may perhaps be supplied in the future publications on this subject which Prof. Pringsheim promises.—*Sydney H. Vines, in Nature.*

LIQUEFACTION OF GASEOUS MIXTURES.

By MM. CAILLETET and P. HAUTEFUILLE.

IN general the assimilation of the solution of a gas to its liquefaction is very imperfect, even in the case where the solution is completely destroyed by the action of a vacuum, for the evaporation-heat of a liquefied gas is always weaker than its solution-heat. We may, therefore, always suppose a chemical action when a gas dissolves in a liquid, but if this chemical action, as measured by the difference of the two heats just mentioned, is equal to the heat of contraction of the mixture of the two bodies taken in the liquid state, the assimilation becomes perfectly legitimate. The mixture of carbonic acid and cyanogen may be considered as the type of the liquids which the authors have been studying. This mixture preserves its characters at temperatures much higher than that which corresponds to the critical point of its more readily liquefiable element.

THE ALLOYS OF MANGANESE.

WHEN the metal manganese was first discovered in 1774 by Fredrik Gahn, the celebrated Swedish mineralogist and chemist, in reducing it from the natural oxide in a small crucible, nobody could have foreseen that the identical body, only combined with a few per cent. of carbon and iron, would, a hundred years hence, be produced in the largest blast furnaces, and at not very much greater cost than common crude iron. When this grayish-white and very brittle metal was first made known, its properties seemed to render it unfit for any practical use, as it required a very great heat for its reduction from the ore, and when exposed to damp air, it would rapidly decay or crumble to pieces. Although the metal was known to exist to some extent in the so-called "spiegeleisen," and although it was many years ago thought to be essential in the manufacture of the very best German shear steel, nobody took the trouble to produce metallic manganese on purpose. Oxidized manganese was, however, at an early date, a frequent admixture in the manufacture of ordinary cast steel or crucible steel, and by the Sheffield steelmakers particular cleansing or strengthening properties were attributed to it, in more good belief than reality.

It was only after M. A. Valenciennes, in 1870, had succeeded in producing, in a magnesia crucible with a gas-furnace, pure manganese metal in the molten state from pure hyperoxide of manganese, and had exhibited this to the French Academy, that fresh attention was directed upon this peculiar and, as is now generally acknowledged, highly useful metal. Thus, Dr. John Percy, in 1873, proposed to employ manganese instead of nickel in the manufacture of German silver, an alloy which contains copper and zinc besides. At that time also H. Tamm was able to produce an alloy of manganese and iron, with 96 per cent. of the former; while at Jauerburg in Carniola, ferro-manganese, an alloy of iron with carbon and up to 30 per cent. of manganese, had been successfully produced in the charcoal blast furnace and on a large scale. Since then the production of either pure metal or of its alloys with iron has been attempted by many English and foreign metallurgists, and by the employment of very different methods. The palm must, however, be given to those who have succeeded in producing ferro-manganese, containing from 80 to 90 per cent. of the metal, by using the ordinary blast furnace as a reductor and coke as fuel. Such specimens were largely exhibited at the late Düsseldorf Provincial Exhibition by the Phoenix Iron Company, of Ruhrort, and the Gutehoffnungs-Hütte of Oberhausen, while alloys of manganese with copper, zinc, tin, and lead were shown by the Brothers Heusler, of Dillenburg, in Nassau. They are remarkable for their extraordinary strength, toughness, and hardness, which may be produced at will by varying the quantities of the component metals.

When we look at the progress which the production of ferro-manganese—or, as we now may well call it, "crude manganese"—has made during the last few years, we find it to be quite astonishing. The reduction of manganese in combination with iron and carbon was attempted as long ago as 1865 by several metallurgists, such as Prieger, Bessemer, and others who employed crucibles, and by W. Henderson, who used the Siemens furnace for this purpose; and while the latter succeeded in getting a compound with about 80 per cent. of the metal, the crucible process was able to produce an alloy with 60 per cent. of manganese, spiegeleisen at that time hardly ever containing above 12 per cent. of the metal. This was the state of the manufacture of manganese compounds when at the Vienna International Exhibition in 1873, the "Kraiser Eisen- und Stahlwerks-Gesellschaft," of Laibach, in Carniola, produced specimens of spiegeleisen with nearly 20 per cent. of manganese, and others of ferro-manganese of a far higher percentage, which were then considered as something quite wonderful among metallurgical products. For, as was stated, they were products of the blast furnace, and very many tons of these compounds could every day be tapped from the blast furnaces of Jauerburg and Sava.

Though these statements met at first with some incredulity, it was nevertheless confirmed that the technical managers of the company, Chevalier von Banz and Mr. C. Luckmann, had indeed succeeded in employing the ordinary blast furnace with charcoal as fuel, for the production of the above-named compounds from a mixture of calcined carbonates and hydrates of iron, with manganese ore from Vigunza. The samples showed the characteristics of spiegeleisen up to a content of 20 per cent. of manganese; above this, they lost all crystalline appearance, and became non-magnetic, with an almost homogeneous or fine-grained fracture. Some of these samples, taken at the Exhibition, gave by analysis, in 100 parts:

Carbon.....	5.33	5.31	5.28	5.27
Manganese.....	22.46	23.48	28.70	35.04

This great success stimulated the managers of the Reschitz Iron Works, in Hungary, to imitate the process, and after a good deal of trouble they were able to produce, with a slag, containing principally lime, manganese, iron, and alumina, and only slightly above 20 per cent. of silica, a compound with over 35 per cent. of metallic manganese. At the same time, in 1874, M. Jordan, at the St. Louis Iron Works, near Marseilles, also succeeded in getting from the blast furnace ferro-manganese with 20 to 25 per cent. At Terrenoire the Siemens furnace had been tried, since about 1868, in such a manner that bricks were made from an intimate mixture of calcareous oxide of manganese with powdered Mokta iron ore, fine coal, and pitch, which bricks were then burned and strongly heated in the Siemens furnace with an addition of spiegeleisen, when alloys with 60 per cent. could be obtained. The blast furnace process at Terrenoire, has, however, only been in use since 1877; and though over three tons of coke are required for one ton of ferro-manganese, an alloy containing from 72 to 74 and even 80 per cent. of manganese can be now made there, when a very basic and refractory green manganese slag is aimed at.

At the Düsseldorf Exhibition of 1880, the Phoenix Company of Ruhrort exhibited specimens of ferro-manganese from the blast furnace, made with coke and an extremely basic slag, in which silica is mostly replaced by alumina. They contained from 22 up to 77 and 80 per cent. of manganese, while the Gutehoffnungs-Hütte of Oberhausen was able to show samples containing 75 per cent. of manganese with about 5 per cent. of carbon, and besides iron only traces of sulphur and phosphorus.

Such is the present state of manufacture of "crude manganese," which will find a still larger use in the metallurgy of steel the more the basic Bessemer process spreads, as its addition is necessary to restore to the overblown iron the required amount of carbon and to free it by the aid of manganese from its last traces of sulphur, which are left even after phosphorus is entirely eliminated. The success of the blast-furnace process depends, next to a high temperature

and to an extremely basic slag with very little silica, to an intimate mixture of the oxides of iron and manganese as it is found in the natural carbonate ore or the knebelite ore of Sweden, which is a silicate of equal proportions of protoxide of iron and manganese. Whenever the mixture is artificial, the most intimate contact must be looked for, because the reduction of manganese is much more owing to the action of metallic iron than to that of carbon, the former playing an intermediate role because it is easily reduced by carbon, and then helps to render the manganese metallic.

Besides the alloys with iron and carbon, those with copper, tin, and zinc are, as before mentioned, destined to become of great importance for many industrial, and especially mechanical and engineering purposes. It is as long ago as 1848 that the late Chevalier von Gersdorff, of Vienna, succeeded in producing alloys of manganese and copper, and that soon afterwards Professor A. von Schrötter, Master of the Mint at Vienna, made similar compounds by reducing a mixture of oxides of manganese and copper with charcoal in a crucible at a very high temperature, which compounds contained from 16 to 20 per cent. of manganese. Professor von Schrötter was also the first to substitute manganese for nickel in German silver and similar alloys, as was later on proposed by Dr. Percy, in London (as already noted above), and by Mr. Allen, in America. The low price of nickel at that time seems, however, to have prevented the more general application of manganese for this purpose. Since Von Gersdorff's endeavors to produce an alloy of manganese with copper, but few experimenters seem to have followed this path. Thus we find only in 1876, in Germany, Brothers F. and C. Heusler, of Isabelle-Hütte, at Dillenburg in Nassau, E. Biermann, of Hanover, and S. Elster, of Berlin, as manufacturers of manganese-bronze; while at the Paris Exhibition of 1878 similar alloys were shown by the White Brass Company of London, and by a copper works in Southern France, which exhibited an alloy of 75 copper with 25 manganese, under the name of "cupro-manganese."

While most experimenters had succeeded in combining both metals *in statu nascendi*, that is, by simultaneous reduction from their respective oxides, Heusler Brothers, of Dillenburg, recognized a greater advantage in reducing metallic manganese from pure pyrolusite for itself, and afterward alloying it in any required proportion with other metals. The reduction takes place in large plumbago crucibles with an admixture of carbon and of very basic materials by which, after six hours' smelting in a powerful coke fire, "crude manganese" is obtained, this containing 90 to 92 per cent. manganese, 6 to 6.5 carbon, 0.5 to 1.5 iron, and 0.5 to 1.2 silicon. The crude metal can be refined to contain 94 to 95 per cent. of manganese when it is remelted with a suitable flux, and this metal contains only combined carbon, while in its crude state graphitic carbon also is almost always present. The refined metal is white with crystalline fracture, and it oxidizes slowly when exposed to damp air; it is, therefore, soon combined with copper, thus forming "manganese copper," with 70 parts of copper and 30 parts manganese.

The alloy is either cast in ingots or shot and becomes a commercial article in this state; its fracture is of steel-gray color and very close, and it is not difficult to combine it in any proportion with other metals or alloys of metals, such as brass, bronze, gun-metal, bell-metal, yellow-metal, and others. The same combination has been found a very powerful "physic" in refining copper, because the manganese will take up all oxygen which is absorbed by the bath of refined copper in the refining furnace before it is made tough, either by an addition of lead or by an insertion of a pole of green wood.

Trials made at the Mansfield Copper Works have proved that an addition of 0.45 per cent. of manganese-copper is sufficient to toughen copper, which only retains from 0.005 to 0.022 per cent., while the greater portion, after having taken away the absorbed oxygen, is carried off in the refinery slag. Manganese-copper has also a beneficial influence upon the toughness and density of thin copper castings, such as thin sheets, tubes, kettles, caldrons, and other kitchen utensils, which formerly were beaten or pressed into shape; copper cast with an addition of the alloy shows itself extremely tenacious, and tubes of 3 centimeters (1½ in.) diameter and only 1.75 millimeters (0.07 in.) thickness will stand a pressure of over 1,100 lb. per square inch, when water begins to be pressed through the pores of the metal. It appears that "cast copper," which can be brought in any required shape without the necessity of soldering, beating, hammering, pressing, or drawing, will in future play a considerable part in the arts and manufactures.

"Manganese bronze," that is, an alloy with copper and 1 to 10 per cent. of manganese, which has been introduced by Mr. P. M. Parsons, is already at this time highly appreciated for its excellent qualities, that is, its strength, ductility, toughness, and hardness. The greatest absolute cohesion of manganese bronze was found with a content of 1 to 4 per cent. of manganese, while with a greater proportion it becomes less, and with above 12 per cent. the alloy is too brittle to stand any great pressure. The subjoined table gives the results of trials made with some alloys of varying composition upon the testing machine at Friedrich Wilhelmshütte to ascertain their absolute breaking strength in kilogrammes for one square millimeter, and in tons per square inch, and the elongation in per cent. before rupture takes place:

Copper (parts).....	96	95	94	90
Manganese (parts).....	4	5	6	10
Breaking strength (kilogrammes per square millimeter).....	19.0	20.62	20.8	16.56
Breaking strength (tons per square inch).....	12.3	13.24	13.46	11.02
Elongation (per cent.)....	14.6	10	14.6	5

This table shows the results with raw ingots; the strength is, however, greatly increased by rolling or hammering, as is also the case with copper.

"Manganese German silver" was made from 70 copper, 15 manganese, and 15 zinc; but as this alloy proved rather brittle in the rollers the proportions were altered to 80 copper, 15 manganese, and 5 zinc, when a beautiful white and ductile metal was obtained, which would take a high polish. It appears, however, that the ordinary nickel alloy will only be gradually superseded by manganese compound.

Of far greater importance are the "manganese tin and zinc bronzes," which were perhaps among the first upon which experiments were made on a large scale. They were obtained by adding to an alloy of copper, tin, and zinc, a certain quantity of "manganese copper," viz., the combination of 70 copper with 30 manganese as above described, by which an increase of at least 9 per cent. of strength is obtained over the ordinary alloy. This seems to be greatly due, as in the case of the refined tough copper, to a chemical