production of this glass is a very remarkable achievement.

"Pyrex" glass and the Empire bulb-blowing machine were only two of the many interesting developments which I was shown at Corning. When I was there, Dr. A. L. Day, who has long been connected with the works, was acting as vice-president of the company; and Dr. E. C. Sullivan and Dr. W. C. Taylor, assisted by a considerable scientific staff, were in charge of the technical side of the work. Dr. Taylor told me that they had been carrying out a systematic survey of possible combinations in glasses, and that as each glass was made experimentally its properties were investigated and recorded. In the Steuben Works, which are under the same management, and only a few hundred yards distant, Dr. J. C. Hochstetter was collaborating with Mr. F. C. Carder in the investigation of problems relating to coloured glasses.

Scientific glassware was also being manufactured at the H. C. Fry Glass Works, where I spent a day with Dr. Scholes and his staff, and at the Macbeth Evans Glass Co.'s plant, also near Pittsburgh, Pa., over which I was shown by Dr. Macbeth and Prof. Hower, who is consultant to the firm. I found quite a numerous scientific staff working in excellent laboratories.

In the bottle-making branch of the industry the engineer predominates. I believe that the first bottle machine was English, and one would like to know why it is that the development of bottle machinery has been practically wholly American. The Owens machine, the Hartford-Fairmont flow feed, the Westlake machine, and the Empire machine are purely American, and they are American because Americans understand the value of science organised in the service of industry, and are willing to give good brains a fair chance and to back them with good money. Developments in this direction are entirely a matter of private enterprise, in which consumers as well as manufacturers are often financially interested.

To no branch of the glass industry has science been of greater service than to that of the electric lamp industry. I was able to spend two days in the research laboratories attached to the great plant of the General Electric Co. at Schenectady, in company with Drs. Whitney, Langmuir, Coolidge, and Hull, whose names are as well known in Europe as in America. The staff of the laboratory is said to number more than 150 members, and the work carried on is in some cases purely scientific, and in others highly technical, processes being actually worked in the laboratory until the demand for the goods or material produced justifies the erection of separate factories. While I was at Cleveland, Ohio, Dr. W. M. Clark, the chief chemist of the National Lamp Association, was good enough to show me over the whole plant of his firm. Here a physical laboratory dedicated to investigations connected with illumination, but only indirectly with artificial lighting, has been established in recognition of the services of science to the industry.

In several of the universities research is being carried out in connection with glass, and I had the good fortune to meet both Prof. Washburn, of Illinois University, and Prof. Silverman, of Pittsburgh University, and to discuss with them their work on the chemistry and physics of glass.

A short article permits me to deal only with isolated incidents in my tour, but the impression which I brought away with me and wish to convey to others is that there are a great many men of high scientific ability engaged in the American glass industry, which has learned, as the German glass industry learned, to our undoing, that industrial progress implies the co-operation of science and industry. American industry is not securing the co-operation of science for sentimental reasons, but with a view to competition with us in the markets of the world. To this movement science, through the National Research Council, organised by the National Academy of Sciences, in co-operation with the national scientific and technical societies of the United States, is giving its heartiest support.

The Circulating Blood in Relation to Wound-Shock.[1]

By PROF. W. M. BAYLISS, F.R.S.

THE system of vessels in which the blood is contained must be conceived of as a *closed* system. But the walls are distensible and elastic; they can therefore stretch and collapse to accommodate varying amounts of liquid. This is possible, however, only to a limited extent. Although the veins have thinner walls than the arteries, and appear to be less supported by surrounding structures than are the capillaries, it is remarkable that they oppose a greater resistance to a bursting pressure than do the arteries. Veins, moreover, have a muscular coat which is in a more or less contracted state during life. Hence the introduction of more fluid into the system must encounter a certain resistance and raise the internal pressure, unless the muscular coat actively relaxes to accommodate the fluid introduced.

This closed system contains, under normal conditions, about four litres of blood in man. It consists, as is generally known, of the heart, of branching tubes (arteries), leading from the heart to the tissues, where they break up into a network of much finer tubes, the capillaries, which unite again to form the veins, and so lead the blood back to the heart. Consider the distribution of the blood at the time when the heart is at rest.

[1] Discourse on "The Volume of the Blood and its Significance," delivered at the Royal Institution on Friday, February 13.

The amount present in each part, including the heart itself, is obviously in proportion to the capacity of each part.

The heart, however, works as a pump. The way in which the blood is circulated was first clearly propounded by Harvey in 1616, although Leonardo da Vinci came very near to the discovery more than a century before. Harvey saw the blood sent out from the heart, propelled to the tissues in the arteries, and returned to the heart by the veins. The course of the blood from one to the other through the minute capillaries could not be seen until the invention of the microscope by Leeuwenhoek, who made use of it in 1686 to observe the blood traversing the capillaries in the tail of the tadpole.

The heart, then, when it contracts, drives out the blood which is contained in its cavities, or nearly the whole of it. This same quantity must be returned by the veins, otherwise the blood would soon all be accumulated in the peripheral parts of the body. Further, the heart is capable of driving out the more blood the greater the quantity it contains when contraction begins. This is what has been called by Starling the "law of the heart." It depends on the fact that muscular fibres contract the more powerfully the greater the length to which they are stretched to begin with—within limits, of course.

We see, therefore, that the amount of blood driven through the organs of the body in a given time depends on the amount present in the heart at rest. Since this is a definite fraction of the whole blood, the irrigation, as we may call it, of the body is in proportion to the total quantity of blood available. The importance of sufficient irrigation is obvious. The blood conveys to the active cells the materials required for their work, and of these the most necessary is oxygen. If the supply is too meagre, the first few cells with which the blood meets exhaust it, and those beyond suffer from deprivation. Waste products are removed at the same time.

Although the part played by the volume of the circulating blood in relation to the capacity of the vascular system was realised by Carl Ludwig and his school, who made many experimental investigations on the subject, the matter came especially into prominence in connection with the explanation and treatment of the state known previously as "surgical shock," but which occurred with alarming frequency in men wounded in the late war. The name "wound-shock" is a more comprehensive name, although the use of the word "shock" is liable to give a misleading impression as to the rapidity of its onset, and to cause confusion with "shell-shock," another unsatisfactory name, but used to designate an affection of the nervous system of quite a different nature from that brought about by the wounds themselves. Wound-shock is not easily defined in such terms as to distinguish it clearly from other similar states, such as that due to loss of blood, but it may be said to be one of general collapse, ending in death if not combated in some way. It does not come on immediately after injury, but in the course of some two or three hours. It shows itself by pallor, coldness, sweating, vomiting, thirst, low blood-pressure, and the other symptoms which were early recognised as indicating a defective circulation.

But what is the actual cause of this collapse of the circulatory mechanism? It was soon realised, by those who examined cases of wound-shock, that it was not due to any failure of the heart itself, nor was the central nervous system involved, except indirectly in the later stages. On the other hand, much difficulty was found in distinguishing between this state, even when attended by very little loss of blood, and that resulting from great loss of blood unaccompanied by serious injury. The latter is obviously the result of the defective volume of blood and its consequences, since blood is known to have left the body. But why do the former cases also appear to be suffering from the same condition, when scarcely any blood has actually been lost?

In the endeavour to find an explanation for this, we may call to mind the circumstance that blood may be effectively removed from circulation by being pooled away in some part or other of the vascular system, as, for example, by a great dilatation of this part. The amount which is available for propulsion by the heart to serve for continuous irrigation of the tissues is reduced as much as it would be if the blood held in the pool were actually lost to the outside. Such changes in the capacity of the peripheral blood-vessels play a large part in the regulation of the blood-pressure and the supply of blood to various organs. We may inquire whether anything of this kind happens after severe injuries.

The first step taken in the course of this inquiry was the discovery that some poisonous substance is produced in injured tissues. This, passing into the blood, is carried to all parts of the body. Sir Cuthbert Wallace, some years ago, had noticed that operations in which the cutting of large masses of tissue was involved were especially liable to be followed by shock. Quénu and others, during the war, were struck by the rapid benefit frequently ensuing from removal of the injured parts or even when they are tied off from connection with the rest of the blood-vessels, if such is possible. Cannon and myself found that we could produce the state of wound-shock in anæsthetised animals in the laboratory, and that it was due to a chemical agent, not to any effect on nerves. This being so, we see that we can replace the name of "wound-shock" by the more descriptive one of "traumatic toxæmia."

But can we form any conclusion as to the chemical nature of this toxic substance or as to the way in which it acts? It is evidently produced too quickly to be a result of bacterial infection, and, indeed, McNee was able to exclude this possibility quite definitely. Dale and Laidlaw, however, showed that there is a compound of known chemical structure, called "histamine," and produced without difficulty from a constituent of the nitrogenous cell structures, which is able to produce a state of the circulation like that present in wound-shock. It was found that the effect was not due to a dilatation of the arterial part of the system, as was known to be the case in the fall of blood-pressure brought about by vaso-motor reflexes. Here the similarity to traumatic toxæmia showed itself again, because it was known that arterial dilatation was not present in this state. Next, Dale and Richards, by a number of ingenious experiments, were able to localise the effect in the capillaries, which became widely dilated and thus capable of taking up the greater part of the blood in the body, leaving the heart nearly empty, with too meagre a supply to carry on the circulation with any degree of efficacy. It is to be admitted that we have not yet definite proof that it is histamine itself which is responsible for the toxæmia of injury. But that the agent is something which acts in the same way is made clear by the observations that have been made on wounded men. The determinations of the volume of the blood in circulation, made by N. M. Keith, may be especially mentioned. Keith showed that, in severe cases, it may be reduced to little more than half the normal amount, although scarcely any has actually been lost by hæmorrhage. The method used was that of introducing into a vein a known quantity of an innocuous dye which does not pass through the walls of the blood-vessels, and, after a short interval, taking a sample of the blood and finding how much the dye has been diluted.

If the toxæmia is severe, a second property of the poison shows itself. This is an effect on the walls of the capillaries such that they allow the liquid part of the blood to escape by filtration. In this way the volume of the blood is still further reduced.

The treatment, in principle, is obvious. Restore the blood-volume. It would appear that when blood has been lost it ought to be replaced by blood. The case of traumatic toxæmia is not so clear at once, because blood has not been actually lost, and it should be possible to keep up an effective circulation by some other liquid until the poison is got rid of and the pooled blood returned to circulation. In fact, as experience increased, it was realised that the important matter is to maintain the volume in circulation, whether by blood or other solution. An innocuous fluid seemed to serve practically as well as blood, and had the advantage of being always at hand and in as large a quantity as required.

As to the properties of such a solution, it was soon found that a simple saline solution is very rapidly lost from the circulation and is useless. It is necessary to add to it some colloid with an osmotic pressure, such as gelatin or gum acacia. The colloid does not pass through the walls of the blood-vessels, and its osmotic pressure causes an attraction of water to balance that lost by filtration. Thus, although the slow circulation incidental to a small volume of blood is inadequate, this very quantity, if diluted to normal volume, is able to serve effectively. Comparing the oxygen carried by the red corpuscles to railway passengers, it will be realised that if we have a limited number of trains, we can carry more passengers in a given time if the velocity of the trains is increased. Animal experiments made by Gasser showed that this is actually the case with the blood. After a loss of blood the injection of gum-saline might even raise the supply of blood-corpuscles to a level beyond what it was before the hæmorrhage.

The general conclusion is that the volume of the liquid in circulation must be kept up to its normal value, whatever this liquid may be. Of course, the number of red corpuscles cannot be allowed to fall below some particular value, and it has been found that about one-quarter of the normal quantity is the lowest compatible with life. If they fall below this, moreover, there is no production of new corpuscles.

In the later stages of the war gum-saline was largely used in the British, American, and French Armies, and is reported to have saved many lives. Unfortunately, if too long a time is allowed to elapse before treatment, nothing avails, not even transfusion of blood. Hence the importance of the early use of intravenous injection, and also of removal of the injured tissue by operation. As the war progressed, these procedures were, therefore, pushed more and more forward to the battle area, and with more and more favourable results.

Characteristics of Pigments in Early Pencil Writing.

By C. Ainsworth Mitchell.

PENCIL pigments may be classified in the following groups: (1) Metallic lead or alloys of lead; (2) graphite cut from the block; (3) early composite pigments containing graphite, sulphur, resins, etc., but no clay; (4) graphite powder compressed into blocks; and (5) composite pigments containing graphite with clay and other ingredients. These pigments usually show distinctive microscopic characteristics in the marks which they produce.

When examined under the microscope with a magnification of about twenty diameters and the light at right angles, ordinary lead shows, in its vertical markings on paper, a series of irregularly distributed patches, uniformly and brilliantly lit up, and marked with regular vertical striations which have the appearance of ridges. In the case of Borrowdale graphite (Fig. 1) the vertical lines show relatively few brilliant straight striations (due to siliceous impurities), and when these occur in the