chased for 50 francs. The volumes form a very mine of recent information, for in addition to the original papers important discussions on them are recorded in full.

REPORTS AND ANALYSES

AND

DESCRIPTIONS OF NEW INVENTIONS

IN MEDICINE, SURGERY, DIETETICS, AND THE
ALLIED SCIENCES.

MEDICINAL AND DIETETIC PREPARATIONS.

Banana Malted Food.—A preparation called "Boyd's Banana Malted Food," and stated to be a combination of banana meal, wheat flour, "wheat phosphates," and casein, is put forward as a specially suitable food for children and for dyspeptic adults. The inventors urge that all travellers in the tropics concur in praising the nourishing properties of cooked bananas, which form in some parts of the world practically the staple food of the people. We are told that "in composition the banana is similar to the potato except that in the former sugar and dextrine take the place of the starch of the potato, and is therefore more nourishing than the latter." It is now admitted that there exist physiological differences in starches and sugars derived from various plants, as shown in their greater or less capacity for being assimilated, so that it is possible the banana may possess advantages over other farinaceous substances. Our analysis of pure banana meal gives the following results:

	Per cent.
Moisture (212° F.)	10.00
Mineral matter... ..	2.40
Nitrogenous matter	4.66
Fat	0.70
Carbonaceous substances (mainly starch) 82.24	

The proportion of the meal soluble in cold water after twelve hours' maceration was 8 per cent. The examination of the meal under the microscope shows that practically all the granules turn blue on the addition of iodine, so that we can hardly regard it as a fact that the starch of the banana is for the most part converted into sugar and dextrine. It is, however, quite possible that banana starch does possess a higher nutritive value than other starches with which we are more familiar, but this is a question which must be decided by clinical experience. The preparation can be obtained from the Medical and General Specialities Company, 300, Clapham Road, London, S.W.

MEDICAL AND SURGICAL APPLIANCES.

Set of Trocars and Cannulae for Empyema.—Mr. WILLIAM TURNER, M.S.Lond, F.R.C.S., Senior Assistant Surgeon, Westminster Hospital, writes: Messrs. Arnold and Sons, London, have made for me a set of special trocars and cannulae for use in certain cases of empyema. They are flattened from side to side

and not circular as usual in other trocars, to enable them to pass through an intercostal space with greater ease. The cannulae are made of silver, and can be left *in situ* for ten days if necessary. The trocars are of very hard steel, and in

consequence of their shape the end and the cutting edge project further than in the ordinary form. To minimize the danger to deep parts when the instrument is used each cannula is fitted with a movable shield, being fixed at any depth by a screw as in Durham's tracheotomy tube. The shape of the shield is similar to that of a bivalve tracheotomy tube, but is perforated by two long slots placed in such a manner that whatever be the inclination of the ribs the tube can be kept in position by tapes threaded through these slots and passed straight round the chest. The set consists of three, with one handle which screws into all the trocars. The sizes are as follows: (1) Small, $\frac{1}{8}$ in. by $\frac{1}{2}$ in. and $1\frac{1}{2}$ in. long; (2) medium, $\frac{1}{4}$ in. by $\frac{3}{8}$ in. and $1\frac{3}{8}$ in. long; (3) large, $\frac{3}{8}$ in. by $\frac{1}{2}$ in. and $1\frac{3}{8}$ in. long. The sizes of the cannulae are inside measurements; the length is the effective length, namely, from the shield to the end of the cannula. The chief use I have put this instrument to, and have found it act extremely well, is to drain an empyema after incision of the skin under eucaine administered hypodermically in those cases where the administration of a general anaesthetic is especially dangerous on account of the condition of the patient.

A Bed-Rest.—The special features claimed for the "Princess Christian" bed-rest are its portability and its adaptability to any degree of recumbency of a person in bed, on a couch, or mattress, or lying on a rug on deck, in the garden, or on the beach. It consists of a light wooden, adjustable framework on which canvas is stretched, and a padded foot-rest i

attached to the framework by straps in such a way that the user is prevented from slipping down. It can readily be cleaned, and in district nursing can easily be carried from house to house. It is supplied by the patentee Miss L. Ealand Todd, of 31, Grosvenor Terrace, York, at prices ranging from 25s. to 31s. 6d. A small size can be made for children's cots.

A SUMMARY AND ANALYSIS OF RECENT OBSERVATIONS AND THEORIES

AS TO

THE PROCESSES OF INFECTION AND PROTECTION IN THE ORGANISM.

By H. W. ARMIT, M.R.C.S.Eng., L.R.C.P.Lond.,

(Continued from 786.)

II.—BACTERIOLYSIS AND HAEMOLYSIS.

Lysin Action.

IN the majority of infective processes, to wit, those which spontaneously come to an end, the natural termination depends on the manufacture of antitoxin, and a concurrent arrangement for the destruction and removal of the bacteria. Pfeiffer⁷ discovered that the latter process depends on the production of a body which is capable of dissolving the bacteria, and which is known as bacteriolysin. He found that if cholera vibriones were introduced into the peritoneal cavity of a guinea-pig immunized by increasing doses of the vibrio, the micro-organisms were immediately dissolved *in situ*. This also occurs under various modifications. Metchnikoff⁸ showed that when the serum of the immunized

⁷ Pfeiffer, *Deut. med. Woch.*, 1896, Nos. 6 and 7.

⁸ Metchnikoff, *Ann. de l'Inst. Pasteur*, June, 1895.

guinea-pig, a small quantity of the peritoneal exudation and the vibriones are brought together in the test tube, the same solution takes place. Bordet⁹ further showed that the experiment could be carried out without any peritoneal exudation, provided that the serum be fresh, and that if older serum be used, and no solution resulted, the addition of the serum of a normal guinea-pig would bring about the solution. Pfeiffer (loc. cit.), following the subject up, came to the conclusion that the immune serum contains a body which produced the first stage of the bacteriolysis, and that a "something" existed in normal serum which is capable of completing the solution, and possesses a ferment-like action.

To understand the processes of bacteriolysis, and, in fact, to demonstrate by analogy the correctness of the side-chain theory, it is necessary to study these changes minutely. This was rendered possible by the happy discovery by Bordet¹⁰ that the injection of defibrinated rabbit's blood into guinea-pigs leads to the appearance of a body in the serum of the guinea-pig which is capable of dissolving rabbit's red blood corpuscles.¹¹ This body is called haemolysin, and since its action—as far as it could be ascertained of bacteriolysin—is analogous to the latter, Ehrlich and Morgenroth¹² have studied the various phenomena which take place both in artificial and acquired haemolysis. The subject is complicated, and the interpretation of many of the appearances have been so varied that in order to gain a clear idea of the process each set of phenomena must be separately considered and the opposing arguments stated as briefly as possible. All the workers have adopted almost identical methods, and the technique of each experiment is so clearly detailed in nearly every report that it will be unnecessary, as a rule, to give an account of these details.

Ehrlich and Morgenroth found that normally haemolysis artificially produced by the injection of the blood of an animal of one species (A) into the subcutaneous tissue of an animal of another species (B), whereby the serum of B is rendered capable of dissolving the erythrocytes of species A, depends on the presence of two bodies, one of which is specifically produced by the injection and is heat-resisting, and the other is normally present in the serum of the animal and is destroyed by heat. The first he names "amboceptor," or immune body, and the second "complement."¹³ Some immuneserums appear to exercise an agglutination of the red cells immediately before the lysis action. This has nothing whatsoever to do with the haemolysin, and is due to a specific agglutinin,¹⁴ which is not disturbed by heating to 55° C. Agglutinin is also occasionally present in bacteriolytic serums, though this is by no means a constant find.¹⁵

Immune Body or Amboceptor.

According to the side-chain theory, if a toxin, a toxoid, a ferment, a portion of a bacterium, or of a red blood cell has the capability of joining with the side chains of the protoplasm, the production of an antibody must be possible. In the case of toxin we are dealing with a soluble body, the substance produced by it joins with the soluble antibody, and the chemical combination takes place in solution. But in the case of the red blood corpuscle, we are dealing with a body not directly soluble, which produces an originally insoluble substance: when it joins the antibody, which is dissolved in the blood, it takes the latter out of solution and anchors it to the cell. To apply this reasoning to haemolysis, the immune body (amboceptor) must be anchored to the red cell. This

was proved to be the case by Ehrlich and Morgenroth¹² (II). A mixture of sheep's blood cells and a haemolytic serum of a goat, rendered inactive by heating to 56° C., was centrifugalized, and the fluid and sediment were separately tested. To the former fresh sheep's blood cells were added as well as normal serum (complement), but no solution resulted; therefore there was no immune body in the fluid. To the sediment was added normal serum, and complete solution resulted. The immune body is anchored by means of a definite affinity toward the red cell, and therefore is not a mere absorption process. Later on it will be shown that the combination takes place as a stereo-chemical combination, and not as a "level attraction," as is the case with carbon compounds. The junction of two bodies in the former case is much firmer than in the latter, and they cannot be separated by attraction from other bodies.

Haptophoric Group: Receptor.

The immune body, therefore, joins with the cell chemically, and this can only be carried out by means of suitable and corresponding atom groups. The group of the immune body is called the haptophoric group and the group of the red cell molecule the receptor. Ehrlich proved experimentally that the complement was incapable of directly attaching itself to the red cell, and that its influence could only be exerted through the intermediation of the immune body. To 5 c.cm. of a 5 per cent. suspension of sheep's blood cells in saline solution 1.3 c.cm. of inactive (heated) immune serum (serum of a goat, injected previously with sheep's blood) and 10.5 c.cm. of normal goat's serum quantities of inactive immune and active normal serum just sufficient to dissolve all the blood cells used, were added at a temperature between 0° and 3° C. The immune body was anchored to the red cell but no solution of the corpuscles took place. The mixture was warmed after centrifugalization, and the sediment suspended in saline solution was tested, as was the fluid. It was found that the blood cells had an excess of immune body and only a little complement anchored to it, while the fluid contained scarcely any immune body but an excess of complement. The deduction from this and many other observations of a similar nature is that the immune body is endowed with

SCHEMATA (after Ehrlich).

Fig. 1.—Normal haemolysin. The above figure represents the anchoring of the haemolysin to the cell, in a purely pictorial form.

another atom group, which corresponds to an atom group of the complement, and which possesses a certain affinity for the latter. The affinity between immune body and complement, however, is much less strong and less regular than that existing between the former and the red cell. It therefore appears that the immune body possesses two atom groups—one a haptophoric cytophile group of greater and the other a complementophile group of less affinity. For this reason Ehrlich speaks of it as amboceptor.

Complement.

The complement is a ferment-like body easily altered by heat, and possesses an atom group (haptophoric) corresponding to the complementophile group of the amboceptor, and a zymotoxic group analogous to the toxophoric group of the toxin (see schema). The action of the complement in haemolysis, although in some respects like that of the toxin, differs from it, inasmuch as the latter corresponds, chemically speaking, with a more simply constructed side chain (the receptor). The giant protoplasmic molecule can only be taken up by such a receptor when split into chemical fragments by the action of some ferment. In the case of haemolysis the receptor is of a much more complex construction, and is only reached by the complement by means of an

⁹ Bordet, *Ann. de l'Inst. Pasteur*, June, 1895.

¹⁰ Bordet, *ibid.*, vol. xii, No. 10.

¹¹ When this serum is heated to 55° C. no solution takes place, but on the addition of normal guinea-pig's serum the power of solution reappears, in analogy to the reactivizing of bacteriolysin.

¹² Ehrlich and Morgenroth, *Zur Theorie der Lysinwirkung*, I, *Berl. klin. Woch.*, No. 1, 1899; Ueber Haemolysine, II, *ibid.*, No. 22, 1899; III, No. 21, 1900; IV, No. 32, 1900; V, No. 10, 1901; VI, Nos. 21 and 22, 1901.

¹³ In order to prevent confusion, only these names will be adopted until the views of Buchner, Bordet, Gruber, and others are discussed, when the terms "substance sensibilisatrice" and "preparator" will be used for the former, and "alexin" for the latter. Ehrlich at first distinguished between intermediate body of natural and immune body of artificial haemolysis. Buchner speaks of this as helping body (*Hilfskörper*) and Metchnikoff as phagocytosis. Ehrlich at first spoke of the ferment-like body as addiment, and later as complement. Buchner and Bordet introduced the name alexin (protective substance) before Ehrlich published his views on haemolysis, when they were dealing with the early bacteriolysis investigations.

¹⁴ Gruber, *Wien. klin. Woch.*, No. 12, 1896.

¹⁵ Pfeiffer and Koller, *Centralbl. f. Bakt.*, vol. xx, Nos. 4 and 5, 1896.

amboceptor of definite constitution. The whole side chain in this case can take up and dispose of the giant molecule. It has been found experimentally that different serums contain complements which differ from each other, that some have the same complements in common with other serums, and that most serums contain a large variety of complements. Ehrlich and Morgenroth¹² (II) obtained a haemolytic serum of a goat, immunized with sheep's blood, which possessed a complement that could not be rendered inactive by heating to 55° C. The complement and amboceptor were both found tied to the red blood corpuscle, after twenty-four hours at 0° C., when tested by centrifugalization. The addition of hydrochloric acid was found to render the serum inactive—that is, destroy the complement, and normal goat's serum was found to contain a suitable complement, which was capable of rendering the amboceptor again active. Thus they were enabled to demonstrate two very different forms of complement—one a thermo-unstable and the other a thermo-stable; the former is usually present, but in a number of goats they found varying quantities of the latter, as well as (in some cases) the former. The varieties of complement can also be shown by its specificity. If an animal of Species A be immunized by the blood of Species B, and the serum of A be rendered inactive by heating, it can be made active again by the serum of normal animals of Series A, and at times of C, E, etc., but not by that of Species D. The existence of two forms of complement in one serum can be demonstrated by the following experiment:

Normal goat's serum is capable of dissolving both guinea-pigs' and rabbits' blood cells. The inactive serum of a goat can be made active by normal horse's serum. Normal horse's serum contains no amboceptors, but only complement. If normal goat's serum be passed through a Pukall's filter, and the filtrate be tested separately on the two kinds of red cells, it appears that, whereas the serum is still capable of dissolving guinea-pig's erythrocytes—just as unfiltered serum is—its power towards the rabbits' cells is greatly diminished. The addition of horse's serum completes the solution, but the addition of amboceptor produces no change.

It is clear, therefore, that the complement in the goat's serum, specifically active towards rabbit's blood cells, is kept back in the filter, while the complement, specific towards guinea-pig's blood cells, can pass through it. Thus there are two forms of complement in goat's serum (normal), and, since inactive goat's serum can be rendered active by normal horse's serum, these two forms are also present in horse's serum.

Anticomplement.

According to the side chain theory, when the complement of one species is introduced into the organism of another species, an antibody must be formed. Von Düngrn¹⁰ found that if bacteriolysin, derived from a certain animal, be introduced into the tissues of another animal, the cells of the new host are capable of interfering with the complement and rendering it inactive. Ehrlich and Morgenroth (fourth communication),¹² and Bordet¹⁷ found that this and analogous appearances in haemolysis were due to the formation of an anticomplement. The serum of a goat which has received injections of the serum of a horse (which is very rich in complements) contains a body which neutralizes the

Fig. 2.—Anticomplement.

action of haemolysin. That this is due to anticomplement can be shown by the fact that if rabbit's red blood cells are brought into contact with inactive goat's serum,¹⁸ and excess of inactive antiserum,¹⁹ and the mixture be centrifugalized, it

¹⁰ Von Düngrn, *Münch. med. Woch.*, No. 20, 1900.

¹⁷ Bordet, *Annal. de l'Inst. Pasteur*, May, 1900.

¹⁸ As has been stated, normal goat's serum contains normal haemolysins, active toward rabbit's and guinea-pig's blood.

¹⁹ The antiserum in an active state contains complement as well as anticomplement. By heating to 56° C. the former can be removed, and this is done in order to free the original mixture from all traces of this body.

will be found that the sediment will be dissolved by the addition of normal horse's serum. The antiserum is, therefore, incapable of attacking the sediment, which contains red cells and amboceptors, but can only act by diverting the other part of haemolysin, that is, the complement.

It has been shown that the complement possesses two atom groups, a haptophoric and a zymotoxin. The anticomplement must anchor itself to the haptophoric group, for if it anchored itself to the zymotoxin group, the addition of fresh complement would be incapable of joining the complementophile group, which is not the case. The dissolving dose of amboceptor (inactive serum) was brought into contact with a given quantity of erythrocytes, and the dissolving dose of complement together with a neutralizing dose of anticomplement was added. The sediment, obtained by centrifugalization, was saturated with fresh complement, and was completely dissolved. The complementophile group of the amboceptor was, therefore, not anchored to the haptophoric group of the complement, as would of necessity be the case if the anticomplement were attached to the zymotoxin group.

Since it has been shown that the complements exist in great variety, and that not only different species may have different complements, but the same animal frequently contains a large number of different complements, the possibility of a large number of anticomplements must be admitted. The partial analogy of the complement to the toxin has been pointed out, and another instance of this occurs in the formation of antibody. Just as the complement and toxin are specific ferment-like bodies, each acting only when in the presence of a group, adapted solely for itself, it must be accepted that the anticomplement, also, is a truly specific body.

Complementoid.

The analogy between complement and toxin can be carried further. Both in haemolysis and bacteriolysis thermic and certain chemical influences inhibit the dissolving action. That this is due to the destruction of the zymotoxin groups (the carriers of specific action) can be shown experimentally. By heating a serum to 60° C. for fifty minutes, it is found to be free from all traces of complementing action, but an anticomplement can be produced and its presence demonstrated. Ehrlich and Morgenroth prove this by various experiments. One of these is as follows:

A dog was injected with inactive goat's serum, and the inactive complement formed an anticomplement, which was capable of diverting a somewhat larger dose of active complement than was neutralised by the control anticomplement obtained by injecting a dog with active goat's serum.

The altered (heated) complement is the analogue of the altered toxin, which has lost its activity and is called toxoid. Ehrlich, therefore, calls the former complementoid. Now, since the zymotoxin group is alone absent in complementoid, it would be expected that the haptophoric group would anchor itself to the complementophile group of the amboceptor, and thus prevent all possibility of its being again made active, but this is shown not to be the case. The affinity between the complementophile group of the amboceptor and the haptophoric group of the complement is not great, and the explanation of this phenomena is that by the destruction of the zymotoxin group this slight affinity is greatly lessened or even destroyed. Neisser and Wechsberg²⁰ have shown that the same loss of affinity takes place in the toxoid of staphylococcus, but Ehrlich²¹ found that with the toxoid of diphtheria bacilli no loss of affinity can be ascertained.

(To be continued.)

HOUSE-TO-HOUSE VACCINATION IN AMERICA.—Free vaccination from house to house by a corps of 134 physicians sent out by the Board of Health has been instituted in Boston, U.S. The districts were divided into sections and a physician assigned to each. Little opposition was encountered.

AN ARSENIC FIND IN AMERICA.—A mountain of arsenic has been discovered fifty miles south-east of Tacoma, Washington. This is claimed to be the first important body of arsenic ever found in America. The supply heretofore has come from Cornwall. The United States now imports nearly £200,000 worth yearly.

²⁰ Max Neisser and Wechsberg, *Münch. med. Woch.*, No. 37, 1900.

²¹ Ehrlich, *Werthbestimmungen des Diphtherieheilsersums*, *Klin. Jahrs.*, 1897.