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## PRACTICAL APPLICATIONS OF THE SPECTROSCOPE.

The uses of the spectroscope may at present be divided into eight classes. The first use is the observation of the luminous colored lines in the spectra of flames, which lines, as it is well known, appear in sets or systems, each substance producing a set of lines, peculiar to itself and not appertaining to any other substance: so that by this means many of the component elements of a substance may be determined by direct observation, without the necessity of going through the laborious process of chemical analysis. Another advantage is that the minutest quantity of material is sufficient for this method: a quantity so small that it would not suffice for a chemical test made in the ordinary way, even if assisted by the microscope.

The second process is effected by enclosing the substance to be examined in a gaseous or vaporous condition in a glass tube, rarefying the gas or vapor, and illuminating it by the passage of an electric spark. Then special lines will appear, which differ, in some instances, from the lines produced by the same substance in a flame, and this by reason of the higher temperature: the local temperature of the atom when exposed to the electric current being the highest we can produce. The current does not heat up the tube, because its quantity of heat is too small, notwithstanding that it is of great intensity. It is evident that any substances easily volatilized, or gases, are adapted to this method of investigation.

The third class of spectroscope observations is especially adapted to solids, and consists in observing the spectrum of the electric spark passing between electrodes of the material to be investigated. Thus the spark passing between two copper electrodes will show the copper line, between iron electrodes the iron lines, etc. The spectrum seen in this way will also be affected by the spectrum of the atmosphere, gas, or vapor between the electrodes, through which the electric spark forces a passage.

A fourth class of observations may be made with the above method, using not the spectroscope, but a microscope with a spectroscopic eyepiece. The easiest way to submit the material under investigation to this test is to reduce the metal to the state of thin foil or plate, cut out a few pointed strips, and attach them to an ordinary glass slide, with the points a distance of $\frac{1}{8}$ of an inch or less apart; then connect them with the poles of a small induction coil, and bring the space between the metallic points into the field and focus of the instrument. Then apply the spectroscopic eyepiece, let the current pass, and the peculiar spectrum of the metal will be seen.

A fifth use of the spectroscope is by attaching the spectroscopic eyepiece to the telescope in place of the microscope: this constitutes one of the most important uses of the spectroscope, and has given rise to a new branch of science, astronomical chemistry; and by its means we have been able to determine the chemical constitution of the sun, stars, and comets, and also of the atmosphere of most of the planets.

A sixth use of the spectroscope consists in the observation of the absorption spectra, when the light forming a complete spectrum is made to pass through a colored transparent medium. A colored glass or a colored liquid is in fact a kind of filter, which lets rays only of a certain color pass, and obstructs all the others. White light consisting of all rays of light, as is proved by its analysis by the spectroscope, we can change it into red by removing all the orange, yellow, green, blue, and violet rays, and this is what a purely red glass or a red liquid accomplishes; we can change it also into blue by removing all the red, orange, yellow, green, and violet rays, and this is what a purely blue glass effects. If, however, we test different colored media in this way with the spectroscope, we find that there are very few pure colors, as most of them will not extinguish all the colors different from their own: thus, for instance, indigo, which is blue, will not extinguish all the red, and its color therefore contains red in its composition. Red blood will not extinguish the blue, but only a portion of the green, forming two broad bands in that part of the spectrum, called the blood bands. These bands are so characteristic of blood, belonging to no other substance whatsoever, that they serve as the basis for legal evidence as to whether suspected spots are blood or not. Some substances, like chlorophyllin, the green coloring matter of leaves, produce a series of such absorption bands in different parts of the spectrum, quite self-characteristic and distinguishing them from all other substances of apparently the same color.

As a seventh class of observations, we may consider the absorption bands produced by colored gases and vapors, such as nitric oxide (especially when heated), chlorine, bromine vapor, iodine vapor, etc., all of which produce peculiar absorption spectra.

Finally we may add an eighth class of observations, that of opaque substances visible by reflected light. Observations of this class are in many instances best made by the microscope armed with a spectroscopic eyepiece; and such observations are best made in direct sunlight. When the sun shines on a piece of white paper placed under the spectro-microscope, the complete spectrum will be seen; but if on the paper a colored spot be present, and this be brought into the field, at once absorption bands will appear, which will of course differ, not only for substances of every color, but also for substances of the same color, if they be composed of different ingredients. A useful application of this property was recently made by Dr. P. H. Vander Weyde, and was mentioned by us on page 293 of our volume XXXIV. Dr. Vander Weyde was a witness in a case before the courts, involving an amount of nearly $100,000, which depended on the question whether the signature certifying a check was genuine or not. One of the arguments brought forward to show that the signature was forged was that the blue ink with which it was written was of a kind different from that used at the bank where the check was claimed to have been certified. Fortunately the different kinds of blue used for inks can easily be distinguished, one from the other, by spectroscopic analysis. Indigo will absorb the whole spectrum except the blue and red; blue verdigris will absorb all except the blue and green; permanent blue will leave, besides the blue, part of the violet visible; Prussian blue will absorb all except the blue. The spectra are of course modified and even disturbed by the enlargement of the coarse fibers of the paper on which the writing is done; and the spectral colors are, in some spots, darker or more intense, in others paler and almost colorless; but after careful comparison with the spectra of various inks, the peculiar absorption of the Prussian blue is seen to be so characteristic that no doubt was left but that the ink used for the check in question was of the same kind as that used for other checks acknowledged to be genuine. The researches described of course cannot settle a matter of the kind in dispute, and are not claimed to do so. All that was intended was to disprove the allegation of the defense that the inks were different; and this it did most effectually, notwithstanding that the spectroscope could not show that the ink of the different signatures proceeded from the same inkstand.

## WHY ARE WE RIGHT-HANDED?

There is, in Sir Charles Bell's Bridgwater treatise, a quaintly-worded passage in which the author endeavors to deal with the reason why we normally use the right hand in preference to the left. After a surfeit of Haeckel and Darwin: after, as must be the case when one attempts to keep *en rapport* with modern scientific thought, becoming fairly imbued with the notion that distinct creative acts never took place, and that the fire mist and the primal germ are our legitimate ancestors in unbroken line: there is something positively refreshing to turn back to earlier writings, and there to find a material theory contemptuously dismissed in order that the author may anchor his faith to the idea that man was created right-handed by Divine intention. He says that "the preference of the right hand is not the effect of habit, but is a natural provision, and is bestowed for a very obvious purpose"; but what that purpose is he fails to make clear, except inferentially in the statement that "there ought to be no hesitation which hand is to be used or which foot is to be put forward; nor is there, in fact, any such indecision." Any one who has ever witnessed the amusing spectacle of a squad of raw recruits learning the goose step will be disposed to combat this last assertion. It requires longer teaching than would be imagined to impress upon the embryo soldier that the left foot is first to be moved. Experience goes clearly to show, besides, that the average individual steps off indiscriminately with either foot; and hence the selection of the left foot, merely to secure uniformity in the military files, has been made, though the very fact again is curiously at variance with the above author's intimation that a heaven-implanted instinct teaches us to put the right foot forward.

We have mentioned Bell's treatise, not, however, for the sake of the theory which he maintains, but for the one which he rejects in a few brief lines. "It is affirmed," he says, "that the trunk of the artery going to the right arm passes off from the heart so as to admit the blood directly and more forcibly into the small vessels of the arm. This is assigning a cause which is unequal to the effect," he adds; and probably supposing that no other causes would ever be combined therewith to bring it up to equality, he curtly pronounces it a "participation in the common error of seeking in the mechanism the cause of phenomena which have a deeper source," said source being supernatural. For the man who discovered the functions of motion and sensation pertaining to the brain and spinal marrow: who located the sensory nerves, and those which form the wonderful telegraph commanded by the will, and who showed that the nerves of the different senses are connected with distinct portions of the brain, so implicit a belief in the active interference of an Unknown Power with human mechanics is indeed strange. It is to this faith, however, that must be ascribed this neglect to prosecute the investigations which, very recently carried through by a French physician, Dr Fleury, of Bordeaux, have adduced facts showing that our natural impulse to use the members on the right side of the body is clearly traceable to probably physiological causes.

Dr. Fleury, after examining an immense number of human encephala, asserts that the left anterior lobe is a little larger than the right one. Again he shows that, by examining a large number of people, there is an unequal supply of blood to the two sides of the body. The brachio-cephalic trunk, which only exists on the right of the arch of the aorta, produces, by a difference in termination, an inequality in the waves of red blood which travel from right to left. Moreover, the diameters of the subclavian arteries on each side are different, that on the right being noticeably larger.

The left lobe of the brain, therefore, being more richly hematosed than the right, becomes stronger; and as, by the intersection of the nervous fiber, it commands the right side of the body, it is obvious that that side will be more readily controlled. This furnishes one reason for the natural preference for the right hand, and another is found in the increased supply of blood from the subclavian artery. The augmentation of blood we have already seen suggested above; but the reason for it is here ascribed to the relative size of the artery, and not to any directness of path from the heart. Dr. Fleury has carried his investigations through