monia is precipitated by an acid, the coagulum formed is very voluminous. [The experiment was shown.] One gram of turacin is capable of forming a semi-solid mass with 600 grams of water. Another character which turacin shares with many other colloids is its solubility in pure water and its insolubility in the presence of mere traces of saline matter. It would be tedious to enumerate all the observed properties of turacin, but its deportment on being heated, and the action of sulphuric acid upon it, demand particular attention.

At 100° C., and at considerably higher temperatures, turacin suffers no change. When, however, it is heated to the boiling-point of mercury it is wholly altered. No vapours are evolved, but the substance becomes black and is no longer soluble in alkaline liquids, nor, when still more strongly heated afterwards can it be made to yield the purple vapours which unchanged turacin gives off under the same circumstances. This peculiarity of turacin caused great difficulty in its analysis. For these purple vapours contain an organic crystalline compound in which both nitrogen and copper are present, and which resists further decomposition by heat. [Turacin was so heated as to show its purple vapours, and also the green flame with which they burn.] This production of a volatile organic compound of copper is perhaps comparable with the formation of nickel and ferro-carbonyl.

The action of concentrated sulphuric acid upon turacin presents some remarkable features. The pigment dissolves with a fine crimson colour and yields a new compound, the spectrum of which presents a very close resemblance to that of hæmatoporphyrin [turacin was dissolved in oil of vitriol; the spectrum of an ammoniacal solution of the turacoporphyrin thus produced was also shown], the product obtained by the same treatment from hæmatin; in other respects also this new derivative of turacin, which I call turacoporphyrin, reminds one of hæmatoporphyrin. But, unlike this derivative of hæmatin, it seems to retain some of its metallic constituent. The analogy between the two bodies cannot be very close, for if they were so nearly related as might be argued from the spectral observations, hæmatin ought to contain not more, but less metal than is found to be present therein.

The percentage composition of turacin is probably carbon 53·69, hydrogen 4·6, copper 7·01, nitrogen 6·96, and oxygen 27·74. These numbers correspond pretty nearly to the empirical formula $C_{82}H_{81}Cu_2N_9O_{32}$; but I lay no stress upon this expression.

I have before said that copper is very widely distributed in the animal kingdom. Dr. Giunti, of Naples, largely extended (1881) our knowledge on this point. I can hardly doubt that this metal will be found in traces in all animals. But, besides turacin, only one organic copper-compound has been as yet recognised in animals. This is a respiratory, and not a mere decorative pigment like turacin. Léon Fredericq discovered this substance, called hæmocyanin. It has been observed in several genera of Crustacea, Arachnida, Gastropoda, and Cephalopoda. I do not think it has ever been obtained in a state of purity, and I cannot accept for it the fantastic formula—$C_{367}H_{1369}CuS_4O_{258}$—which has recently been assigned to it. On the other hand, I do not sympathise with the doubts as to its nature which F. Heim has recently formulated in the *Comptes Rendus*.

It is noteworthy in connection with the periodic law that all the essential elements of animal and vegetable organic compounds have rather low atomic weights, iron, manganese, and copper representing the superior limit. Perhaps natural organic compounds containing manganese will some day be isolated, but at present such bodies are limited to a few containing iron, and to two—hæmocyanin and turacin—of which copper forms an essential part.

If I have not yet unravelled the whole mystery of the occurrence and properties of this strange pigment, it must be remembered that it is very rare and costly, and withal difficult to prepare in a state of assured purity. It belongs, moreover, to a class of bodies which my late master, Dr. A. W. von Hofmann, quaintly designated as "dirts" (a magnificent dirt, truly!)—substances which refuse to crystallise, and cannot be distilled. I have experienced likewise during the course of this investigation, frequent reminders of another definition propounded by the same great chemist when he described organic research as "a more or less circuitous route to the sink"!

I am very glad to have had the opportunity of sharing with an audience in this institution the few glimpses I have caught from time to time during the progress of a tedious and still incomplete research into the nature of a pigment which presents physiological and chemical problems of high, if not of unique, interest.

Let my last word be a word of thanks. I am indebted to several friends for aid in this investigation, and particularly to Dr. MacMunn, of Wolverhampton, the recognised expert in the spectroscopy of animal pigments.

ARTIFICIAL IMMUNITY AND TYPHOID FEVER.

THE announcement by Metchnikoff of his beautiful theory of the "mechanism," as it were, of immunity, which he conceives as dependent upon the activity of the phagocytes or migratory cells of the body in the presence of disease germs, has called forth an immense number of researches in this direction from all parts of the world. But whilst some bacteriologists are engaged upon studying critically the experimental evidence which can be adduced in support of this theory, others are busy with the practical side of the subject and are devoting themselves to the investigation of what substances are capable of conferring immunity upon animals towards any particular disease, and hardly a month passes without some contribution being made to this important inquiry. The great discovery made by Behring that the blood serum of animals rendered artificially immune against a particular disease will, on being introduced into other animals, protect them from an attack of that particular disease, has been confirmed in the case of tetanus or lockjaw by Behring and Kitasato, and as regards diphtheria by Behring. In a more recent contribution Brieger, Kitasato, and Wassermann ("Ueber Immunität und Giftfestigung," *Zeitschrift für Hygiene*, vol. xii. 1892) have, amongst other investigations, succeeded in protecting and healing mice from the evil effects of inoculations with the typhoid bacillus by the introduction of serum obtained from a guinea-pig immune against typhoid. The further study of immunity with reference to this disease is the subject of two elaborate memoirs in the *Annales de l'Institut Pasteur*, November, 1892, by Sanarelli in Siena, and Chantemesse and Widal in Paris, and the ground covered by these two investigations is to a great extent identical. Sanarelli selected guinea-pigs as the subjects for his experiments, these animals being, as is well known, more difficult to protect from the fatal results of typhoid inoculations than mice. He states that if 0·5 c.c. of therapeutic serum be simultaneously introduced with an otherwise fatal dose of a typhoid culture, these animals *without exception* develop no typhoid symptoms, whilst guinea-pigs inoculated with an equally fatal dose of typhoid, but without the curative serum, invariably die. Chantemesse and Widal have pursued the inquiry still further, and have investigated the properties of serum taken from normal animals—that is to say, from animals which have not been infected with or rendered artificially immune from typhoid. Investigations similar to those made previously by Stern have also been conducted with human serum obtained from patients who have recovered from typhoid fever and also from those who have never been attacked by this malady.

Chantemesse and Widal state that whereas the serum derived from typhoid patients and from immune animals invariably confers protection upon infected animals, that obtained from normal animals and from people who have never had typhoid, only exceptionally exercises any curative power. These authors have also compared the degree of immunity induced in animals by the inoculation of curative serum and sterilised cultures of the typhoid bacillus respectively. This latter process is another method of protecting animals against infection, and was resorted to before the experiments with serum were made. It was found that whilst the serum acts rapidly, and confers immunity when administered in small quantities, its protective power only extends over a short period of time, apparently disappearing in less than a month. The sterilised typhoid cultures on the other hand, although working more slowly and requiring to be introduced in larger doses than the serum, endow the animal with immunity over a longer space of time, animals having been found immune even after the lapse of two months. Finally, attempts were made to arrest the progress of typhoid fever in people by the inoculation of therapeutic serum obtained from guinea pigs. So far, however, these investigations have not been successful, and if it be remembered that one point of cardinal importance in the

production of immunity or in healing the disease is the time which elapses between the infection and the protective inoculation, that the action of the latter is the more rapid and the more successful the sooner it follows upon the former, it is at once apparent where, at any rate, some of the difficulties lie in its successful application to human beings. Whereas the exact moment is known when the experimental infection in the animal takes place, in the human subject days or weeks may pass between the infection and the declaration of the disease.

THE CENTENARY OF GILBERT WHITE.

THE wonted tranquillity of the little Hampshire village of Selborne was disturbed on Saturday by the invasion of a band of pilgrims who came to look upon the shrine of Gilbert White, and by the sight obtained a renewed love of nature. Drawn by a feeling of regard, members of the Selborne Society, and other disciples of White, congregated from all parts of the country, and paid homage to their master. Never within the memory of the oldest inhabitant had so many people been gathered together at Selborne, and we doubt not that the villagers failed to realise what attraction there could be in a man whose characteristics, according to an old woman who remembered him, were that "he would walk about the lanes tap-tapping at the trees, and stooping every now and then to wipe the dust off his shoes." But one thing marred the enjoyment of Saturday's meeting. A band of gipsies, with a terrible barrel-organ, and all the paraphernalia of a country fair, had installed themselves not a stone's-throw from the house in which Gilbert White lived his peaceful life. And, worst of all, they possessed a steam-syren, the shriek and screech of which penetrated everywhere, even to the high Hangers, in which the Selborne naturalist supposed that swallows hibernated.

The Earl of Selborne presided at luncheon, and, in proposing "The Memory of Gilbert White," dwelt upon the sterling qualities of the man, and the remarkable character of his books dealing with the natural history and antiquities of Selborne. White's life was devoted to observing and recording natural productions and phenomena. He was gifted with shrewdness of discernment, and that one essential qualification of a true man of science—the power of faithfully chronicling all and every observation. It was thought by some that the naturalist whose centenary they were commemorating had nothing else to do but wander about, and observe the habits of birds, beasts, fishes, and insects; but that was a great mistake. He had to perform "the daily round, the common task" that falls to the lot of all, and diligently did he fulfil his duties.

Mr. Darwin proposed "Prosperity to the Selborne Society and its branches." In responding, Mr. Otter, one of the founders of the society, dwelt upon the fact that their object was to inculcate and foster a love of nature, and to wage war in defence of her beauties. To them the ruthless field-naturalist and the sporting collector of specimens were enemies.

Mr. Wakefield followed with a description of the good work done by the Thames Valley branch in preserving "beauty-spots" from jerry-builders and their kindred.

The Earl of Stamford, in proposing "Prosperity to the Hampshire Field Club," the members of which joined the London party at Selborne, remarked that he had found reason to believe that one of the figures shown in the quarto edition of White's book is a likeness of the author himself, hence it could no longer be said that no portrait of him was in existence. Mr. R. H. White, however, was of the opinion that the evidence was not of a positive character.

The question of a memorial to White was touched by the Earl of Selborne, but he thought that the best plan would be to "Look not on the picture, but the book," and leave that to be handed down to the end of time, for nothing more was needed to perpetuate the memory of the man. With this sentiment we by no means agree. A monument is not erected merely to prevent a man's name and deeds from sinking to oblivion. It should show to the people that he was one whom men delight to honour. We are apt to be far too prosaic in these matters, and to consider the raising of images and other memorials as more or less unnecessary conventionalities. This conviction has grown upon us because we have seen statues erected to comparatively obscure individuals time without number, while the works of men of science are unrecognised. It does not say much for the naturalists of this country if the centenary of Gilbert White is allowed to pass without some tangible illustration being given of their regard for the father of them all.

INTERFERENCE BANDS AND THEIR APPLICATIONS.[1]

THE formation of the interference bands, known as Newton's rings, when two slightly curved glass plates are pressed into contact, was illustrated by an acoustical analogue. A high-pressure flame B (Fig. 1) is sensitive to sounds which reach it in the direction EB, but is insensitive to similar sounds which reach it in the nearly perpendicular direction AB. A is a "bird-call," giving a pure sound (inaudible) of wave-length (λ) equal to about 1 cm.; C and D are reflectors of perforated zinc. If C acts alone, the flame is visibly excited by the waves reflected from it, though by far the greater part of the energy is transmitted. If D, held parallel to C, be then brought into action, the result depends upon the interval between the two partial reflectors. The reflected sounds may co-operate, in which case the flame flares vigorously; or they may interfere, so that the flame recovers, and behaves as if no sonnd at all were falling upon it. The first effect occurs when the reflectors are close together, or are separated by any multiple of $\frac{1}{2}\sqrt{2}.\lambda$; the

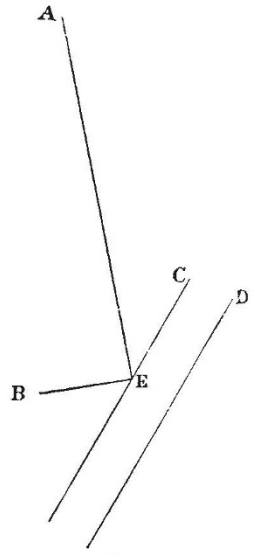

FIG. 1.

second when the interval is midway between those of the above-mentioned series, that is, when it coincides with an odd multiple of $\frac{1}{4}\sqrt{2}.\lambda$. The factor $\sqrt{2}$ depends upon the obliquity of the reflection.

The coloured rings, as usually formed between glass plates, lose a good deal of their richness by contamination with white light reflected from the exterior surfaces. The reflection from the hindermost surface is easily got rid of by employing an opaque glass, but the reflection from the first surface is less easy to deal with. One plan, used in the lecture, depends upon the use of slightly wedge-shaped glasses (2°) so combined that the exterior surfaces are parallel to one another, but inclined to the interior operative surfaces. In this arrangement the false light is thrown somewhat to one side, and can be stopped by a screen suitably held at the place where the image of the electric arc is formed.

The formation of colour and the ultimate disappearance of the bands as the interval between the surfaces increases, depends upon the mixed character of white light. For each colour the bands are upon a scale proportional to the wave-length for that colour. If we wish to observe the bands when the interval is

[1] Abstract of a lecture delivered at the Royal Institution, on Friday, March 24, 1893, by Lord Rayleigh.