and 1 P. M., having noted the frequency of the pulse and respirations and the exhalation of carbon dioxide at 12 M., he found at 2 P. M., the pulse and respirations increased in frequency, the volume of expired air augmented, and the carbon dioxide exhaled increased from 15·77 to 18·22 cubic inches (258·43 to 298·6 c. c.) per minute. In order to ascertain that this variation did not depend upon the time of day, independently of the digestive process, he made a comparison at 12 M., at 1 and at 2 P. M. without taking food, which showed no notable variation, either in the pulse, number of respirations, volume of expired air or quantity of carbon dioxide exhaled.

The effect of inanition is to gradually diminish the exhalation of carbon dioxide. Bidder and Schmidt noted the daily production in a cat which was subjected to eighteen days of inanition, at the end of which time it died. The quantity diminished gradually from day to day, until just before death it was reduced a little more than one-half. Edward Smith noted in his own person the influence of a fast of twenty-seven hours. There was a marked dimunition in the quantity of air respired, in the quantity of vapor exhaled, in the number of respirations and in the rapidity of the pulse. The exhalation of carbon dioxide was diminished one-fourth. An important point in this observation was that the quantity was as small four and a half hours after eating as at the end of the twenty-seven hours.

Influence of Diet.—The most extended series of investigations on the influence of diet upon the absolute quantity of carbon dioxide exhaled are those of Edward Smith. This observer made a large number of experiments on the influence of various kinds of food, and extended his inquiries into the influence of certain beverages, such as tea, coffee, cocoa, malt liquors and fermented liquors. He divided food into two classes: one which increases the exhalation of carbon dioxide, which he called respiratory excitants, and the other, which diminishes the exhalation, he called non-exciters. The following are the results of a large number of observations upon four persons:

"The excito-respiratory are nitrogeneous food, milk and its components, sugars, rum, beer, stout, the cereals, and potato.

"The non-exciters are starch, fat, certain alcoholic compounds, the volatile elements of wines and spirits, and coffee-leaves.

"Respiratory excitants have a temporary action; but the action of most of them commences very quickly, and attains its maximum within one hour.

"The most powerful respiratory excitants are tea and sugar; then coffee, rum, milk, cocoa, ales, and chiccory; then casein and gluten, and lastly, gelatin and albumen. The amount of action was not in uniform proportion to their quantity. Compound aliments, as the cereals, containing several of these substances, have an action greater than that of any of their elements.

"Most respiratory excitants, as tea, coffee, gluten, and casein, cause an increase in the evolution of carbon greater than the quantity which they supply, while others, as sugar, supply more than they evolve in this excess, that is, above the basis. No substance containing a large amount of carbon evolves more than a small portion of that carbon in the temporary action

occurring above the basis-line, and hence a large portion remains unaccounted for by these experiments."

The comparative observations upon the four persons who were the subjects of experiment demonstrated one very important fact; namely, that the action of different kinds of food upon respiration is modified by idiosyncrasies and the tastes of different individuals.

The following are the results of observations upon the effects of different alcoholic beverages taken during the intervals of digestion:

"Brandy, whiskey, and gin, and particularly the latter, almost always lessened the respiratory changes recorded, while rum as commonly increased them. Rum-and-milk had a very pronounced and persistent action, and there was no effect on the sensorium. Ale and porter always increased them, while sherry wine lessened the quantity of air inspired, but slightly increased the carbonic acid evolved.

"The volatile elements of alcohol, gin, rum, sherry, and port-wine, when inhaled, lessened the quantity of carbonic acid exhaled, and usually lessened the quantity of air inhaled. The effect of fine old port-wine was very decided and uniform; and it is known that wines and spirits improve in aroma and become weaker in alcohol by age. The excito-respiratory action of rum is probably not due to its volatile elements."

From these facts it would seem that the most constant effect of alcohol and of alcoholic liquors, such as wines and spirits, is to diminish the exhalation of carbon dioxide. This effect is almost instantaneous, when the articles are taken into the stomach fasting; and when taken with the meals, the increase in carbon dioxide, which habitually accompanies the process of digestion, is materially lessened. Rum, which was found to be a respiratory excitant, is an exception to this rule. Malt liquors seem to increase the exhalation of carbon dioxide. "The action of pure alcohol was much more to increase than to lessen the respiratory changes, and sometimes the former effect was well pronounced."

Influence of Sleep.—All who have directed attention to the influence of sleep upon the respiratory products have noted a marked diminution in the exhalation of carbon dioxide. According to Edward Smith, the quantity during the night is to the quantity during the day, in complete repose, as ten to eighteen.

It has already been stated that there is great diminution in the quantity of oxygen consumed in hibernating animals while in a torpid condition. Regnault and Reiset found that a marmot in hibernation consumed only $\frac{1}{30}$ of the oxygen ordinarily appropriated in the active condition. In the same animal they noted an exhalation of carbon dioxide equal to but little more than half the weight of oxygen absorbed.

Influence of Muscular Activity.—Vierordt, in a number of observations on the human subject, ascertained that moderate exercise increased the average quantity of air respired per minute by nearly nineteen cubic inches (311·4 c. c.), and that there was an increase of 1·197 cubic inch (19·63 c. c.) per minute in the absolute quantity of carbon dioxide exhaled.

The results of the experiments of Dr. Edward Smith on the influence of exercise are as follows:

In walking at the rate of two miles (3·22 kilometres) per hour, the exhalation of carbon dioxide during one hour was equal to the quantity produced during $1\frac{1}{8}$ hour of repose with food or $2\frac{1}{2}$ hours of repose without food.

Walking at the rate of three miles (4·828 kilometres) per hour, one hour was equal to $2\frac{3}{4}$ hours with food or $3\frac{1}{2}$ hours without food.

One hour's labor at the tread-wheel, while actually working the wheel, was equal to $4\frac{1}{2}$ hours of rest with food or 6 hours without food.

It has been observed, however, that when muscular exertion is carried so far as to produce great fatigue and exhaustion, the exhalation of carbon dioxide is notably diminished.

Influence of Moisture and Temperature.—It has been shown that the exhalation of carbon dioxide is greater in a moist than in a dry atmosphere (Lehmann). It has also been ascertained that the exhalation is much greater at low than at high temperatures, within the limits of heat and cold that are easily endured, amounting, according to the experiments of Vierordt on the human subject, to an increase of about one-sixth, under the influence of a moderate diminution in temperature. It was found, also, that the quantity of air taken into the lungs was slightly increased at low temperatures.

Influence of the Season of the Year, etc.—It has been shown by the researches of Edward Smith, that spring is the season of the greatest, and fall the season of the least activity of the respiratory function.

The months of maximum are January, February, March and April.

The months of minimum are July, August and a part of September.

The months of decrease are June and July.

The months of increase are October, November and December.

Observations on the influence of barometric pressure have not been sufficiently definite in their results to warrant any exact conclusions.

Some physiologists have attempted to fix certain hours of the day when the exhalation of carbon dioxide is at its maximum and at its minimum; but the respiratory activity is influenced by such a variety of conditions that it is impossible to do this with any degree of accuracy.

Relations between the Quantity of Oxygen consumed and the Quantity of Carbon Dioxide exhaled.

Oxygen unites with carbon in a certain proportion to form carbon dioxide, the volume of which is equal to the volume of the oxygen which enters into its composition. It is possible, therefore, to study the relations of the volumes of these gases in respiration, by simply comparing the volumes of the inspired and expired air. It is now generally recognized that the volume of air expired is less, at an equal temperature, than the volume of air inspired. Assuming, then, that the changes in the expired air, as regards nitrogen and all gases except oxygen and carbon dioxide, are insignificant, it must be admitted that a certain quantity of the oxygen consumed by the economy is unaccounted for by the oxygen which enters into the composition of the

carbon dioxide exhaled. It has already been stated that $\frac{1}{70}$ to $\frac{1}{50}$ (1·4 to 2 per cent.) of the inspired air is lost in the lungs; or it may be said in general terms, that the oxygen absorbed is equal to about five per cent. of the volume of air inspired, and the carbon dioxide exhaled, only about four per cent. A part of the deficiency in volume of the expired air is to be accounted for, then, by a deficiency in the exhalation of carbon dioxide.

The experiments of Regnault and Reiset have an important bearing on the question under consideration. As these observers were able to accurately measure the entire quantities of oxygen consumed and carbon dioxide produced in a given time, the relation between the two gases was kept constantly in view. They found great variations in this relation, mainly dependent upon the regimen of the animal. The total loss of oxygen was found to be much greater in carnivorous than in herbivorous animals; and in animals that could be subjected to a mixed diet, by regulating the food this was made to vary between the two extremes. The mean of seven experiments on dogs showed that for every 1,000 parts of oxygen consumed, 745 parts were exhaled in the form of carbon dioxide. In six experiments on rabbits, the mean was 919 for every 1,000 parts of oxygen.

In animals fed on grains, the proportion of carbon dioxide exhaled was greatest, sometimes passing a little beyond the volume of oxygen consumed.

"The relation is nearly constant for animals of the same species which are subjected to a perfectly uniform alimentation, as is easy to realize as regards dogs; but it varies notably in animals of the same species, and in the same animal, submitted to the same regimen, but in which we can not regulate the alimentation, as in fowls."

When herbivorous animals were entirely deprived of food, the relation between the gases was the same as in carnivorous animals.

The final result of the experiments of Regnault and Reiset was that the "relation between the oxygen contained in the carbon dioxide and the total oxygen consumed, varies, in the same animal, between 0·62 and 1·04, according to the regimen to which it is subjected." These observations on animals have been confirmed in the human subject by Doyère, who found a great variation in the relations of the two gases in respiration; the volume of carbon dioxide exhaled varying between 0·862 and 1·087 for 1 part of oxygen consumed.

As regards the destination of the oxygen which is not represented in the carbon dioxide exhaled, it is certain that a part of it, at least, unites with hydrogen to form water, this contributing to the production of animal heat, a question that will be fully discussed in another connection.

The variations in the relative volumes of oxygen consumed and carbon dioxide produced in respiration are not favorable to the hypothesis that the carbon dioxide is always a result of the direct action of oxygen upon the carbohydrates and fats. Such a definite relation between these two gases can not be assumed to exist, in view of the fact that carbon dioxide may be given off by the tissues in the absence of oxygen.

Many of the points that have been considered with relation to the variations in the exhalation of carbon dioxide have been investigated in Pettenkofer's chamber, and the results very nearly correspond with the observations quoted from Scharling, Edward Smith and others.

Sources of Carbon Dioxide in the Expired Air.—All the carbon dioxide in the expired air comes from the venous blood, where it exists in two forms; in a free state in simple solution, or at least in a state of very feeble combination, and in union with bases, forming the carbonates and bicarbonates. The fact that carbon dioxide, as regards the quantity absorbed by the blood, does not obey, in all regards, the laws which regulate the absorption of gases by liquids under different conditions of pressure, has led some physiologists to regard all of this gas as existing in the blood in a condition of chemical combination; the greater part being very loosely united with certain other substances, and a small quantity of that which is thrown off in the expired air being in a condition of union much more stable. The greater part of the carbon dioxide exhaled comes from the plasma, where it is in feeble combination, if it be not simply in solution. Another and a smaller part is probably set free by the action of the oxyhæmaglobine, which is distinctly acid. It has been shown that more carbon dioxide can be extracted by means of a vacuum from the entire blood than from the serum; and this gas is more readily extracted from arterial than from venous blood. The mechanism by which the carbon dioxide is discharged from the venous blood is probably the following:

Carbon dioxide is carried from the tissues to the lungs, in the venous blood. Here it exists mainly in the plasma, a small quantity, only, existing in the corpuscles. As the venous blood passes through the lungs, the greater part of the carbon dioxide of the plasma either simply diffuses from the blood into the air-cells or passes out by a process known to chemists as dissociation (Deville). It is certain that the oxyhæmaglobine, which is constantly forming in the lungs, assists materially in this process.

There can be no doubt with regard to the existence of an acid of some kind in the lungs, which possibly decomposes a portion of the bicarbonates of the blood, in ordinary respiration. When sodium bicarbonate is injected into the jugular of a living animal, a rabbit, for example, it is decomposed as fast as it gets to the lungs, and carbon dioxide is evolved. This experiment produces no inconvenience to the animal when the bicarbonate is introduced slowly; but when it is injected in large quantity, the evolution of gas in the lungs is so great as to fill the pulmonary structure and even the heart and great vessels, and death is the result (Bernard).

Exhalation of Watery Vapor.—From a large number of observations on his own person and upon eight others, collecting the water by sulphuric acid, Valentin made the following estimates of the quantities of water exhaled from the lungs in twenty-four hours:

In his own person the exhalation in twenty-four hours was 5,934 grains (384·48 grammes).

In a young man of small size the quantity was 5,401 grains (350 grammes).

In a student rather above the ordinary height the quantity was 11,929 grains (773 grammes).

The mean of his observations gave a daily exhalation of 8,333 grains (540 grammes), or about a pound and a half.

The extent of respiratory surface has a marked influence on the quantity of watery vapor exhaled. This fact is very well shown by a comparison of the exhalation in the adult and in old age, as in advanced life the extent of respiratory surface is much diminished. Barral found the exhalation in an old man less than half that of the adult. It is evident that the absolute quantity of vapor exhaled is increased when respiration is accelerated. The quantity of water in the blood also exerts an important influence. Valentin found that the pulmonary transpiration was more than doubled in a man immediately after drinking a large quantity of water.

The vapor in the expired air is derived from the entire surface over which the air passes in respiration, and not exclusively from the air-cells. The air which passes into the lungs derives a certain quantity of moisture from the mouth, nares and trachea. The great vascularity of the mucous membranes in these situations, as well as of the air-cells, and the great number of mucous glands which they contain, serve to keep the respiratory surfaces constantly moist. This is important, for only moist membranes allow the free passage of gases, which is of course essential to the process of respiration.

Exhalation of Ammonia, Organic Matter etc.—A small quantity of ammonia is exhaled by the lungs in health, and this is increased in certain diseases, particularly in uræmia. Its characters in the expired air are frequently so marked, that patients who are entirely unacquainted with the pathology of uræmia sometimes recognize an ammoniacal odor in their own breath.

The pulmonary surface exhales a small quantity of organic matter. This has never been collected in sufficient quantity for analysis, but its presence may be demonstrated by the fact that a sponge completely saturated with the exhalations from the lungs, or the vapor from the lungs condensed in a glass vessel, will undergo putrefaction, which is a property distinctive of organic substances.

It is well known that certain substances which are but occasionally found in the blood may be eliminated by the lungs. Certain odorous matters in the breath are constant in those who take liquors habitually in considerable quantity. The odor of garlics, onions, turpentine and of many other articles taken into the stomach, may be recognized in the expired air.

The lungs eliminate certain gases which are poisonous in very small quantities when they are absorbed in the lungs and carried to the general system in the arterial blood. Hydrogen monosulphide, which produces death in a bird when it exists in the atmosphere in the proportion of one to eight hundred, may be taken in solution into the stomach with impunity and even be injected into the venous system; in both instances being eliminated by the lungs with great promptness and rapidity (Bernard). The lungs, while they present an immense and rapidly absorbing surface for volatile poisonous substances, are capable of relieving the system of some of these by exhalation when they find their way into the veins.

Exhalation of Nitrogen.—The most accurate direct experiments, particularly those of Regnault and Reiset, show that the exhalation of a small quantity of nitrogen is a nearly constant respiratory phenomenon. As the result of a large number of experiments, these observers came to the conclusion that when animals are subjected to their habitual regimen, they exhale a quantity of nitrogen equal in weight to $\frac{1}{100}$ or $\frac{1}{50}$ of the weight of oxygen consumed. In birds, during inanition, they sometimes observed an absorption of nitrogen, but this was rarely seen in mammals. Boussingault, estimating the nitrogen taken into the body and comparing it with the entire quantity discharged, arrived at the same results in experiments upon a cow. Barral, by the same method, confirmed these observations by experiments on the human subject. Notwithstanding the conflicting testimony of physiologists, there can be little doubt that under ordinary physiological conditions, there is an exhalation of a small quantity of nitrogen by the lungs.

Changes of the Blood in Respiration (Hæmatosis).

It is to be expected that the blood, receiving, on the one hand, all the products of digestion, and on the other, the products of disassimilation, or wear of the tissues, connected with the lymphatic system, and exposed to the action of the air in the lungs, should present important differences in composition in different parts of the vascular system.

In the first place, there is a marked difference in color, composition and properties, between the blood in the arteries and in the veins; the change from venous to arterial blood being effected almost instantaneously in its passage through the lungs. The blood which goes to the lungs is collected from all parts of the body and presents great differences in its composition in different veins. In some veins it is almost black, and in some it is nearly as red as in the arteries. In the hepatic vein it contains sugar, and its nitrogenized constituents and the corpuscles are diminished; in the portal vein, during digestion, it contains matters absorbed from the alimentary canal; and finally, there is every reason to suppose that parts which require different substances for their nutrition and produce different excrementitious matters exert different influences on the constitution of the blood which passes through them. After this mixture of different kinds of blood has been collected in the right side of the heart and passed through the lungs, it is returned to the left side and sent to the system, thoroughly changed and renovated, and as arterial blood, it has a nearly uniform composition. The change, therefore, which the blood undergoes in its passage through the lungs, is the transformation of the mixture of venous blood from all parts of the organism into a fluid of uniform character which is capable of nourishing every tissue and organ of the body.

The capital phenomena of respiration, as regards the air in the lungs, are loss of oxygen and gain of carbon dioxide, the other phenomena being comparatively unimportant. As the blood is capable of absorbing gases, the

essential changes which this fluid undergoes in respiration are to be looked for in connection with the proportions of oxygen and carbon dioxide before and after it has passed through the lungs.

The change of color in the blood from dark-blue to red, in its passage through the lungs, was recognized by Lower, Goodwyn and others, as due to the action of the air, long before the discovery of oxygen. Since the discovery of oxygen, it has been ascertained that this is the only constituent of the air which is capable of arterializing the blood. Priestley showed that venous blood is not changed in color by nitrogen, hydrogen or carbon dioxide; while all these gases, by displacing oxygen, will change the arterial blood from red to black. Carbon monoxide, although it is not a respirable gas and does not properly arterialize the blood, changes it from black to red.

The elements of the blood which absorb the greater part of the oxygen are the red corpuscles. While the plasma will absorb, perhaps, twice as much gas as pure water, it has been shown that the volume of oxygen fixed by the corpuscles is about twenty-five times that which is dissolved in the plasma (Fernet, Lothar Meyer).

Comparison of the Gases in Venous and Arterial Blood.—The demonstration of the fact that oxygen and carbon dioxide exist in the blood, with a knowledge of the relative proportion of these gases in the blood before and after its passage through the lungs, are points hardly second in importance to the relative composition of the air before and after respiration. The idea enunciated by Mayow, about two hundred years ago, that "there is something in the air, absolutely necessary to life, which is conveyed into the blood," except that the vivifying principle was not named or its other properties described, expresses what is now regarded as one of the great objects of respiration. This is even more strictly in accordance with facts than the idea of Lavoisier, who supposed that all the chemical processes of respiration took place in the lungs. Mayow also described the evolution of gas from blood placed in a vacuum. Many observers have since succeeded in extracting gases from the blood by various processes; but notwithstanding this, before the experiments of Magnus, in 1837, many denied the existence of free gases in the blood.

Analysis of the Blood for Gases.—There were certain grave sources of error in the method employed by Magnus, which render his observations of little value, except as demonstrating that oxygen, carbon dioxide and nitrogen may be extracted by the air-pump from both arterial and venous blood. The only source of error in the results which he fully recognized lay in the difficulty in extracting the entire quantity of gas; but a careful study of his essay shows another element of inaccuracy which is even more important. The relative quantities of oxygen and carbon dioxide in any single specimen of blood present great variations, dependent upon the length of time that the blood has been allowed to stand before the estimate of the gases is made. As it is difficult to make this estimate immediately after the blood is drawn, on account of the froth produced by agitation with a gas when the method by displacement is employed, and the bubbling of the gas when extracted by the air-pump, the objection is very serious. It is necessary to wait until the froth has subsided before attempting to make an accurate estimate of the volume of gas given off. This fact is illustrated by one of the published observations of Magnus upon three different specimens of human blood. In this observation the specimens of blood were thoroughly mixed with hydrogen. The excess of carbon dioxide found twenty-four hours after, over the quantity found six hours after, in two specimens, was a little more than fifty per cent., while in one specimen it is very nearly one hundred per cent. In these analyses the proportion of oxygen was not given. The question naturally arises as to the source of the carbon dioxide which was evolved during the last eighteen hours of the observation. The question is readily solved by certain experiments, which are by no means of recent date, although the results of these observations have been confirmed by modern investigations. A number of years ago, Spallanzani demonstrated that in common with other parts of the body, fresh blood has, of itself, the property of consuming oxygen; and W. F. Edwards has shown that the blood will exhale carbon dioxide. In 1856, Harley found that blood, kept in contact with air in a closed vessel for twenty-four hours, consumed oxygen and gave off carbon dioxide. More recently, Bernard has shown that for a certain time after the blood is drawn from the vessels, it will continue to consume oxygen and exhale carbon dioxide. If all the carbon dioxide be removed from a specimen of blood by treating it with hydrogen, and if it be allowed to stand for twenty-four hours, another portion of gas can be removed by again treating the blood with hydrogen, and still another quantity, by treating it with hydrogen a third time. From these facts it is clear that in the experiment of Magnus, the excess of carbon dioxide involved a post-mortem consumption of oxygen; and no analyses made in the ordinary way, by displacement with hydrogen or by the air-pump, in which the blood is allowed to remain in contact with oxygen for a number of hours, can be accurate. The only process which can give a rigorous estimate of the relative quantities of oxygen and carbon dioxide in the blood is one in which the gases can be estimated without allowing the blood to stand, or in which the formation of carbon dioxide, at the expense of the oxygen in the specimen, is prevented. All others will give a less quantity of oxygen and a greater quantity of carbon dioxide than exists in the blood circulating in the vessels or immediately after it is drawn from the body.

Carbon monoxide, one of the most active of the poisonous gases, has a remarkable affinity for the blood-corpuscles. When taken into the lungs, it is absorbed by and becomes fixed in the corpuscles, preventing the consumption of oxygen and the production of carbon dioxide, which normally take place in the capillary system and which are indispensable conditions of nutrition. The mechanism of poisoning by the inhalation of this gas is by its fixation in the blood-corpuscles, their consequent paralysis, and the arrest of their action as oxygen-carriers. As it is the continuance of this transformation of oxygen into carbon dioxide, after the blood is drawn from the vessels, which interferes with the ordinary analysis of the blood for gases, it would seem possible to extract all the oxygen by immediately saturating the blood with carbon monoxide. The experiments of Bernard on this point are conclusive. He ascertained that by mixing carbon monoxide in sufficient quantity with a specimen of fresh arterial blood, in about two hours, all the oxygen which it contained was displaced. Introducing a second quantity of carbon monoxide after two hours and leaving it in contact with the blood for an hour, a quantity of oxygen was removed so small that it might be disregarded. A third experiment on the same blood failed to disengage any oxygen or carbon dioxide.

The view entertained by Bernard of the action of carbon monoxide in displacing the oxygen of the blood is that the former gas has a remarkable affinity for the blood-corpuscles, in which nearly all the oxygen is contained, and when brought in contact with them unites with the hæmaglobine, setting free the oxygen, in the same way that an acid entering into the composition of a salt is set free by any other acid which has a stronger affinity for the base. There is every reason to suppose that this view is correct, as carbon monoxide is much less soluble than oxygen and as it has the property of disengaging this gas only from the blood, leaving the other gases still in solution. In drawing the blood for analysis, Bernard took the fluid directly from the vessels by a syringe and passed it under mercury into a tube, in such a way that it did not come in contact with the air. In this tube, which was graduated, the blood was brought in contact with carbon monoxide, which displaced the oxygen from the corpuscles and prevented the formation of carbon dioxide at the expense of a portion of the oxygen.

As carbon monoxide displaces the oxygen alone, it is necessary to resort to some other process to disengage the other gases contained in the blood. Modern experimenters, Ludwig, Lothar Meyer and others, have made use of the mercurial gas-pumps, either of Ludwig or of Pflüger, in which all the gases of the blood are disengaged by removing the atmospheric pressure. By means of a "froth-chamber," the gases can be collected and analyzed, with but little loss of time; but it is probable that there is always a slight error in estimates, made in this way, of the relative proportions of oxygen and carbon dioxide, the proportion of oxygen being too small, and of carbon dioxide, too large. Nevertheless, the results obtained by this method correspond pretty closely with what is known of the nature of the respiratory process; and analyses of the blood taken at different periods show variations in the quantities of oxygen in the arterial blood and of carbon dioxide in the venous blood, corresponding with some of the variations which have been noted in the loss of oxygen and gain of carbon dioxide in the air in respiration. Nearly all the gases contained in the blood may be disengaged by means of the gas-pump, but according to most observers, a small quantity of carbon dioxide remains in the blood in combination. This may be removed by the introduction into the apparatus of a small quantity of tartaric acid. It was justly remarked by Bert, that as the apparatus for the exhaustion of