be of the greatest value. The readers of NATURE will appreciate anything that helps the scientific worker. Now, at last, we are going to the root of things in biology, and only the embryologist knows fully what a boon an egg-hatcher, convenient and easy to work, would be. The eggs of the hen will be wanted in their various stages of incubation, as long as there are workers in these departments, but many other sorts of oviparous animals have to be worked out in all their stages besides the common fowl. Snakes, lizards, tortoises, crocodiles, all these are rivals of the bird in their embryology, and of many kinds the eggs could be procured and their embryos developed if the worker had some such apparatus as Mr. Christy is bringing out. We want, not merely the general embryology of these ovipara, such as is so excellently illustrated and described in Messrs. Foster and Balfour's work, but the special development of any important organ ought to be traced in all its stages through not one, but many types of the vertebrata: through *all* the principal kinds indeed.

Some of us are trying to do this in the skeletal structures; the nervous system, still more important, wants an army of workers, then there are the respiratory, digestive, excretory, and generative organs, all these want a complete history in all their stages, not in one type merely, but in scores of types. We therefore wish well to all energetic and enterprising men who put it into our power to work on a wider scale; such means and appliances as can be brought out by men too restless for close and patient study, may be of infinite service to the close and patient student, who is too dreamy and abstracted to invent for himself. W. K. P.

## NOTES ON SOME NATAL PLANTS

GROWING plentifully among the grass on the coast hills of Natal is a small blue flower belonging to the Rubiaceæ. In this plant, generally speaking, there are two forms only, in one of which the five stamens are exserted considerably beyond the tube of the rotate corolla, and the stigma is included in the tube; in this form the tube is almost devoid of hairs. In the other common form the position of these essential organs is reversed, the stigma protruding to about the same extent that the stamens do in the first mentioned, and the stamens being included; here, however, the upper part of the corolla tube is *thickly* covered with downy hairs—of course this is an ordinary dimorphic plant. But I find lately a third form of the same species (only, however, rarely) in which both stamens and stigma are exserted and are of the same length, so that here self-fertilisation must take place, as the stamens and stigma touch at the time the former dehisce. I do not think this can be termed a cleistogamic form, as, although rather smaller and lighter in colour than the others, the difference is only trifling. The hairs which cover the corolla-tube in the form with included stamens serve to keep the pollen collected near the upper part of the tube, as, if it fell to the base it would not be so easily transferred by the proboscis of an insect as when lightly held by the hairs through which the insect must make way. As these hairs would be for this purpose useless when the stamens are exserted they do not occur in the other form.

I notice the same arrangement of hairs in another dimorphic plant belonging, I think, to the same order, which grows on the marshy flats near the sea. I have found on the coast lands here four other plants, in which cross-fertilisation is secured by dimorphism, one of them being a monocotyledonous plant.

There is a species of *Polygonum* which climbs in the bush which well illustrates another plan ensuring cross-fertilisation; while the flower is young and the perianth still closed, enveloping the immature stamens, the three branching stigmas protrude from between the segments in a fit state to receive the pollen. If (as is usual) the ripe stigmas were only exposed when the flower opens, although the evils of self-fertilisation would of course be avoided by the plant being proterogynous, still, as it is wind-fertilised, the perianth and stamens would be in the way of any stray pollen-grains reaching the stigmas; while as it is, nothing interposes between pollen and stigmas.

Lately I have found a curious aberration of form in *Tecoma capense* growing here. It is very common in the bush, forming great beds of bright colour, and normally has a scarlet trumpet-shaped corolla, with one rudimentary and four perfect stamens. I found, however, three or four plants growing within a short distance of each other, in which there were eight perfect stamens; they seemed, however, to have been formed at the expense of the corolla, for there was only one segment coloured at all, the remainder being colourless and small. The ovary seemed in several cases to have been fertilised. The ordinary form of this plant, although individually so brightly coloured, growing in large numbers and secreting much nectar, is seldom or never visited by Lepidoptera. It is, however, frequented by honeysuckers and small bees in numbers. All through the day you can hear the shrill chirp of the small bright honeysucker among the blossoms. The immediate reason why butterflies and moths do not visit it I cannot give; but the stamens and stigma (which are beneath the large upper segment of the corolla) are long, and so high above the opening of the corolla-tube that those insects, in visiting the flower for its nectar, would not be at all certain to touch either, and so in comparison to the honeysucker and small bees would be of little benefit to the plant; for when the former of these visits the flower the feathers of his head are just of the height to brush off the pollen, and the latter in collecting the pollen is equally certain to distribute it, as the bifid stigma is about the same length or only slightly longer than the stamens. Can the nectar have been modified to suit the taste of the useful honeysucker without reference to the useless butterfly?

Natal, June 27 M. S. EVANS

## PHYSICS IN PHOTOGRAPHY[1]

### III.

THESE last experiments were remarkable in another point of view, as they opened out the question as to whether the salts of silver might not prove sensitive to rays to which they had been supposed hitherto to be insensitive. Silver iodide, for instance, when exposed to the spectrum in a solution of potassium sulphite proved sensitive as far as "*a*" of the spectrum instead of stopping short at the point indicated in Fig. 2 (p. 529); and silver bromide in the molecular grouping which absorbed the red proved sensitive to a wave-length of somewhere near 11,000, whereas in its normal state 9,600 was its limit.

Similarly silver chloride proved sensitive to an extent which presumably may be increased till it is equal to that of the bromide. In both these instances we have a proof that the compound was sensitive to these abnormal rays, and that the image formed by those rays was destroyed as soon as formed by their oxidising action giving an undevelopable form of salt. It may be remarked that by exposing films in reducing solutions such as ferrous sulphate, and pyrogallic acid rendered very slightly alkaline, that an image can be developed as fast as it is formed.

The natural outcome of the experiments on the oxidation of the photographic image just narrated is that it should lead to the solution of the problem of photography in natural colours, such as that of Becquerel, Niepce de St. Victor, and others. In the fourth edition

[1] Continued from p. 531.

of Hunt's "Handbook of Photography," we read, at p. 161, "Niepce de St. Victor has made many experiments to produce the colours upon salts of silver and copper spread upon paper, but without success; the metallic plate appears absolutely necessary, and the purer the silver the more perfect and intense is the impression." The following is recommended as the most effectual mode of manipulating:—"The plate is highly polished with tripoli powder and ammonia; being perfectly cleaned, it is connected with the battery and plunged into the bath prepared in any of the ways stated. [The baths were made from ferric chloride, cupric chloride, hydrochloric acid, &c.] It is allowed to remain in the bath for some minutes, taken from it, washed in a large quantity of water, and dried over a spirit-lamp. The surface thus produced is of a dull neutral tint, often almost black; the sensibility of the plate appears to be increased *by the action of heat*, and, when brought by the spirit lamp to the cerise red, it is in its most sensitive state."

"The sensibility, however, of the plates is low—*two or three hours* being required to produce a decided effect in the camera obscura. . . . These, when I first saw them, were perfectly coloured in correspondence with the drawings of which they were copies, but the colours soon faded, and it does not appear as yet that any successful mode of fixing the colours has been discovered." The coloured spectra which Becquerel photographed were produced in a somewhat similar way, the variation from which need scarcely be repeated.

In Hunt's work we also find that natural colouration of photographs was found to be possible by one or two other processes, but that the above gave the most satisfactory results. Mr. Simpson also noticed when using an emulsion of silver chloride and after exposing the film to white light so as to tint the surface with a lavender colour, that he was able to reproduce on the film the tint of different coloured glasses to which such a surface might be exposed.

It will be noticed that the coloured spectra were produced on a dark compound of silver which gradually responded the colour falling on it. We have first a case of total or nearly total absorption of all the rays, and a subsequent production of compounds of varying tints. In order to produce any variations of colour it is only necessary that we should have at the most three molecular groupings, one of which should absorb the blue and green, another the green and red, and the last the red and blue. Whether the number of groupings may be reduced to two is a question for future consideration. In Lockyer's note read before the Royal Society on June 11, 1874, "On the Evidence of Variation in Molecular Structure," we find statements which might have been conceived to be almost too bold at the time when they were made, but which subsequent investigations seem to prove to be exact. In this note he refers to definite molecular groupings of compounds and the absorption caused by them, and indicates that we may have a group which will absorb at the blue end and another which will absorb the red end of the visible spectrum. It has already been shown that the silver bromide can be reduced to two groupings, one absorbing the blue and the other the red, and it is somewhat remarkable that, by applying pressure to the latter molecular grouping, it is gradually resolved into the former grouping, and passes through all tints of spectrum between the blue and the red. It must be remembered that these colours are not the colours of thin plates, but are totally independent of the thickness of the film so long as light can penetrate through it. It is not too much to assume that if silver bromide can be made to group itself into these two states, that the subbromide when oxidized should also assume a similar molecular condition. With this compound in a state which practically absorbs all rays, it is easy to imagine that particular sets of vibrations may cause it to resolve itself into groupings which answer to them. We have, in fact, the inverse of the reduction of the silver bromide by different portions of the spectrum. It is found that one molecular grouping can be reduced by a whole series of vibrations; thus the blue absorbing molecular group is altered by all the radiations from the ultra violet to the yellow, and the red absorbing molecular group by the radiations from the ultra-red to the green. If there were a green absorbing molecular group, of which there is a strong suspicion of the existence, it would probably be altered by radiations from the blue to the orange. If, then, one silver compound can exist in two or three states of molecular grouping, it is quite within the range of reason that the oxidised compound should exist in the same three groupings. The black compound to which we have already referred, in fact, does arrange itself thus, probably by a re-arrangement of molecules, as formed when it absorbs oxygen. If a plate be prepared in a similar manner to that described above, and if it be exposed in an oxidising medium, these groupings are attained rapidly, a few minutes sufficing where previously hours were required. The images thus formed, however, appear not to be unchangeable, as exposure to white light, or to any colour except that in which the re-arrangement takes place causes the colours to fade. The feat of producing *permanent* photographs in natural colours is as yet unsolved, but it may not be so far distant as may be imagined. In order to obtain them it is necessary that a method should be found by which the molecular groupings of metallic silver can be formed in either of the two (or three) states already described. As is well known, the absorption by metallic silver in a thin film takes place entirely in the red end of the spectrum, but it is a fact well known to photographers at large, that in certain processes it is perfectly feasible to obtain silver in which the transmitted light is of a pink red colour, whilst tints varying from indigo, passing through olive green to rich brown are familiar. In order to obtain permanent photographs in natural colours, the object to be sought is a method by which the sensitive silver compound may be reduced by the red rays to a molecular grouping, which on development (probably by the alkaline method) shall be grouped into the red transmitting molecular grouping, and so on. When this is discovered, the leap between monochromatic pictures, and chromatic, will have been taken, and the once apparent improbability have become more than a possibility.

We have finally to return to the subject of photography with the light of those rays which are usually inactive upon sensitive salts, and at which we have already glanced.

To Dr. H. Vogel, of Berlin, is undoubtedly due the new interest which has been taken in this branch of photography. Towards the end of the year 1873 he announced that he had discovered a method of making the non-actinic rays in certain circumstances actinic. We quote his own words[1]:—"I have found that bodies which absorb the yellow ray of the spectrum make bromide of silver sensitive to the yellow ray. In like manner I find bodies which absorb the red ray of the spectrum make bromide of silver sensitive to the red rays. For example, by the addition of *corallin*—which absorbs the yellow ray—to a bromide of silver film, it becomes as sensitive to the yellow ray as to the blue ray." In articles which he published at various times he enlarged on this idea, some of his most striking experiments being conducted with aniline dyes of various kinds. He and Waterhouse have shown that a silver bromide film becomes sensitive to the part of the spectrum which certain of those dyes absorb, whether the absorption be due to a compound formed between the dye and silver, or to aqueous or alcoholic solutions. This at once opened

[1] *Photographic News*, December 5, 1873.

out a large field for inquiry, and made research in this direction doubly interesting owing to the fact that apparently certain physical laws would have to be modified if Vogel's theory were correct. He divided the action of the substances so added into two, the dye he called an optical sensitiser for that particular part of the spectrum which it absorbed, whilst bodies which absorbed the halogen (thrown off by the reduction of the molecule) he called a chemical sensitiser, and a combination of both properties in a dye made the film sensitive to the absorbed rays. The theory of the optical sensitiser seemed to clash with the received notion of molecular motion, but before analysing the results the accompanying figure should be studied, which is taken from Vogel's work on Photography (Fig. 5).

Let us take one or two examples from the above figures and see whether they agree with Vogel's assumption. We will take VIII. as a standard of comparison, being the effect on unstained bromide, and this will be fair (though it does not take the form given, shown in Fig. 2, p. 529), as it is presumed that this sample of bromide was worked with throughout. Comparing say IV. with VIII. we see that in the blue the sensitivenesses, as shown by the ordinate of the curved line, are very similar, but that the action is got in the yellow. In examining cyanine blue, the dye used, we find that the absorption takes place just at that part of the spectrum. Similarly examining V. and VI. we arrive at the same results, and in fact the absorption of the rays invariably corresponds with the photographic action.

It will be seen then that without doubt the principle Vogel contends for might explain the phenomena. He, however, found that if the silver bromide film had been prepared with an excess of bromide, that the actions indicated did not take place. This seemed to indicate a weak spot in the theory, and it pointed at first sight to the idea that it was necessary to form a coloured compound of the dye with silver, in order to render it sensitive. In the majority of cases this still seems to be, if not a necessity, yet a cause of increase of sensitiveness to the region of the spectrum absorbed. Vogel, however, shows that, if the silver bromide film, prepared with an excess of bromide, be washed, and be then treated with a dye, and a chemical sensitiser, such as tannin, that the same action takes place. The theory of a silver compound in this case must evidently be abandoned, and would point to

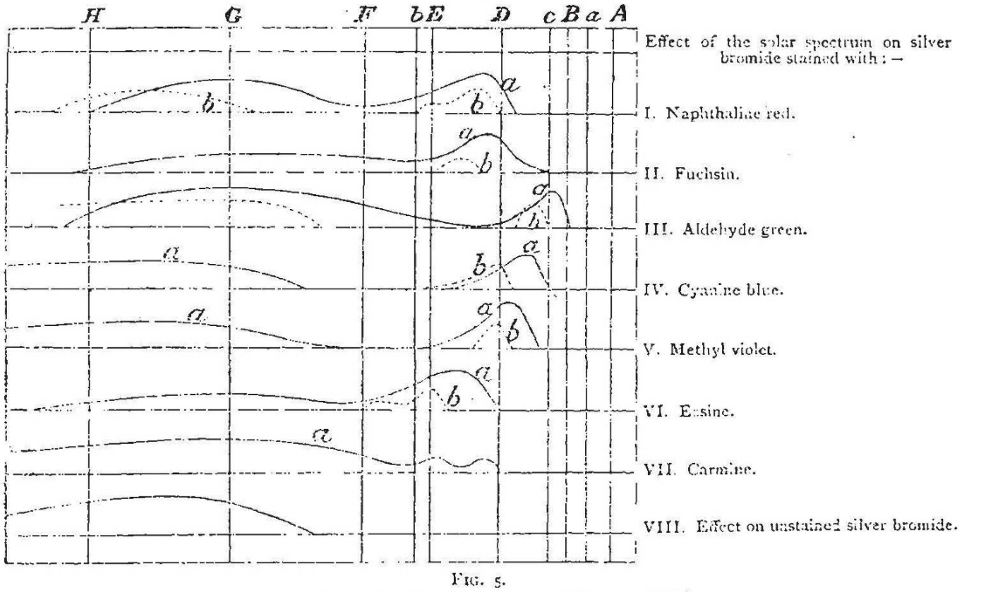


Fig. 5.

The curves marked *a* show longer exposure than those marked *b*.

the correctness of Vogel's theory, did not other experiments in a certain degree offer an explanation more accordant with our preconceived ideas. Let the dye be mixed with *plain* collodion and a film of it be exposed to the spectrum, it will soon be visibly evident that there is a marked effect produced by the rays absorbed. Thus cyanine blue will be found bleached in the region near D and below it. If over the dyed film of collodion thus exposed, a film of silver bromide in collodion be poured in the dark, and the alkaline developer be applied gradually, a silver image of the altered portion of the dyed collodion film will make its appearance, although the film of silver bromide has received no impression by light. The explanation of this remarkable phenomenon is to be found in the theory of alkaline development already given in these articles. The reduced dye acts as a nucleus on which the metallic silver will first adhere, and this first reduction of metallic silver determines the position which the further reduced silver shall occupy, and thus the image is built up. When there is an excess of soluble bromide in the film the developing action will be retarded. This series of experiments seems, then, to indicate that there is no need for optical sensitisers to alter the oscillation of the molecules or molecular groups, but that, in some instances, the same theory may be applied to the action of dyes as may be applied to the deposition of metallic silver on a glass plate which has not been freed from "dirt," a disagreeable phase which is well known to photographers at large. The explanation of the diagram is, therefore, not hard to understand when viewed in this light. The theory of rendering the silver salt sensitive to the red has already been explained, and the same explanation is naturally applicable to those dyes which, when brought in contact with silver, form a definite compound with it.

There are many interesting physical researches which spring out of these various experiments, amongst which may be mentioned a method of determining the size of atoms and their arrangement in the molecule, and last and not least, the production of permanent photographs painted in natural colours by light itself. The attempts made of late to form photographs in proper colours by taking distinct negatives through blue, through green, and through red media and then printing positives from such, and finally obtaining red, green, and blue prints and superimposing them, is not a step in a scientific direction, since it is utterly impossible to secure monochromatic colours which are pure enough to give the truth of nature. Such efforts, though they may be commercially valuable, yet are not to be followed with too much zeal by scientific photographers.

We may now axiomise the results we have indicated:—

1. That the undeveloped photographic image on a silver compound is formed by the reduction of that compound.

2. That the compound may exist in two (or three) molecular groupings.

3. That the compound can only be sensitive to the rays which it absorbs.

4. That the reduced silver compound may be rendered incapable of development by combining with oxygen.

5. That light of every refrangibility may cause an acceleration of oxidation provided the compound acted on absorbs such light.

6. That the oxidation of the compound reduced by any particular ray may be as rapid as the reduction, and thus to give a false idea of their limit of sensitiveness to the spectrum.

7. That the oxidation of the reduced silver compound may account for the phenomenon of photographs in natural colours hitherto produced.

8. That in all probability the action of dyes on silver bromide is a secondary one.

W. DE WIVELESLIE ABNEY

## GELATIN AS A FOOD-PRESERVER

REMOVAL of water and exclusion of air are amongst the most effective conditions for the preservation of animal and vegetable foods. If you coat an egg with collodion you may keep it a year, and yet will find it perfectly sound at the last. By dipping a mutton-chop in melted paraffin, putrefaction will be prevented. But in both these examples of preservative processes, dependent upon the exclusion of air, you make use of materials which are costly and uneatable. There are analogous drawbacks to all similar plans for preventing injurious changes in articles of food. The tinning method, and the method of simple desiccation in warm dry air, are satisfactory in their results; but the range of alimentary substances amenable to such treatment is not very extensive. In Dr. Campbell Morfit's new "Gelatin Process" we seem to see several points of superiority over most of the older plans for attaining the same end. It is true that chemists have not been in the habit of looking upon gelatin (or indeed any other similar complex nitrogenous body) as likely to prevent or arrest decay. On the contrary, few solutions afford a more suitable *nidus* for the development of fungoid germs than a liquid containing gelatin. But the experience of a good many months tends to show that food-preparations containing gelatin, if once dried so as not to contain more than 10 or 12 per cent. of moisture, do not become mouldy even when exposed to warm and moist air. A large number of Dr. Morfit's experimental mixtures have been so exposed for some weeks, lying on my office table: yet they have not suffered any decided deterioration. They comprise many perishable foods, such as cabbage, tomato, milk, and meat. Though not of equal merit as specimens of the gelatin process, all are edible, and some positively palatable. Further experiment will doubtless enable the inventor to improve his process by modifying it still further, so as to suit a greater variety of vegetable and animal foods.

Perhaps the best way of explaining the nature of Dr. Morfit's invention will be to take as an illustrative example the case of milk. The mere drying-up of milk has been tried with but moderate success—the resulting powder becoming quickly rancid on exposure to the air. The preserved or condensed milk now in such extensive use is in many respects a satisfactory and convenient preparation, but it is mawkishly sweet, containing more than one-fourth its weight of added cane sugar. Moreover, in consequence of this addition, the proportion of nitrogenous or flesh-forming substances in it has been seriously lowered. Now the substitution of gelatin for cane sugar in preserving milk meets both these objections to ordinary condensed milk. The milk preserves its natural and moderate degree of sweetness, while the gelatin, even if its own value as a nitrogenous nutrient be not considered, certainly does not *lower* the proportion of flesh-formers to heat-givers in the product.

In order to apply his process to the preservation of milk, Dr. Morfit directs us to dissolve 1 lb. of gelatin in 1 gallon of milk at a temperature of 130° to 140° Fahr., and then to allow the solution to set into a jelly; this is then cut into slices and dried. By employing the product of this first operation in lieu of fresh gelatin, for gelatinising a second gallon of milk, a jelly is obtained in which the milk-solids are just doubled in amount. As a gallon of milk contains about 6,400 grains of these solid nutrients, casein, milk-sugar, milk-fat, and phosphates, their ratio to the gelatin will become as 12,800 to 7,000 after the second operation just described. If then the dried *milk-jujube*, as we may call it, be again and again employed with successive quantities of milk, a limit is reached, when the 1 lb. of gelatin has been incorporated with ten gallons. At this stage the mixture will contain no more than one part of gelatin to ten parts of the nutritive matters of milk—a proportion of added preservative material which contrasts very favourably with the 25 to 28 per cent. of sugar found in ordinary preserved milk. If the 1 lb. of gelatin required could be at once dissolved in the whole eight or ten gallons of milk, the process would be simplified and cheapened, but gelatinisation, an essential part of the method, could not then be secured. For it is the gradual drying up of the slabs of jelly, with which the animal and vegetable food-materials have been uniformly incorporated, that leaves every particle of changeable substance with an adequate protective coating of gelatin.

One at least of Dr. Morfit's preparations has become an article of commerce. He dissolves gelatin in lime-juice at a gentle heat, and after removing much of the water and adding sugar, incorporates the mixture with the powder of navy-biscuit. Pressed in moulds and carefully dried, a granular acidulous and agreeable biscuit is produced, which should combine a considerable alimentary value with the anti-scorbutic properties of lime-juice. On analysing the lime-juice jujube, the basis of these biscuits, I find about 8 per cent. of water, 8 of gelatine, 5 of free citric acid, much sugar, and less than 1 (0·7) per cent. of mineral matter or ash. This proportion of gelatin is rather high when compared with the free citric acid, the characteristic ingredient of lime-juice; but the sample analysed was made in April, 1877, and may not represent the exact composition of the recent product. And it becomes a question, whether for travellers' use, it would not be advisable in this preparation to neutralise a little of the acidity of the lime-juice with potash, rather than to mask its presence by an excessive quantity of sugar. Pure lime-juice itself contains very little potash and phosphoric acid or other mineral matter; but that fact affords no argument against the introduction of small quantities of these compounds into such a preparation as that now under consideration.

It would be impossible to discuss in detail the applicability of the gelatin process to the preservation and concentration, in an uninjured, compact, and available form, of fruits, of meat, of cheese, &c., &c. But it may be safely affirmed that Dr. Morfit's invention has already been successfully applied in several directions, and that it is full of promise for the future.

A. H. CHURCH