an opportunity of discussing the matter, came to the conclusion that the symptoms which had alarmed growers were attributable to bad cultivation and water-logging of the soil.

Since 1913 the experimental work commenced by Mr. Parnell at the now abandoned Indigo Research Station at Sirsiah has been continued at Pusa by Mr. and Mrs. Howard, whose work, as detailed in their First Report for 1914, has satisfactorily disposed of the unfounded dread that East African indigo had in India fallen a victim to some mysterious malady. In this and in their Second Report for 1915, the authors have further shown planters how a recurrence of the difficulties experienced since 1910 may be avoided, and have taught them that a treatment with which they were familiar as regards Malayan indigo calls for modification when the East African plant is in question. But they have done more than this; in the words of a writer in the *Allahabad Pioneer*, one result of the work of Mr. and Mrs. Howard is that "one bugbear of the Java indigo planter—the impossibility of obtaining good seed—is on the highway to being removed." The beneficial effect of their work, however, does not end here; in their Second Report they point out with a directness to which the planting community have not been accustomed, that the future of their industry in Bihar will depend on their ability to increase the yield of indigo from the plant. If the advice given in the Report for 1915 be followed, there may still be some hope as to the future in store for the industry, the object of which is the production of natural indigo. It is true, as the sympathetic writer in the *Pioneer* remarks, that many improvements will be necessary if this industry is to re-establish itself. The friends of the Bihar planter—he has, and he deserves to have, many—for years past have urged this necessity upon him, and it is but fair to say that he has taken the advice to heart. But his most genuine well-wishers have not hesitated to remind him that, so far, he has failed in one important particular—he has not recognised, as he might, his own limitations. His "associations" and his "syndicates" serve many legitimate and useful purposes. But the direction of research in connection with indigo has clearly not been their *métier*, and if the two Reports by Mr. and Mrs. Howard enable this truth to be realised they will have done good which should outweigh even the immediate material benefit which they confer on a singularly deserving community.

For his attitude towards the plant and its product the indigo-planter is not wholly to blame. The stranger can teach him little with regard to the cultivation of the particular plant with which he is familiar. To his colleague the chemist there is, after all, but one indigo. When the indigo-planter knows, as the botanist tells him, that among the forty kinds of tobacco, the twenty kinds of wheat which surround his dwelling, he has to do with but one species of *Nicotiana* and one of *Triticum*; when he observes that it is easy to find two tobaccos and two wheats differing in outward characters more markedly than any two indigo plants of his acquaintance do; it is scarcely surprising if he be influenced by a subconscious belief that, after all, the indigo plants may be only forms of one *Indigofera*, and that the treatment suitable for one may well serve for another. Nor is it quite certain that the botanist, whose task it is to keep the planter right, is always free from a similar unwitting prejudgment. The tangled synonymy with which the history of these tinctorial species of *Indigofera* is loaded, and the instinctive tendency to suggest that each new one may be a modified form of *I. tinctoria*, point to this possibility. That

this is not the case those who have grown the different tinctorial species together and have compared them at various stages of growth can testify; those who have made a critical herbarium study of the material available express the same judgment. Even in such as have not enjoyed these opportunities, a consideration of the history of these tinctorial indigos from a botanical point of view may perhaps induce a reservation of judgment. The hope of effecting this, and the desire to assist the planter to realise that the displacement of one indigo plant by another is nothing new and has never been unreasonable, may serve as an excuse for the *résumé* of these displacements here given.

RESEARCHES ON PHAGOCYTOSIS.

I.—Introduction.

ALTHOUGH the number of the white blood-corpuscles, compared with that of the red, is small (1 leucocyte to ± 350 red blood-corpuscles), the absolute number of them is rather considerable; for in the five litres of blood, which is the usual quantity for a man of normal size, there are 80,000,000,000 leucocytes.

A part of these leucocytes has, owing to their plasticity, the property of enveloping and in this way taking up all sorts of particles, as, for instance, coal-dust, grains, and also bacteria. It is because of this property that these cells, which have a diameter not larger than about 0.008 of a millimetre, have engaged our attention, especially since Metchnikoff has established that bacteria englobed by these cells are killed in them, and are thus made innocuous to our body. For this reason he has called them phagocytes (eating cells), and their process of eating *phagocytosis*.

The life of these cells deserves our interest; but until now it has not been, as such, the object of a systematic investigation, a fact Metchnikoff himself regretted in a paper he read some years ago to the students of the University of Amsterdam on "Réactions Phagocytaires."¹

Now I must confess that the importance of the phagocytes for the defence of our body against bacteria has not been the first and principal reason of my investigations with these cells: the principal reason was their being an excellent object for researches of a general biological nature.

I think a physiologist in the first place must practise science for its own sake, not asking whether his work may be of immediate practical use, but should he, however, accidentally stumble upon an idea which may be directly used for the bodily welfare of mankind, this should not prevent him from giving his attention to this; in fact, it is his duty to do so.

The phagocytes are a suitable object for studying life phenomena. In the first place, they are not such complicated organs as the muscles, heart, brain, etc.; they are simple cells, easily isolated. Secondly, it is possible to follow quantitatively the effect on their life of slight alterations of their natural medium.

It is obvious that the phenomena produced by the agency of solutions not dangerous to life are, in fact, nothing else but the effects of reactions which finally will help us to penetrate further into the physical and chemical structure of the living cell.

The investigations on the life of phagocytes, which during the last years have occupied myself and my collaborators, are a continuation of researches begun several years ago (1883) with the object of ascertaining the influence of salt solutions of various concentra-

¹ Nous ne sommes qu'au début. Lorsqu'on connaîtra mieux la physiologie des phagocytes, on cherchera des méthodes pour augmenter l'activité de ces éléments dans la lutte contre les microbes et on cherchera d'autres pour résister contre l'attaque des phagocytes les cellules nobles de notre corps.

tions upon the red blood-corpuscles, and of the significance of these results with regard to the functions of the body. These researches on the red blood-corpuscles, which introduced physical chemistry into medical science, were confined to the study of their chemical and volumetrical alterations.

But the influence of the salt solutions on the very life of the cells could not well be tested on those particular objects, although systematically investigated. We have felt this from the beginning, and repeatedly asked ourselves whether the solutions producing the chemical and volumetric changes of the red blood-corpuscles had or had not seriously damaged these cells, and thus, whether it was possible to apply the conclusions arrived at to problems regarding life itself. Therefore, wherever it was possible, we examined whether the phagocytes, being submitted to the same agencies, kept their phagocytarian power. This was always the case. This conclusion enhances the value of our researches on the red corpuscles, the more so because the chemical and volumetric alterations of the white cells corresponded with those of the red ones. But a systematic study of the life of the leucocytes had not, previous to our researches, been undertaken, and this is rather surprising.

II.—Method of Investigation.

Our method has been very simple. White corpuscles (leucocytes) from the blood of a horse are transferred to various media mixed with very small particles of carbon. After having stood some thirty minutes in an incubator at body temperature a great many of the cells have eaten up carbon. Microscopical preparations are made, and it is ascertained what percentage of the leucocytes has taken up carbon. *This percentage is the measure for the degree of phagocytosis and gives the value of the influence of the various agents used on that function of life.*

Suppose in examining 600 leucocytes lying in their natural medium (blood serum) I find that 300 of them have taken up carbon, the percentage of phagocytosis can then be expressed by $300/600 \times 100 = 50$ per cent. In order to examine, for instance, the influence of small amounts of acid, I add this substance to the serum and repeat the same experiment under the same conditions. I now find that of the 540 examined leucocytes only 200 have taken up carbon. The phagocytosis is now expressed by $200/540 \times 100 = 37$ per cent. Thus the addition of acid to the serum has lowered phagocytosis.

This calculation is based on the principle that the phagocytic power of the individual phagocytes present in a suspension is unequal, a fact which cannot be wondered at when we take into consideration that they are of different age. The more detrimental the action of the agent, the smaller should be the number of phagocytes which take up carbon in the same space of time.

Our selection of an indifferent substance such as carbon instead of bacteria, was based upon the fact that we otherwise feared our work would become too complicated. We here refer to the fact established by Sir Almroth Wright and his school that most kinds of bacteria, before they can be taken up by the phagocytes, must undergo a certain amount of sensitisation. Hence it follows that the intensity of phagocytosis will not only be influenced by the agent, as such, but also by the degree of "sensitisation" the particles have undergone. Another fact which had to be borne in mind was that the bacteria sometimes secrete poisons, which have an injurious effect on the phagocytosis. Even dead bacteria contain poisons.

The selection of carbon as an indifferent substance instead of the usual grains of carmine was based upon

the greater facility and accuracy with which the taking up of carbon can be ascertained. I shall not here give a detailed description of the method of obtaining the leucocytes, or of preparing the carbon, or of the method of determining the percentage of cells which have eaten carbon. I prefer to give some of the more striking results.

III.—RESULTS.

(1) *The Influence of Small Amounts of Calcium.*

In examining systematically the influence of the addition of small amounts of various salts (ions) to the blood-serum, it was found that very small quantities of calcium increased the phagocytosis to a considerable extent. An addition, for instance, of 0.005 per cent. of chloride of calcium (CaCl_2) to the natural medium (serum) caused an increase of about 22 per cent. in the phagocytic power. This favourable effect becomes even more strongly manifest when, instead of being added to the suspension of phagocytes in serum, the calcium is added to a suspension of phagocytes in a solution of chloride of sodium (common salt), in which phagocytosis occurs almost to the same extent as in serum.

These investigations have been continued in two directions. In the first place, we asked ourselves whether the influence of calcium would also manifest itself in the living body. All experiments had hitherto been made outside the body. It will be remembered that on placing under the skin (for instance, on the inside of the thigh of a rabbit) small capillary tubes, closed at one end and filled with an extract of bacteria in a solution of chloride of sodium, phagocytes enter these tubes. This phenomenon is called Chemotaxis, and is based upon the creeping movement of the phagocytes towards the excretions and secretions produced by the bacteria.

After a certain lapse of time, the open part of the capillary tube is filled with a white column consisting of phagocytes. If, in fact, calcium promotes the activity of the phagocytes, not only in the phagocytic process described above, but also in the living body, we argued it might be expected that by calcium that mobility of the cells, which here finds its expression in chemotaxis, would be accelerated. Therefore we determined the length of the white column formed in the capillary tube with animals, either treated with calcium or not so treated.

We expected to find that in rabbits treated with calcium the white column would after the same space of time be longer than in animals not having been treated with calcium. We have used two methods, which gave the same result. I will mention one only. It consisted in injecting into the rectum of two series of animals a solution of chloride of sodium mixed for one series with calcium, and for the other without calcium, and then examining the length of the column of phagocytes penetrating into the capillary tubes.

The difference between the two series was considerable. The calcium-rabbits showed the greatest degree of chemotaxis, although the amount of chloride of calcium used was very small, viz., 0.06 gr., a quantity corresponding with that given to man in mineral waters rich in calcium. Let us add that a natural mineral water used in our experiments gave the same results as the chloride of calcium solution.

What can be said of the mechanism of this effect? The calcium, on being absorbed by the mucous membrane of the rectum, enters the blood-circulation and by this is carried into the lymph of the tissue-spaces; where the glass capillary tubes are placed. The phagocytes which are there will soon undergo the stimulating influence of the calcium thus introduced, i.e. their mobility will be increased and chemotaxis will be promoted.

Even without measuring the length of the phagocyte columns, we may convince ourself that our conclusion as to calcium promoting the activity of the phagocytes is the correct one. On opening the skin wound, it is immediately seen that in the mineral-water-rabbits a much thicker mass of phagocytes is gathered round the tubes than in the pure sodium-chloride-rabbits. The same thing we observed invariably in all experiments where NaCl-solution containing calcium-chloride was injected.

Taking for granted that phagocytosis is playing a part in defence against microbes, we may infer from the above that an enrichment of our blood, and through this also of the lymph spaces, with small amounts of calcium must have a favourable effect on local and other infections.

There are many experiences supporting this view. I will mention only two examples. In the first place, Sir Lauder Brunton has used with great success chloride of calcium in pneumonia. Other clinicians have also met with success along the same lines; for instance, Crombie, who some years earlier, in the hospital of Calcutta, saw the mortality decrease from 38.6 to 5 per cent. He is inclined to attribute the influence of calcium to an action on the poison excreted by the pneumonia bacteria. But for this there is no evidence. Sir Lauder Brunton has recommended calcium for getting amelioration of the heart-action. In recovery from pneumonia the amelioration of the heart-action is of the greatest importance. So it was quite rational that the famous clinician and pharmacologist advised calcium for this purpose: in the first place, because it was pointed out by the work of Sydney Ringer that calcium is absolutely necessary for the heart-function, and, on the other hand, Langendorff and Hueck had found that by the injection of calcium into the circulation of a cat the action of the heart was considerably strengthened.

Sometimes it happens that during surgical operations the heart-beat is stopped by the inhalation of chloroform. The idea occurred to me that in this case calcium might be able to be of good service. Therefore I tried to improve the heart-action by intravenous injection of calcium in animals, which had been given purposely too much of the anæsthetic. I had no success; so I began to doubt whether calcium was really capable of stimulating even the normal heart. In a number of experiments I made I found that injection of calcium had no effect on the heart-beat of a normal animal. Studying the original article of Langendorff with renewed attention, I saw that he had performed only one experiment. His great reputation had given his assertion general acceptance, and so it had become a fact in the literature. Obviously the amount of calcium in the normal blood-serum provides already just the optimum quantity for the heart function.

Thus this favourable effect of calcium in pneumonia not being explained by the influence of calcium on the heart, we had to look for another reason. It was therefore most natural to remember the stimulating action of the calcium on phagocytes, which in pneumonia play such a preponderant part.

My second argument for the probability that calcium is of importance in infectious diseases is this: labourers in lime-kilns do not get tuberculosis; in Holland these workmen cover any wound they receive with lime.

The significance of calcium has for some time past been occupying the special attention of biologists and pathologists in an increasing degree, and I shall speak of it further now, and of the cause of the promoting of the activity of the phagocytes in phagocytosis and chemotaxis by calcium, only to make one remark. We might be inclined to attribute the increase of the

plasticity to a modification in the aggregation of the colloid-protoplasm-particle as a consequence of the electric charge caused by the entering of a number of bi-valent calcium ions into the cells. This explanation, however, can scarcely be the correct one here; for experiment shows that other bi-valent kations, namely, barium, strontium, and magnesium, do not augment the amoeboid motion, i.e. of phagocytosis and chemotaxis. It must be assumed, then, that the action of calcium in this case is based upon a hitherto unknown specific biochemical property of this metal.

(2) Influence of Iodoform on Phagocytosis.

Everyone knows that for the last thirty years iodoform has been successfully applied in the treatment of wounds and chronic inflammations. At first it was thought that this favourable effect was based upon an antiseptic action, but the idea was relinquished when it was found that lower organisms develop fully in a medium containing iodoform. Then other hypotheses were suggested, which need not be dwelt on. They are founded mainly on iodine being split off. None of these have proved satisfactory suggestions. For reasons unnecessary to state here, we have raised the question whether the favourable effect of iodoform on local infections may be due to the stimulating effect of this substance on phagocytosis. To answer this question iodoform solutions of different concentrations in a common salt solution of 0.9 per cent. were prepared and mixed with a thick suspension of white blood-corpuscles. After having added carbon particles, the mixtures were left to themselves for half an hour in an incubator at 37° C., and then cooled down. Finally, microscopic preparations were made and examined to determine what percentage of the total number of white blood-corpuscles had taken up carbon particles. The following table contains the results of the experiment.

Concentration of Iodoform Solutions in which the Effect on Phagocytosis is still perceptible.

Fluids	Percentage of leucocytes having taken up carbon Per cent.
NaCl 0.9 per cent. (common salt solution of 0.9 per cent.)	$\left. \begin{array}{l} \frac{171}{388} \times 100 = 44 \\ \frac{151}{345} \times 100 = 43.7 \end{array} \right\} 43.8$
1 iodoform to 100,000 NaCl 0.9 per cent.	$\left. \begin{array}{l} \frac{221}{374} \times 100 = 58.6 \\ \frac{226}{377} \times 100 = 59.9 \end{array} \right\} 58.2$
1 " 500,000 " "	$\left. \begin{array}{l} \frac{228}{371} \times 100 = 61.4 \\ \frac{208}{398} \times 100 = 52.2 \end{array} \right\} 61.4$
1 " 2,000,000 " "	$\left. \begin{array}{l} \frac{231}{445} \times 100 = 51.9 \\ \frac{292}{621} \times 100 = 46.9 \end{array} \right\} 52$
1 " 5,000,000 " "	$\left. \begin{array}{l} \frac{176}{374} \times 100 = 47.3 \end{array} \right\} 47$

This table shows that, in the pure salt solution, of the 388 examined leucocytes 171 have taken up carbon, i.e. 44 per cent. In a parallel experiment the percentage was 43.7 per cent. Thus the average was 43.8 per cent. In the salt solution containing iodoform in a proportion 1 gr. iodoform to 100,000 gr. NaCl solution, the percentage in two parallel experiments was 58.6 and 59.9; average 58.2 per cent. Evidently the iodoform promoted phagocytosis.

These and other parallel experiments illustrate also the exactitude of the method. As a matter of course, control experiments have been made in all cases.

Further, it appears that a weaker solution of iodoform (1 : 500,000) yields a still higher phagocytosis (61.4 per cent.). The explanation of this phenomenon will afterwards be given. It is seen that in still weaker concentrations the phagocytosis is diminished, but even in a solution of 1 iodoform to 5,000,000 salt solution, the promoting effect of iodoform is still perceptible, for it is 47.1 per cent., whereas in a pure NaCl solution it was $\frac{1}{3}(44+43.7)=43.9$ per cent.

The favouring effect of iodoform is still more evident when the leucocytes are placed for several hours in a pure NaCl solution. Then the phagocytosis falls to a considerable extent. Sometimes the phagocytes are quite paralysed. The addition of iodoform in a concentration 1 : 5,000,000 then raises the phagocytic power by 30 per cent. or more. Thus there is no doubt that iodoform is able to promote phagocytosis. *Is it the iodine or the iodoform as such?* We have found that iodine is noxious in a high degree. We must conclude, therefore, that iodoform as such causes the increase of the phagocytic power.

The question now suggests itself: How can the favourable effect of iodoform be explained? It may be accepted from numerous investigations that the outer layer of the cells consists of a fatty substance, a so-called lipid membrane. Now iodoform is soluble in fat, and it is quite obvious that such a membrane will grow more soft and more flexible after having absorbed iodoform, and that consequently the plasticity and mobility will be facilitated.

If this interpretation be correct, then other substances soluble in fat, such as chloroform, chloral, alcohol, benzine, camphor, fatty acids (propionic, butyric acids) should affect phagocytosis in a similar way. This is found to be invariably the case.

(3) Effect of Chloroform, Alcohol, Camphor, Benzine, and other Substances Soluble in Fat on Phagocytosis.

I shall not give an account of all our experiments made in this direction. I only give as an example an experiment with chloroform, from which one can at once get an idea as to the exactitude of the method. It was soon found that dilutions 1 : 2000, 1 : 6000, and also 1 : 10,000 paralysed the phagocytes. The following table contains some experiments with weaker solutions:—

Effect of Chloroform on Phagocytosis.

Fluids	Percentage of leucocytes having taken up carbon	
	Per cent.	
NaCl 0.9 per cent.	$\frac{174}{428} \times 100 = 40.6$ $\frac{238}{562} \times 100 = 41.2$	40.9
Chloroform 1 : 20,000	$\frac{244}{480} \times 100 = 50.8$ $\frac{225}{451} \times 100 = 49.8$	50.3
„ 1 : 100,000... ..	$\frac{254}{519} \times 100 = 60.6$ $\frac{382}{455} \times 100 = 60.1$	60.3
„ 1 : 500,000... ..	$\frac{332}{582} \times 100 = 57$ $\frac{219}{370} \times 100 = 59.1$	58
„ 1 : 5,000,000	$\frac{379}{868} \times 100 = 43.6$ $\frac{298}{661} \times 100 = 45$	44.3

From this table it appears that chloroform 1 : 20,000 raises the phagocytosis power from 40.9 per cent. to 50.3 per cent.; further, that phagocytosis

is considerably increased by chloroform 1 : 100,000, in which case it rises to 60.5 per cent. Evidently in the chloroform-solution 1 : 20,000 the paralysing influence also makes itself felt. In a dilution of 1 : 500,000 the favourable effect remains to about the same extent as in 1 : 100,000, and finally in a solution of 1 chloroform to 5,000,000 NaCl-solution, this favourable effect is still visible, though slight.

Similar results were obtained with benzine, camphor, turpentine, alcohol, chloral, fatty acids (propionic and butyric), and also Peruvian balsam. These all, without exception, promoted phagocytosis. Hence our hypothesis for explaining the effect of iodoform was fully confirmed. Another strong support to our hypothesis was obtained by comparing the concentrations of the named substances which were able to increase phagocytosis. It appeared that the relation between these concentrations corresponded with that existing between the solubility of these substances in fat.

Further, all the substances applied in very small doses showed a stimulating effect, but paralysed when given in greater quantities. This can be explained by distinguishing two factors. First, slight quantities of the substance by dissolving in the outer layer of the cell weaken it and increase the plasticity and mobility. Then, greater quantities having entered the cell, a second factor, the paralysing effect on the protoplasm, comes into play. As the amount of chloroform is increased, the paralysing effect gets the precedence and no carbon at all is taken up.

4. Other Phenomena seen in the Light of the Foregoing Facts.

The effect of fat-dissolving substances on phagocytes throws a new light on several facts which were until now for the most part entirely unexplained. In the first place, we may refer to the power of turpentine to cause local exudations, and the favourable effect of a subcutaneous injection of the same substance in the treatment of pneumonia with horses and of mastitis with cows, which for some time has been practised with great success in France, Denmark, and Holland. Experiments made by us in this direction have shown that there is much reason to attribute this effect to very small quantities of turpentine dissolving in the lymph of tissue-spaces and afterwards entering the blood circulation and promoting the phagocytic power of the phagocytes in lung and udder.

In the same way we can explain the marked effect of camphor-treatment in inflammatory processes of the uterus and its adnexa, an effect not understood hitherto. Then there is the great effect of covering infected wounds with "balsam of Peru," the therapeutic value of inhalation of turpentine-vapour in tuberculous and other infectious processes in the respiratory organs.

In all these cases a stimulating action on the phagocytes, and probably also on other cells (granulation-cells), which play a part in the healing process, may come into play. Yet more becomes clear to us from the above researches.

It is well known that various narcotics applied in smaller doses have a stimulating effect and paralyse in greater quantities. Engelmann observed this many years ago on ciliated cells, but he did not try to explain it. Also as regards the nervous system we know with regard to chloroform and ether that, when administered, they first cause excitement and afterwards insensibility. So far as we know, this contrast has never been explained, but when viewed in connection with our experiments, the phenomenon becomes clear. In the beginning of narcosis only small quantities have entered into the nerve cells. The consequence is a softening in the first place of the outer layer. This weakened state of the cells produces an

increase of activity (amoeboid motion?). Later, when a greater amount of the substance has been taken in, the paralysing effect gets the upper hand. With alcohol the same experience is well known.

In following this point we are led to think of the remarkable influence of a sojourn in high mountain regions, on metabolism, on sleep, and on the state of the mind. The cause is entirely unknown. It has been proved that these phenomena are not due to the height as such, for in balloons they do not occur, nor are they found in high mountain regions, but when examining where they are observed, we find that it is in the neighbourhood of coniferous woods. So we are inclined to think that it is due to the stimulating effect of the odour of resin (turpentine, etc.) on the nerve-cells.

Prof. Sherrington and Miss Sowton, in their studies on the dosage of the mammalian heart by chloroform, found that, especially with greater amounts of the drug, it was usual for the first effect of the administration to be a distinct though slight increase in amplitude of the contractions. After cessation of the administration of the drug in moderate dose, it was not unusual before the recovery of the beat for the heart to pass over for a short time into a condition of super-activity. These phenomena suggest an irritative excitatory effect of small doses of the substance on muscle or nerve-fibres (or both) of the heart. These results agree with those previously obtained by Prof. A. D. Waller in his experiments with the isolated nerve.

There are experiments also with other organs which may be considered in the same light. Thus Prof. J. Loeb discovered that substances dissolving fat have the power of rendering possible the parthenogenetic development of eggs. Now we may imagine, with Loeb, that the substance dissolves in a lipid of the outer layer of the egg, thus giving rise to the formation of a fertilising membrane. We think we may safely go one step further and assume that it is owing to the weakening of the membrane that the movement of the protoplasm underlying every cell division manifests itself. This view is confirmed by the observation of Prof. R. S. Lillie, who saw also that by a short transitory raising of the temperature in the eggs of starfishes a typical fertilising membrane may be formed, which formation is followed by the development of part of the eggs into larvæ. J. Loeb was able to confirm this for *Medusa*.

After consideration of the foregoing facts and suggestions, we were inclined to think that the stimulating effect of traces of substances which dissolve fat on the activity of cells is a widespread phenomenon. Hence we have investigated whether this influence might also be seen in *plant-cells*. To do so, we chose the germination of seeds, a process in which a considerable division and growth of cells manifests itself. The seeds we chose were grains of wheat, and for the fat-solvent we took chloroform. With chloroform, 1 part to 100,000, an important acceleration in the germination was observed; chloroform 1 to 1000, on the contrary, impaired the germination, evidently because a second factor made itself felt, viz. paralysis of the protoplasm. Later I heard that in practice the growth of snowdrops is promoted by ether. In recent times Chiari succeeded in forcing blossoms to a considerable extent by ether-vapour, and Mansfield the germination of pumpkin-seeds by vapour of alcohol and ether.

Hence it is clear that the observations on phagocytosis deserve our attention on general grounds as well as special. We do not at all mean to say that all substances dissolving fat have the same effect on cells of all kinds; far from it. I would emphasise

that, in order to be brief and to avoid complexity of detail, I have here presented the matter somewhat simpler than it really is. Nor have all the suggestions here made towards explaining facts regarding other cells than phagocytes been actually proved. Without hypothesis, science cannot progress. Fortunately we need not stay in error for long, for we can always appeal to the supreme judge, experiment.

This account of results and views, the fruit of some years' work with several collaborators (Hekma, de Haan, etc.),² being of necessity incomplete, I have attempted to select what may specially interest the general scientific reader.

We are continuing our study of the biology of phagocytes, and each day we become more convinced of their excellence as a simple object, for the study of problems of a general biochemical nature, and for some of practical interest as well.

H. J. HAMBURGER.

IRELAND'S INDUSTRIAL OPPORTUNITIES.

A LECTURE delivered in April last before the Insurance Institute of Ireland by Mr. George Fletcher, the assistant secretary of technical instruction, and recently issued in pamphlet form, deserves the serious attention of all well-wishers of Ireland. We have in Ireland a population little more than half of what it was in 1841, and which is now annually depleted by emigration to such an extent that any increase in its population is well-nigh impossible.

It is obviously, therefore, of the highest possible importance to the well-being, not merely of Ireland, but also of the kingdom generally, that means should be taken to ensure the utmost development alike in agriculture as in manufactured products, since it is now clearly realised that it is only by a combination of both that the well-being of Ireland can be firmly established.

The Department of Agriculture and Technical Instruction established in 1899, mainly through the strenuous efforts of Sir Horace Plunket, the first vice-president, has done much for the promotion of agriculture and its products and of manufacturing industry. Improved methods have been introduced into farming, fishery, and industrial operations, especially in the latter case by the encouragement of cottage industries, with a view to find employment for the rural population in times and seasons not devoted to agricultural work, and with a view also to add to the interest of an otherwise monotonous life.

Large sums have been spent as a result of local and Governmental effort in the promotion of technical education, with the result that now practically all over Ireland facilities exist for the due training of the workers engaged in agricultural and industrial pursuits. At the same time, the Department has persistently urged the necessity, if technical training is to be of any real value, of a better and more pervading system of elementary and secondary education upon which to found it, and also for the reason that it is desirable to widen by means of a sound general education the mental horizon of the people.

Believing that no permanent good can be ensured except by the co-operation of the people themselves, it has been the aim of the Department to encourage the formation of associations of farmers and manufacturers, so as to secure a sense of solidarity and of common effort.

² A full account of the researches as far as the year 1912 can be found in my monograph "Physikalisch chemische Untersuchungen über Phagozyten. Ihre Bedeutung vom allgemein biologischen und pathologischen Gesichtspunkt." (Wiesbaden: J. F. Bergmann, 1912.)