

of publication by the Government of Assam. Of these and of the valuable "Gazetteer of Upper Burma and the Shan States," by Sir J. G. Scott and Mr. J. P. Hardiman, Colonel Shakespear has made much use. But his own experiences have enabled him to add interesting material, and the large collection of photographs and drawings adds to the value of the book. It has passed the censor attached to the Headquarters staff in India, and it is creditable to that department that they have not suppressed the outspoken criticisms on our methods in the past of dealing with these troublesome neighbours. We have been too prone to delay action for the punishment of raids, to impose inadequate penalties on the guilty tribes, to use



FIG. 2.—Angami Nagas. From "History of Upper Assam, Upper Burma, and North-Eastern Frontier."

large and expensive expeditions to effect what might have been, and has been, done by smaller detachments. Hence, we have met with many regrettable incidents which by prescience and better management might have been avoided.

The publication of the book is timely because it impresses the need of a firm policy on this frontier, particularly as China is beginning to show her power. If the new Republic succeeds in organising an army capable of meeting disciplined troops we may have trouble before us. To meet this emergency the extension of our railway system to the strategical points on the frontier is an obvious necessity.

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COLLOIDAL CHEMISTRY IN RELATION TO INDUSTRIES.¹

II.

PRACTICALLY the only inorganic colloidal preparation made on a large scale at present is the colloidal graphite manufactured by Acheson and used as a lubricant under the name of "Aquadag." Colloidal tungsten was at one time employed in the manufacture of squirted filaments for incandescent lamps, but these have been superseded by drawn wire. The use of colloidal sulphur as spray for hops and vines has been patented and seems likely to be more efficacious than the coarser suspensions of flowers or milk of sulphur.

Of far greater technical importance, however, than these colloidal preparations of inorganic substances are the bodies which, to the layman, are exclusively suggested by the terms "Colloids" or the colloids of Graham. This class comprises such important constituents of organic raw materials as albumen, hide substance, starch, and cellulose; also the various derivatives of the latter, india rubber, gutta percha, and, finally, many manufactured products, among which glue and gelatin may be mentioned as typical. These various substances naturally exhibit a somewhat bewildering variety of individual behaviours, and it is therefore impossible to do more than refer to some properties they possess in common.

Most of them in contact with water—or, in the case of india rubber and nitrocellulose, in contact with certain organic solvents—exhibit the phenomenon of swelling, *i.e.* they imbibe the liquid with increase in volume. The process may either come to an end without solution or dispersion, as with cellulose, or it may proceed as far as the latter either at ordinary or higher temperature, as with albumen and gelatin respectively. This swelling is obviously an inevitable concomitant or antecedent of any treatment with liquids, and therefore of importance in processes differing as widely as tanning and malting. It is well known empirically that the amount of water taken up is affected by even small concentrations of acid, alkali, and neutral salts. The important fact brought out by colloidal research is that this action, particularly in the case of neutral salts, is in no sense chemical, since it is the same on substances differing as widely as gelatin and agar. This knowledge has already been of great value in elucidating the *rationale* of many empirical processes, and its systematic application is likely to be far-reaching. Particularly interesting is the effect of iodides and thiocyanates, which promote the absorption of water to such an extent that, for instance, gelatin dissolves in *cold* solutions of such salts, and that cellulose (as has been shown by v. Weimarn) can be dissolved in hot solutions of calcium iodide or thiocyanate.

A further general rule is that solutions of all these bodies, whatever their nature or that of the solvent, exhibit two peculiarities: the physical

¹ Continued from p. 422.

properties do not depend simply on the concentration, but on the whole previous treatment, especially as regards temperature, and they are not in any event stable, but vary with the age of the solution, although no chemical change whatever may be demonstrable. It is therefore of the utmost importance that a solution, such as the cellulose or nitrocellulose solutions used in making artificial silk, should possess identical properties at a given moment, and research has shown that the most sensitive and most easily measured "indicator" constant is the viscosity. Viscosity measurements accordingly form a recognised means of control in these and other industries. The theoretical study of viscosity is also gradually throwing light on the mechanism of the changes which colloidal solutions undergo in ageing.

A very general property of finely divided matter, and therefore of colloids *par excellence*, is the power of taking dissolved substances out of solution. This phenomenon, so far as it consists in a concentration of such dissolved substance on the surface of the colloid, is called adsorption, and is of the greatest importance in nature and in the arts. The use of Fuller's earth and of gelatin or isinglass for decolouring and clarifying liquids is one of the familiar applications: other instances are so numerous that the difficulty is one of selection. Thus the processes of dyeing and of tanning begin with adsorption, which may be followed by chemical reaction or by diffusion of the substance, concentrated in the first instance on the surface, into the body of the fibre. According to the personal bias of investigators each of the factors involved has been credited with preponderating importance, and it will require much patient work to settle their relative share in processes so complicated. Adsorption, as distinct from chemical combination, has also been advanced as the explanation of certain peculiarities in the vulcanisation of rubber, and forms a subject of rather acute controversy. The adsorptive action of various constituents of the soil on the salts necessary to plant life, a line of investigation first pursued by van Bemmelen, is gradually becoming clear, and light is thereby thrown on a subject of extraordinary intricacy. The so-called humus substances, in particular, have received attention recently, and there seems to be sound evidence in favour of the view that their effect is largely due to their adsorbent action rather than to their somewhat indefinite acid character. In photographic chemistry the proof that the photohaloids, *i.e.* the coloured products obtained by exposing certain forms of silver halogen salts to light, are adsorption compounds of silver and silver salt, has been established experimentally by preparing these products from silver salt and colloidal silver. Incidentally, it may be remarked that the connection between degree of dispersity, mentioned in the last article, and colour has provided the explanation for the great range of shades of the silver image which can be obtained by

varying the exposure and the concentration of the developer.

We have so far considered colloids chiefly in a state of suspension or solution, and have now to refer briefly to the equally important "gel" condition, *i.e.* the more or less solid form they assume when solutions of sufficient concentration are allowed to set by cooling, *e.g.* gelatin and agar, or when the solvent is removed by some means. The most familiar example is the gelatin jelly. These gels possess a number of properties of great technical importance. Many of them retain their cohesion and elastic properties when the greatest part of the solvent is removed, so as to yield elastic filaments or films; cellulose and several of its derivatives are thus used in the manufacture of artificial silk and of photographic films. The elastic properties can be varied considerably by the addition of other soluble substances to the solvent: one of the most important instances is celluloid, consisting of nitrocellulose and camphor or various related bodies. Another important feature of certain gels is that of being rendered insoluble and also incapable of absorbing water by various agents: thus casein treated with formaldehyde becomes a very stable plasmic mass, used industrially as "galalith," while gelatin, to which a small amount of a bichromate has been added, becomes insoluble on exposure to light—a property utilised in the "carbon" process of photographic printing and other methods of photographic reproduction.

Since gels contain very large percentages of liquid the diffusion of dissolved substances in them is very little impeded, as was known already to Graham. Solutions of two reacting substances may, therefore, easily be brought into contact in a gel, and reactions carried out in these conditions exhibit a number of very striking and important peculiarities, of which space permits us to mention only one. By a suitable choice of concentrations the reaction may be slowed and may be arrested at an intermediate stage, which in aqueous solutions would be quite transitory. Perhaps the most striking instance is the extremely sensitive silver bromide of the photographic dry plate, which cannot be produced at all in aqueous solution. It is very probable that this effect of gels may become of technical importance in many other directions, and it deserves careful consideration.

Although the survey here given has necessarily been very brief and incomplete, it is probably adequate to show in how many directions industry is likely to profit by research in colloidal chemistry. To sum up briefly, the latter has demonstrated the bearing on chemical processes and their results of a number of factors which are in no sense of the word "chemical," such as the degree of dispersity; the electrical properties of finely divided matter and the possibility of modifying them by the reaction of the medium; the effect of the latter on such universally important phenomena as swelling of organic substances and on their elastic properties and, finally, the in-

numerable manifestations of adsorption. The recognition of all these factors will naturally be a somewhat arduous task, but will furnish at the very least a new method of attacking problems which cannot be solved by chemistry—in its narrower sense—alone.

E. HATSCHEK.

PROF. J. W. HITTORF.

THE death of Johann Wilhelm Hittorf, at the age of ninety years, removes an eminent and honoured leader from the ranks of German physicists. Born and brought up in Bonn, Hittorf devoted himself to the study of mathematics and natural science at the Universities of Bonn and Berlin, and became Doctor of Philosophy in 1846. Shortly afterwards he attached himself, as privatdocent, to the Academy (later the University) of Münster in Westphalia, the institution with which he was to be associated during his lifetime. Appointed "ausserordentlicher" professor in 1852, Hittorf became full professor of physics and chemistry four years later, and this post he held till 1879. On the re-organisation of the institution in that year, the chair of physics and chemistry was divided, and Hittorf continued as director of the physical laboratories until serious illness compelled him, in 1889, to seek relief from active teaching work. With rest came recovery and renewed activity, to such good purpose that between his seventieth and eightieth years Hittorf published some half-dozen memoirs. He died on November 28 last, as professor emeritus of the University of Münster, full of years and honour.

Hittorf's investigations dealt with a number of problems on the borderland of physics and chemistry, and the results are embodied in about thirty communications to scientific journals. In appraising this output of original work, it must be borne in mind that the earlier researches were carried on under serious disadvantages in respect of laboratory equipment, and that he himself was personally responsible for all the experimental work described in these memoirs.

Some of the first researches were concerned with the allotropy of selenium and phosphorus, and the discovery of the so-called "metallic" variety of the latter element was made by Hittorf. This work, however, is quite overshadowed by the remarkable series of investigations (published 1853-9) on the migration of the ions during electrolysis. Whilst Faraday had studied mainly the nature and the quantity of the substances produced at the electrodes by electrolytic decomposition, Hittorf investigated the more subtle changes of concentration that take place in the electrolyte itself. From these concentration changes, the relative rates at which the ions of an electrolyte move during the passage of a current, and their relative share in the transport of the electricity, were deduced.

This work met with practically no recognition from Hittorf's contemporaries, and indeed was vigorously attacked by the leading German

physicists of the time. Twenty years later the significance of these investigations began to be appreciated, and fortunately Hittorf lived to see his great work accepted as a fundamental part of the science of electrochemistry.

A prominent place among Hittorf's researches must be assigned also to investigations, carried out at the suggestion of his master Plücker, on the spectra of ignited gases and vapours. The memoir embodying this work, which was published in the Philosophical Transactions for 1865, deals with the plurality of spectra, and shows, more especially for the case of nitrogen, that the same substance can give two different spectra. Hittorf's association with Plücker may be further traced in a series of important papers on the passage of electricity through gases; the foundation of what is known regarding kathode rays, discovered by Plücker in 1859, was laid in these investigations.

The remarkable activity of Hittorf's later years, already referred to, was shown chiefly in a study of the passivity of metals, more especially chromium; it was found that this phenomenon cannot be attributed to the presence of a film of oxide on the surface of the metal. It is a striking fact that in his last published memoirs Hittorf returns to the transport of electricity in electrolytes, the field of research in which he laboured fifty years before, and with which his name will be inseparably associated.

J. C. P.

DR. N. C. DUNÉR.

THE death of Nils Christoffer Dunér has deprived Sweden of one of her most distinguished men of science, and astronomy of an active and devoted student. Born on May 21, 1839, Dunér entered the University of Lund in 1855, and took his doctor's degree in 1862. He became a member of the staff of the Lund Observatory in 1864, and occupied that position until his appointment, in 1888, as Professor in the University and Director of the Observatory of Upsala. He died at Stockholm on November 10, after a brief illness following his return from a journey to observe the solar eclipse of last August.

Dunér made notable contributions to many departments of astronomy, and his name will be especially remembered in connection with his work on double stars, variable stars, the spectra of red stars, and the investigation of the sun's rotation by the spectroscopic method. His work on double stars during the years 1867 to 1875 at once placed him in the front rank of double-star observers and computers.

Several variable stars were discovered or investigated by Dunér. Two of them—Y Cygni and Z Herculis—have proved to be of exceptional interest. Dunér not only found that the light-changes of these stars could be completely explained by supposing them to be eclipsing variables of the Algol type, with the difference that both components are bright, but was able to determine the elements and dimensions of the two systems.