from the facts he had previously considered. Every one of these, without exception, expresses the views now current and generally advocated; yet his manifesto raised such a storm of indignation against him, that he had to retire from the editorial chair, and more than half of those who supported him by contributions to the new department of his journal shrank from making their names known to the profession. Reading my own again after the lapse of twenty-two years, I find little to change except as to style, albeit much to add; so that the methods and principles I then advocated and practised as far as possible, I advocate, teach, and practise, as far as possible, now.* The principles I then laid down were briefly these: 1. The medical history of normal structure and function (medical physiology and histology) must be the basis of both observation and classification of the abnormal, but mainly as to abnormal structure; or, pathological anatomy should be a tissue and a diathetic anatomy, in which the observation of the order of changes in the tissues and organs should have regard to the order of development of tissues and organs in the embryo and in organisms generally. 2. The order of morbid phenomena (as symptoms) in time should be observed in relation with the order of healthy phenomena in time as indicated by laws of vital periodicity, and thus the natural course of diseases—i.e., the order of development of disease and of return to health from disease—be determined. 3. The influence of the nervous system must be more regarded. In advancing these and other views, I differed from Forbes and his contributors. They dwelt upon "Nature" and "her" operations, and on the *vis medicatrix nature*, in the old Hippocratic and empirical way; but, coming fresh from inquiries into the relations of the *vis conservatrix* and *vis medicatrix* to molecular power and to physiological and pathological changes, it appeared to me that the old way had served its purpose, and that Nature must be investigated by a more purely scientific method. I soon found myself, however, far beyond the current wave of opinions and facts as to the fundamental questions involved. The inquiry, I saw, too, involved a knowledge of the correlation of forces—at that date (1845) hardly thought of, and as to which my own small attempts had experienced little encouragement.

There are the three courses open to the practitioner; he may be a meddler with Nature in the old empirical way; or he may be an effete truster in Nature; or, recognising the value of both science and experience, he will, while cultivating science, not rely too much upon it, but rather upon solid experience, enlightened, corrected, and advanced by science. In this spirit, at least, I shall next endeavour to illustrate the fundamental relations of the physical forces, *vis nervosa*, *vis medicatrix*, and vital force, to chemical affinity and nutrition.

ON THE USE OF THE SPECTROSCOPE AND MICROSCOPIC TOSCOPE IN THE DISCOVERY OF BLOOD- STAINS AND DISSOLVED BLOOD.†

By W. BIRD HERAPATH, M.D., F.R.S., Bristol.

THE discovery and recognition of blood-stains, and more especially of human blood, has been a problem which has long baffled the skill of the chemist, and the more highly trained medico-legal eye of the microscopist; and any means by which our medical jurists can lessen the difficulties and facilitate the inquiry, must be hailed as a boon by all scientific observers. Hitherto the chemical difficulties of the question have been the greater in the inverse proportion to the quantity of stain; and many minute and perfectly evident spots would even evade recognition by the test-tube in consequence of the smallness of their size, or the disadvantages of their position. The microscope would also fail in their detection if, from any peculiar circumstances, the blood-corpuscles could not be safely and securely removed from the tissues which were under careful examination; independently of which, the chemical and physical changes induced in the characters of the blood-corpuscles by the various menstrua employed in their removal rendered recognition by micrometrical admeasurement a very doubtful and uncertain operation. When blood-corpuscles are to be discovered floating in a saline fluid, as urine, saliva, or the generality of mucous discharges, the microscope will readily detect their presence; and, should the density of the fluid be very closely equal to the specific gravity of the serum of the blood, scarcely any change in their physical characters would occur, and it would then be possible to determine their exact form and size and render their probable source a question of easy solution. But when blood has been dried and long exposed

to the air, it is no longer easy to reproduce the blood-corpuscles of their pristine form and optical characters, as the various media employed to dissolve the clots act on the corpuscles with more or less celerity.

It is usual to employ either solutions of cane-sugar or grape-sugar, or mixtures of glycerine and distilled water, having a density of 1.030. Some observers have employed saline solutions for this purpose; others have used a strong solution of arsenious acid in distilled water; the objects which both classes have in view being the removal of the blood-discs and the preservation of their physical characters.

If the action of the solvent or medium, from its deficient density or peculiar chemical properties, have resulted in a destruction of the blood-corpuscles and a solution of the colouring matter, the microscope would no longer either recognise the mammalian character of the blood, or even assure us of its presence. In this condition of the inquiry the chemist alone, by the employment of tests, could decide the question of the presence of dissolved hæmatine, and would chiefly rely on the action of heat in coagulating the albumen and destroying the colour; whilst upon another portion of the fluid he would assure himself that ammonia would not produce any great change of colour, thus deciding the non-vegetable character of the colouring matter.

But during the past two or three years an addition has been made to our optical instruments, in the aid which we have obtained in the recognition of various substances by the effects which they have on the absorption of different portions of the spectrum; and we have various forms of spectroscope according to the purposes for which they were intended. The first invented spectroscope was a very efficient but cumbersome instrument, and astonished the world by the discovery of four new metals in consequence of the remarkable peculiarities of their coloured flames; and thallium, cesium, rubidium, and indium have been thus isolated from other substances and added to the list of elementary bodies. Many of those around me are familiar with that form of instrument, and need no further description. Shortly afterwards, Professor Stokes introduced a modification of this instrument, which enabled liquids and coloured fluids to be submitted to the same mode of testing them by their absorption spectra; and on the table is a form of fluid spectroscope, which I have long employed for this purpose, a more powerful and efficient instrument than that recommended by him for these experiments.

In this instrument, essentially a direct vision or Hofmann's spectroscope, the liquid to be examined is placed in a small test-tube, and that is held in a clipped spring, which supports it during the examination, whilst a bright light is transmitted through the liquid previously to its analysis in the spectroscope. The spectrum shews various bands of absorption in well-marked optical liquids—some of the most beautiful of which are certainly weak solutions of permanganate of potassa and dilute solutions of crocine and hæmatine.

In the first case, five dark bands are seen in the green part of the spectrum, and in that of blood two sharply defined black bands are seen, one in the green, and another on the border of the orange ray. The intensities and positions of these bands vary according to the age of the blood-stain, and result from the alteration in the colouring matter of the blood by drying and by exposure to air.

The stains when old have a much less decided or evident absorption, the bands are weaker, and an additional band of a diffuse character is found in the red ray. But it does not appear to be possible to form any positive or accurate opinion on the age of blood; from various observations it has been ascertained that these changes take place with more rapidity under some circumstances than in other apparently similar cases. In all optical experiments on blood, it is necessary to use *excessively dilute* solutions of the colouring matter; otherwise the fluid is either absolutely opaque to light, or, if it transmit any light at all, nothing but the extreme red rays are observed. When still more dilute solutions are used, the blue end of the spectrum is quite absorbed, and so are two bands in the green, and occasionally also one in the red. These optical properties of blood were first pointed out by Hoppe (*Virchow's Arch.*, 1862, p. 446), and subsequently more minutely by Professor Stokes (*Proceedings of the Royal Society*, 1864), and Mr. Sorby (*Quarterly Journal of Science*, 1865). Professor Stokes has investigated the effects of different chemical re-agents upon the colouring matter of blood (*Proceedings of the Royal Society*, 1864, p. 355 *et seq.*); and he has arrived at a very intelligible solution of the various phenomena exhibited by this remarkable substance, and has come to the conclusion that arterial and venous blood in the recent fluid condition contains a substance called crocine, which, like indigo, is capable of existing in two different states of oxidation and colour; that in arterial blood scarlet crocine is the form in which it is found, and in this condition very dilute solutions produce two very sharply defined black bands of absorption; one, the more intense of the two, close to and parallel with the sodium line D; whilst the second is found in the green ray about the breadth of the previous band distant from it.

* I proposed also, as the means to the proposed reformation, an entirely new organisation of the profession. Age and experience have cooled my enthusiasm as to that scheme; but I still think it applicable to the more limited field of the British Medical Association.

† Read before the Bath and Bristol Branch, January 1867.

On submitting this scarlet cruorine to deoxidising agents to a moderate extent, the cruorine becomes the deoxidised or purple cruorine, and then the solution is light or deep purple, according to its degree of concentration. On examination by the spectroscope in this condition, only one deep broad band of absorption is found, which commences about the solar or sodium line D, and then passes onwards to the green, absorbing the whole of the yellow and part of the green bands of the spectrum. It is remarkable that, upon shaking up a dilute solution of scarlet cruorine with an atmosphere of carbonic acid, the fluid does not exhibit the appearance or spectrum of venous blood. It is evident, therefore, that the blue colour of venous blood is not produced by the presence of carbonic acid in solution, but by a *reducing action* in the capillaries analogous to that of other reagents; whilst the influence of sulphide of ammonium, sulphuretted hydrogen, or the hydrated protoxide of iron, or the protochloride of tin, or the peculiar deoxidation of arterial blood due to the changes going on in the systemic circulation, are all instances in which such a deoxidation or reduction has been in action. A dilute solution of scarlet cruorine set aside in a full closely corked phial, or with very little air, will shortly pass by spontaneous deoxidation to the purple cruorine; and will then exhibit all the optical phenomena of this peculiar substance, but resumes its scarlet colour on agitation with air.

Professor Stokes says that of all reducing agents an ammoniacal solution of protochloride of tin (previously treated with sufficient tartaric acid to prevent the precipitation of oxide of tin) is the most efficient reducing agent; and, as it is colourless, it does not interfere with the spectroscopic appearances. He says that, when a few drops of this solution are added to a solution of scarlet cruorine, the latter is presently reduced, and we have the spectrum of purple cruorine. If the solution be now shaken up with air, the cruorine is reoxidised to the scarlet form; on standing a few minutes it again becomes reduced, and the solution may be made to go through these changes repeatedly until all the tin has passed to complete oxidation.

But when blood or scarlet cruorine is treated with an *excess* of deoxidising material, or has become changed by long exposure to air, or by drying, or by the effect of sulphurous and some other acids, the colouring matter becomes brown and more insoluble in water; it is, in fact, then changed into *brown hæmatine*, which has very different optical properties from those of either scarlet or purple cruorine. The two dark bands of absorption are still found, but have become very faint and much less sharp in outline, whilst a third dark band is seen in the red ray; of course, on the less refrangible side of the solar or sodium line D.

This change, when produced by age and exposure, is sometimes months in being fully accomplished, and is only well-marked on the appearance of the dark band in the red ray. Now, just as cruorine can exist in two different forms, so can hæmatine; and we have either the brown or the red hæmatine, the latter being produced by deoxidising the brown hæmatine by some reducing agents, as hydrated protoxide of iron. Then two bands of absorption occur as in scarlet cruorine, but are capable of being readily distinguished from those by their position and different degrees of intensity. In red hæmatine an interval exists between the sodium or solar line D and the margin of the first band of absorption; which in red hæmatine is less distinct or sharp than in scarlet cruorine, or than its fellow in the same spectrum: both of these, therefore, are in red hæmatine found in the green rays. Most chemical re-agents convert scarlet cruorine into brown hæmatine, without any previous passage through the stage and properties of purple cruorine. The effects of reduction on brown hæmatine are evanescent, and the solution rapidly becomes deficient in optical power; it does not assume the former properties of brown hæmatine. The absorption bands fade away and disappear—the one nearer to the sodium line D being the more persistent and remaining sharp during several days; this takes place even if the bottle be airtight. Re-treatment with protoxide of iron will again re-produce the two absorption bands as before.

It is brown hæmatine which is generally discovered in old blood-stains; but red hæmatine in dry and more recent blood-clots. A specimen on the table, six months old, still shews the two bands of red hæmatine, whilst one of two years old shews the spectrum of brown hæmatine. It may be as well to state that these specimens of dried blood have been kept in a moderately dry room, powdered and in a paper pill-box, for some portion of the time; but during the major part of the period on cloths exposed to the air, without any care, and in the ordinary atmosphere of an inhabited room with gas burning nightly. Solutions of these specimens of blood in distilled water, after having been kept closely corked for some days, underwent a peculiar change. Both the brown and the red hæmatine were *spontaneously changed* into purple cruorine; and now shew only the one broad band of absorption due to that colouring matter. This effect is probably due to reduction by sulphuretted hydrogen.

There are also on the table many preparations of blood exhibiting the

actions of various re-agents on cruorine and hæmatine; but in no specimen would it be possible to detect any corpuscles by the microscope, as the colouring matters have all been dissolved in distilled water and the corpuscles destroyed. The microscope would, therefore, fail in detecting blood in all of them, whilst the chemist might probably recognise it in most of the fluids, and so will the spectroscope. When an old blood-stain has been so changed by exposure to air that the hæmatine gives but very faint and indistinct absorptive bands, it is possible, by deoxidising the solution of hæmatine by means of a little recently precipitated hydrated protoxide of iron, to reproduce the bands in nearly the same intensity, though slightly differing in position, as in blood-stains of very recent formation, in which scarlet cruorine would be, of course, the colouring material.

This experiment is readily made by adding a few drops of a weak solution of protosulphate or protochloride of iron, and then a little liquor ammoniæ. The green hydrated protoxide of iron resulting has a great affinity for oxygen, and at once reduces the hæmatine and restores its colour and optical properties. It is essential that putrefaction should not have actually destroyed the hæmatine.

[To be continued.]

OBSERVATIONS ON PLEURITIC ACCUMULATIONS.

By WILLIAM V. BIRD, M.D.,

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THERE are, I find, many medical men who consider that the results of the operation of Paracentesis Thoracis are as yet very discouraging; indeed, I may say that the operation is regarded with suspicion and dislike. By some it has been considered as so dangerous a proceeding, on account of the risk of admitting air into the cavity of the thorax, that it has not been resorted to in a sufficiently early stage of disease to have afforded a fair prospect of success. Not many years ago, more than one eminent writer held that the chest should never be punctured unless for

1.—Trocar, cannula, and tap. 2.—Cannula and tap. 3.—Trocar.

the evacuation of pus; and not even then, unless the life of the patient were in immediate danger from its presence; and, up to this time, the operation has been too often resorted to merely as a palliative measure