Smith, Geoffrey. 1912. Studies in the experimental analysis of sex. Part 9. On spermatogenesis and the formation of giant spermatozoa in Hybrid Pigeons. Quart. Journ. Micro. Sci. 58: 159—170. pl. 8.

Stomps, Theo J. 1911. Kernteilung und Synapsis bei *Spinacia oleracea* L. Biolog. Centralbl. 31: 257—309. pls. 3.

— 1912 a. Die Entstehung von *Oenothera gigas* de Vries. Ber. d. d. Bot. Gesellsch. 30: 406—416.

— 1912 b. Mutation bei *Oenothera biennis* L. Biolog. Centralbl. 32: 521—535. pl. 1. fig. 1.

Strasburger, Eduard. 1910. Chromosomenzahl. Flora 100: 398—446. pl. 6.

Tahara, M. 1910. Über die Zahl der Chromosomen von *Crepis japonica* Benth. Bot. Magazine 24: 23—27. pl. 2.

Tischler, G. 1910. Untersuchungen über die Entwickelung des Bananen-Pollens. I. Arch. f. Zellforsch. 5: 622—670. pls. 30—31. figs. 4.

Wiemen, H. L. 1910. A study of the germ cells of *Leptinotarsa signaticollis*. Journ. Morphology. 21: 135—207. figs. 73.

Wilson, Malcolm. 1911. Spermatogenesis in the *Bryophyta*. Annals of Botany. 25: 415—457. pls. 37—38. figs. 3.

Wilson, E. B. 1909. Studies on chromosomes. IV. Journ. Exptl. Zool. 6: 69—99. pls. 2. figs. 2.

On the Occurrence of Dextro-rotatory Albumins in Organic Nature.

By **John Beard D. Sc., Edinburgh.**

Twenty-four years ago the discovery of a transient nervous apparatus in the developmental histories of certain fishes directed my attention to the problems of alternation of generations in general, and of antithetic alternation in particular. Research in the intervening years was devoted mainly to the unravelling of the thread of animal development regarded as based in such an antithetic alternation of asexual and sexual generations. A review of the problems, which occupied the investigator during these years, and of their solutions, cannot be given here: the finds are recorded in the literature of science and most of the salient points may be found in detailed form in the memoirs, cited below[1]). These com-

1) Beard, J. The History of a Transient Nervous Apparatus in certain Ichthyopsida: An Account of the Development and Degeneration of Ganglion-Cells and Nerve-Fibres, Part I. *Raja batis*, in: Zool. Jahrbücher, Morph. Abteil., Vol. 8, with eight Plates, 1896.

idem. On Certain Problems of Vertebrate Embryology, Jena, Gustav Fischer, 1896.

idem. The Span of Gestation and the Cause of Birth, Jena, Gustav Fischer, 1897.

idem. A Morphological Continuity of Germ-Cells as the Basis of Heredity and Variation, in: Review of Neurology and Psychiatry, Vol. 2, 1904.

idem. The Enzyme Treatment of Cancer, London, Chatto & Windus, 1911. See also Haydon, W. T. — The "Biogenetic Law" considered in relation to an Antithetic Alternation of Generations in the Metazoa, in: 26th Annual Report of the Liverpool Science Students' Assoc, 1907.

mence with "The History of a Transient Nervous Apparatus" and end in "The Enzyme Treatment of Cancer".

To the investigator, groping slowly along an untrodden path, it was of very great value, when, in 1907, it was recognised, that the antithetic alternation of generations, which by observation had been found to underlie the cycle of animal development, was in reality based in the same antithesis of isomeric compounds of carbon as that laid bare by the epoch-making researches of Pasteur. These, as is well known, culminated in the foundation of a science of stereochemistry. Since 1860 stereochemistry has been advanced by the researches of many chemists, and here of these the names of Le Bel, van't Hoff, Wislicenus, and Emil Fischer need alone be mentioned.

Modern Embryology, like modern Zoology in general, has concerned itself little with Chemistry. As can be perceived now, many questions, which have troubled embryologists and zoologists, might have been settled easily once and for all and long ago, had the contending investigators occupied themselves with the problem of the true chemical nature of the animal under discussion, instead of assuming, that, of necessity, all animals were alike in chemical nature and composition. The embryology of Carl Ernst von Baer and of his successors until recent times was exclusively a descriptive science based in observation. There was, indeed, but a single criterion, by which anything embryological could be determined, and that was the fate of the cells concerned. But, since in any developing "germ" the cells composing it are living, all questions concerning their fate during development are bound up with chemical, and indeed stereochemical, problems, which demand answers.

In 1906 it first dawned upon me, that in organic nature there must exist at least two sorts of living albumins, laevo- and dextro-rotatory respectively, and in 1907 the conclusion was published, that the albumins of cancer and of malignant tumours in general must be dextro-bodies, because of the destructive action, ending in liquefaction, of active pancreatic ferments, especially trypsin, upon them. Because of all this it became desirable to demonstrate, and by some method above reproach, that dextro-rotatory albumins, similar to those of cancer, did exist, and, indeed, were widely present in other portions of organic nature. With this end in view in the summer of 1912 I began a series of experiments, and now record some of the results. The vastness of the fields of animal development and of the unicellular animals or Protozoa would, no doubt, permit of a wide series of experiments, but to carry out very full series would require much time, material, and financial means not at my disposal.

There are several ways known by which stereochemical questions can be solved. Of these two only need be referred to as connected with the present enquiry. These are 1) examination of the optical rotations of isolated (dead) liquid albumins in the polarimeter, and 2) the "lock and key" method, that is, the positive or negative action of certain ferments, as employed by Emil Fischer. Regarding the first, the isolation of the albumins in a state suitable for the study of optical rotation is beset with great intrinsic difficulties, more especially in dealing with minute micro-organisms. Since all living matter is bound up with, and depends upon, the action of ferments, it is anything but easy so to isolate the albumins that they do not undergo autolysis or self-digestion quickly. The second method, that of the action of ferments, is much simpler in practice, and there only remains for brief discussion the reliability of this method of investigation, the question of how far it is to be considered as being a severely scientific criterion.

Probably to-day a stereochemist would not admit, that these matters were open to doubt or discussion, but mindful of the circumstance, that these lines are written for readers, of whom many are not conversant with the facts of stereochemistry, it may not be superfluous to adduce reasons. One may read — I have myself written it — that "a ferment fits the substance upon which it acts 'as a key fits a lock'". This simile, and the foregoing thesis, we owe to the genius of Emil Fischer. The dictum is quoted not infrequently, but, as happens with other classic scientific quotations, at times one may doubt whether the citation was made after a study of the original memoirs. It is an excellent rule to verify one's citations, and that I propose to do in this instance.

Since it is my contention, that the original words and proofs adduced by Professor Emil Fischer suffice amply to establish the legitimacy of this scientific test by means of ferments, and to make it at least equal in value to the test of the optical rotation in the polarimeter, it may be well worth while to give some account of Fischer's fundamental researches upon the question, and in his own words. This is all the more desirable in that, to my knowledge, there is at present in the English language no concise account of how Fischer arrived at the simile of "lock and key", on what cogent evidences its truth was based. A search of the chemical literature of the matter under discussion will show, that the main facts and conclusions are contained in three memoirs. Of these two will be found in one immense volume (vol. 27) of the Reports of the German Chemical Society, and the third in the 26th volume of the German Journal of Physiological Chemistry. The first paper bears the date 1894, and treats of the behaviour of different sugars towards pure yeasts. From p. 2036 the following

citation is taken: "That micro-organisms generally of two optically isomeric compounds prefer the one has long been known from the investigations of Pasteur and others; but with the yeasts and the sorts of sugars the matter lies somewhat differently, since here it is not alone a question of the antithesis of two optical antipodes, but out of a great number of geometrical forms some only satisfy the needs of the cell. It may be anticipated, that the same observation will be found in other micro-organisms, and, moreover, in other groups of organic substances, and perhaps very many chemical processes, which happen in the organism, are influenced by the geometry of the molecule. Under these circumstances it is worth while to seek after the reason of the phenomenon, and it lies on the surface, that the explanation is first of all to be sought in the region of stereochemistry.

Among the agents, which the living cell makes use of, the different albuminous substances play the chief rôle. They are also optically active, and since they arise synthetically from the carbohydrates of plants, one may, indeed, conclude, that the geometrical build of their molecule, in respect of asymmetry, is in essentials similar to that of the natural hexoses. Under this conclusion it is not difficult to understand, that the yeast-cell with its asymmetrically formed agent can only attack, and force into fermentation, the sorts of sugars the geometry of which departs not too far from that of grape-sugar[2])."

The second memoir bears the date Oct. 29, 1894, and in it, under the title "The Influence of the Configuration upon the action of the Enzymes" the author, Prof. Emil Fischer, set up the simile of "lock & key" in the course of the following discussion (on p. 2992—2993): "But the observations suffice already to approve (the principle) that with respect to the configuration of their objects of attack the enzymes are just as elective as the yeasts and other micro-organisms. In this respect the analogy of both phenomena appears so complete that one may adopt the same reason for it, and with this I return to the hypothesis of Thierfelder and myself, already referred to. As is well known, invertin and emulsin have many resemblances to the proteid stuffs, and like these they possess an asymmetrically built-up molecule. Their restricted action upon the glucosides would permit of explanation by the supposition, that only with similar geometrical build can that approach of the molecule take place, which is requisite for the resolution of the chemical process. To use a simile, I should like to say, that enzyme and glucoside must fit each other like

2) Fischer, Emil und Thierfelder, Hans. „Verhalten der verschiedenen Zucker gegen reine Hefen", in: Ber. d. d. chem. Ges., V. 27, p. 2031—2037, 1894.

lock and key in order to be able to exert a chemical action upon each other. This conception has certainly gained in probability and in value for stereochemical investigation since the phenomenon itself has been transferred from the biological to the purely chemical region. It forms an extension of the theory of asymmetry, but without being a direct consequence of it, for the conviction, that the geometrical build of the molecule even in looking-glass image forms should exercise so great an influence upon the play of the chemical affinities could, in my opinion, be gained only by new observations founded on fact. The experience hitherto, that the salts composed of two asymmetrical compounds may differ in solubility and melting point would certainly not suffice for it. That the fact established now for the complicated enzymes will also soon be found for the more simple asymmetrical agents I doubt as little, as the usefulness of enzymes for the ascertaining of the configuration of asymmetrical substances.

The experience, that the efficacy of the enzymes is restricted in so high a degree by the molecular geometry, ought also to be of some use for physiological investigation. But still more important for this appears to me the proof, that the difference previously accepted between the chemical agents in respect of molecular asymmetry does not in fact exist. Thereby the analogy emphasized more especially by Berzelius, Liebig, and others of 'living and lifeless ferments' is again set up in a not unessential point[3])."

The third memoir, by Prof. Emil Fischer, is a summary of the chief points of the two earlier ones, and in it (p. 81) under the heading "Theoretical Considerations" the author writes: "But the enzymes are quite especially valuable, as I first emphasized, as means of recognition of stereochemical differences, and with this I come back to the object, which I consider to be the most important result founded upon fact of my experiments. These furnish the unchallengeable proof, that of two molecular looking-glass-image forms the one is broken up by enzymes under the same conditions, under which the other remains intact. For this there are two examples, the behaviour of β-methyl-d-glucoside (plus) and of β-methyl-l-glucoside (minus) towards emulsin, and the behaviour of α-methyl-d-glucoside (plus) and of α-methyl-l-glucoside (minus) towards the enzyme of yeast." On p. 82 "The ground of these phenomena lies in all probability in the asymmetrical build of the enzyme-molecule. For although these substances are not yet known in pure form, their similarity to the proteid stuffs is yet so great and their origin from these latter so probable, that undoubtedly

3) Fischer, Emil. „Einfluss der Konfiguration auf die Wirkung der Enzyme", in: Ber. d. d. chem. Gesellsch., V. 27, p. 2985–2993, 1894.

they are themselves to be regarded as optically active and thus asymmetrical molecular structures. That has led to the hypothesis, that between enzyme and its object of attack a similarity of molecular configuration must exist, if a reaction shall ensue. 1) In order to make this thought intuitive, I have used the simile of lock and key 2)[4])." Further, on p. 84 we read: "If one carry this over to the chemical processes of the higher developed organisms, one arrives at the conception, that generally in the transformations, by which the proteid stuffs function in active masses, as undoubtedly that is the case in protoplasm, the configuration of the molecule frequently plays just as great a rôle as its structure. For this reason it is no longer astonishing, that of two stereo-isomeric substances the one reacts strongly upon our sense organs, such as taste and smell, while the other is quite indifferent, or produces a very much weakened reaction[5])."

In the foregoing citations there are two things, to which I would direct special attention. The first is the repeated emphasis, which the author lays upon the use and value of ferments as reagents for the determination of stereochemical differences, and the other the number of experiments, to wit two, from the positive results of which the investigator maintained the establishment of his thesis, that "of two molecular looking-glass-image forms the one is broken up by enzymes under the same conditions, under which the other remains intact". It may suffice for an embryologist, who is not a stereochemist, to refer to the works and researches of this distinguished chemist, Emil Fischer, for the scientific reasons for the employment of enzymes or ferments as testing agents. As to the second point to be noted, Fischer's two experiments in proof of his thesis remind one of Pasteur's words "If a doctrine be challenged, it happens seldom that its truth or falsehood cannot be established by some crucial test. Even a single experiment will often suffice either to refute or to consolidate the doctrine". In the following, as proving to the hilt the truth of my thesis, that dextro-rotatory albumins occur, and, indeed, are widely represented in organic nature, several experiments and their positive results will be adduced. Here it may be added, that the cases described under the experiments are only a few, taken at random, merely because the organisms dealt with happened to be accessible readily, and that the number can be increased to any extent desired, on due cause being shown. He, who may feel inclined to contradict the thesis, can by taking the trouble to repeat and extend my

4) The references under 1 & 2 are to Vol. 27 of the Ber. d. d. chem. Gesellsch., p. 2036 & 2992 respectively.

5) Fischer, Emil. „Bedeutung der Stereochemie für die Physiologie", in: Zeitschr. f. physiol. Chemie, V. 26, p. 60—87, 1898—99.

experiments, using the same Fairchild preparations, and as I have employed them, convince himself, that his contemplated contradiction and refutation are futile.

A condition of all the experiments is, that the micro-organisms used should be in an active healthy state. It would, of course, be feasible to carry out the experiments to a successful issue with much smaller quantities of ferments, provided the experiments were made at a higher temperature, for instance, at blood-heat or between 38 and 40 degrees Centigrade. It was, however, more convenient to make the experiments at the ordinary temperature of a room, and with such dilutions of the combined ferments, trypsin and amylopsin (Fairchild), as would enable their deadly disintegrating effects upon healthy living asexual micro-organisms to be observed, as a rule, within the space of an hour or less. It is, be it remarked, quite unnecessary for any critic to point out, that the finds recorded here could have been obtained by the use of trypsin alone without the aid of amylopsin. Of that fact I am aware. But the reason why amylopsin was also invoked in the experiments was, because I thought, and shall always think, that the use of trypsin alone in the treatment of cancer, various tropical diseases, tuberculosis, etc. is a very dangerous proceeding, even in many cases a deadly one. I wished, therefore, to avoid doing anything to encourage a belief, that in the practice of medicine trypsin without the aid of its complement, amylopsin, could be regarded as a safe and efficacious remedy.

The reagents and the conditions under which they were used were as follows. Since there are on the market preparations, even injections for use in medicine, of pancreatic ferments, trypsin and amylopsin, which are either excessively weak, or unreliable, or even quite inert, it was necessary to take for the experiments such injections of trypsin and amylopsin in combination as were strong, of known strength, standardised, and of a stable character. As W. Bätzner has shown[6]), the most powerful, reliable, and stable pancreatic injections are the ones manufactured by Messrs Fairchild Bros & Foster. To distinguish them from earlier and weaker injections made by the same firm, they will be referred to here as the Fairchild "1912" injections of trypsin and amylopsin. These injections are standardised in various ways, not in a single one, and thus it is possible to refer to the trypsin-injection, for example, as Bätzner does, as possessing a potency in dilution of 1 : 4000, tested by the Jochmann method, or by the Roberts

6) Bätzner, W. Trypsinbehandlung der chirurgischen Tuberkulose, in: Arch. klin. Chirurgie, Vol. 95, p. 5, 1911.
idem. The Practitioner, Jan. 1913, p. 205.

methods as containing per cubic centimetre 1250 tryptic units, while the amylopsin-injection, which like the trypsin-injection is of maximum potency, possesses per cubic centimetre 500 units of amylolytic activity. The procedure was to mix the contents of an ampoule of each of the ferments, trypsin and amylopsin, and then to dilute the fluid with clean fresh rain-water, until the bulk of liquid equalled ten cubic centimetres. This stockfluid, freshly prepared for each occasion, was further diluted as described under the account of the experiments. These latter were made in watch-glasses, containing the organisms and a given number of drops of clean fresh rain-water, to which at a given time a certain amount of the diluted ferments was added. On all occasions the temperature of the room was noted. The changes are quite easily observed under the microscope, and except with such forms as *Amoeba* no higher power than a Zeiss AA is needed. In instances like *Amoeba* it is more convenient to use a slide with a deep cell in it and to cover the preparation. Here also higher powers of the microscope are called for. The ampoules used contain somewhat more than one cubic centimetre, and in instances measured accurately the contents of the two ampoules before dilution totalled $2^1/_2$ cubic centimetres. It should be added, that these preparations are stated to be put up in a menstruum of 60 % glycerin, and that they contain no antiseptic. No statement is made in the present writing, that any other pancreatic preparations upon the market used in the like dilutions will give the same results. The finds are recorded for certain specified pancreatic preparations, and for these only, and used as described here. The necessity of this warning may be judged from the fact, that even in the present year 1912 ampoules of injection, labelled "trypsin", have been offered for sale in Great Britain, and on assay it was found, that all the "trypsin" connected with them in any way was contained in the label.

Experiments.

I. *Hydra fusca.* Temperature of room 19° C. Two individuals of the common fresh water "polype", *Hydra fusca*, in nine drops of clean fresh rain-water. 11. 8 a. m. Added one drop of the 10 c. c. dilution of T. & A., and allowed this to diffuse through the water. Contraction of the animals in one minute or less. 11. 14 Slight expansion, then contraction, tentacles knobbed. 11. 15 One animal contracted, the other somewhat expanded, but anterior part of body strongly contracted. 11. 18 Both much contracted. 11. 19 In one a tentacle in disintegration. 11. 20 Bodies pilose, as though stinging-cells had shot out. 11. 31 Both much digested and tentacles becoming indistinguishable. 11. 45 Greatly disintegrated, and cell-

remains breaking away. 12. 12 Shockingly disintegrated. Experiment ended.

II. *Hydra fusca*, and its unicellular parasite, *Trichodina pediculus*. Same day and like solution. Three specimens of the common hydra, *Hydra fusca*, infested with parasitic *Trichodina*, in ten drops of clean fresh rain-water. 11. 36 Added five drops of the 10 c. c. solution of T. & A. 11. 38 Polypes contracted strongly. Two parasites moving on one. 11. 39 Tentacles of polypes twisted at ends. 11. 40 Parasites gyrating slowly on one polype. 11. 41 Parasites dead and fallen off. 11. 42 Parasites dissolving and their nature no longer recognisable. 11. 50 Tentacles of polypes breaking up. Experiment ended.

III. *Vorticella*. In ten drops of clean fresh rain-water. 11. 52 Added one drop of the 10 c. c. solution of T. & A. 11. $54^1/_2$ Vorticellids still moving. 11. 55 Movements slight, more gyrations. 11. 57 More vigorous short, not elongating, gyrations. 12 noon Individuals fully extended. 12. 2 Slow contractions, not complete, remaining half-way. 12. 4 Individuals all dead, that is, in ten minutes. 12. 10 No movements, clarifying and in disintegration. Experiment ended.

IV. Various flagellate "monads". Same day. Ten drops of water, containing many flagellate "monads". 12. 40 Added one drop of the 10 c. c. dilution of T. & A. All movements cease at once. Experiment ended.

V. *Amoeba* and Crustacean "*nauplii*". Same day. *Amoeba* in a cell with five drops of water. 12. 48 Added one drop of the 10 c. c. solution of T. & A. There were many *Amoebae* in this fluid. 1. 2 *Amoeba* contracting. 1. 6 Another *Amoeba* apparently in disintegration, no movements. 1. 12 No *Amoebae* moving, where seen always contracted. At nine p. m. on the same day, that is, eight hours later, two Crustacean "*nauplii*" were still swimming about in this mixture of water and ferments, and there were no traces of *Amoebae*. A Desmid appeared to be unaltered.

VI. *Hydra fusca* and *Trichodina*. Room-temperature 18° C. A stock-solution of 10 c. c. of T. & A. was made up (A solution). Of this 2 c. c. were nearly boiled to destroy the ferments, and as the result a turbid mixture and flocculent precipitate were obtained. This was filtered to obtain the menstruum of the ferment-solution (B solution). 10. 13 Two watch-glasses, each containing two *Hydra fusca* in ten drops of clean fresh rain-water. 10. 15 Added to watch-glass no. 1 one drop of the A solution, to no. 2 one drop of the B solution. Phenomena observed in no. 1. 10. 17 The parasitic *Trichodinae* have dropped off the *Hydra*. 10. 20 One *Hydra* much contracted. 10. 23 Both *Hydra* much contracted and one

pilose. 10. 45 Both *Hydra* much macerated. This portion of experiment ended. Phenomena observed in no. 2. 10. 22 a. m. *Trichodinae* still alive and moving on hosts. 10. 45 *Hydra* still alive. 11. 15 *Hydrae* still alive, fluid removed, and fresh rain-water given. This portion of experiment ended. Comparison of the two portions shows clearly, that the menstruum (glycerin) was not answerable for the deadly disintegrating effects observed.

VII. Various undetermined flagellate micro-organisms. Same day. One drop of the stock-solution of T. & A. added to twenty drops of water. 11 a. m. Of this mixture one drop added to various flagellate micro-organisms in a cell. 3. 30 p. m. All the flagellate organisms dead, but various "swarm spores", which are vegetable, not animal, were still alive and active.

VIII. *Amoeba*. *Amoeba* in a cell with three drops of water. 12. 2 p. m. One drop of the 10 c. c. solution of T. & A. added. 12. 8 An *Amoeba* found under the microscope, and in movement. 12. 15 Appears to be contracted and not moving. 12. 22 Slight movements. 12. 27 Globular, no pseudopodia, gyrating slowly. 12. 31 Still globular. 12. 33 Slight alterations in shape, but no pseudopodia. 12. 37 Floating freely in the water, and apparently dead. 12. 38 Nucleus escapes. *Amoeba* seems to be breaking to pieces. 3. 15 p. m. Still much the same, but obviously the cytoplasm has all gone, and what is left is mainly made up of products of excretion, vacuoles, diatoms, etc.

IX. *Hydra fusca* and *Trichodina*. One *Hydra* in a cell with many parasitic *Trichodinae*. 2. 48 Added one drop of the 10 c. c. dilution of T. & A. to three drops of clean fresh rain-water. *Hydra* contracts at once, and to all appearance is killed instantaneously. The parasites also seem to be killed at once, and they begin quickly to disintegrate. 2. 52 Tentacles of *Hydra* in disintegration. 3. 16 *Hydra* is a shapeless mass, and the ectoderm is nearly all dissolved off. Experiment ended.

X. *Hydra fusca* and *Daphnia pulex*. Temperature 17° C. Two watch-glasses, the one containing two *Hydra* and a few *Daphnia*, the other five *Daphnia*. In each watch-glass there were twenty drops of clean fresh rain-water. 10. 7 To each glass one drop of the 10 c. c. solution of T. & A. was added. 10. $8^1/_2$ The parasitic *Trichodinae* have fallen off their hosts. 10. 9 *Hydra* contracted, *Daphnia* active. 10. 10 The parasitic *Trichodinae* are dead and in disintegration. 10. 15 *Hydra* in disintegration, *Daphnia* alive and active — there is absolutely no change apparent in the latter. 10. 17 The parasitic *Trichodinae* are shapeless and disintegrated. 10. 18 Each parasitic *Trichodina* is becoming a mere patch of granules. 10. 22 *Trichodina* quite disintegrated. 10. 24 Some of the examples of *Trichodina* are represented merely by a collection

of loose particles. 10. 25 *Daphnia* active, heart pulsating. Ectodermal cells of *Hydra* largely macerated off. 10. 37 *Hydra* now shapeless and largely disintegrated. Parasitic *Trichodinae* dissolved. *Daphnia* active and apparently unchanged. Experiment closed. The specimens of *Daphnia* with their ferment-environment were now placed in a beaker, and 50 c. c. of fresh clean rain-water were added. Thirty hours later the *Daphnia* appeared to be all alive and active. Forty-eight hours after the close of the experiment some, at all events, of the *Daphnia* were alive and active. The weather had now become very warm.

XI. *Amoeba*. An *Amoeba* was placed in a cell along with three drops of clean fresh rain-water and one drop of the 10 c. c. solution of T. & A. This was done at 10. 50 a. m. By 10. 51 the *Amoeba* had been found under the microscope. It was then rounded and its pseudopodia, such as they were, gave it the appearance of a horse-chesnut in its shell. 10. 52 *Amoeba* sending out pseudopodia. 11. a. m. There are still movements in its interior, and pseudopodia are still present. 11. 7 Contraction of contractile vacuole. 11. 10 Still moving by means of pseudopodia. 11. 17 No pseudopodia. Curious linear wormlike movements. 11. 21 Nuclear end contracted, while the other end is still moving in wormlike fashion. 11. 28 Appearance tadpole-like. 11. 29 Nuclear end a rounded mass with soap-bubble-like ectosarc. 11. 30 Dumb-bell-shape with narrow bridge between the two ends. 11. $30^1/_2$ No movements in interior. 11. 32 New blunt process formed at side of larger portion. 11. 34 Contents of new process now flowing back into main portion. 11. 40 Another blunt process formed, quick movements in its interior. 11. 45 Broken into two pieces, of these the one never stirs again, the other moves a little, then rounds up, and remains still. Both dead. Experiment ended.

XII. *Cordylophora lacustris*, *Carchesium polypinum*, and a Hydrachnid or water-mite. The material of this experiment consisted of two asexual generations, *Cordylophora*, a fresh and brackish water polype, a very fine collection of it, and upon it here and there colonies of the beautiful bell-animalcule, *Carchesium*, and a sexual generation, a water-mite or Hydrachnid. This latter was found in one of the watch-glasses used. In the following experiment the glasses were under observation from 11. 15 a. m. until 5 p. m., and 24 hours later than this the glass containing the Hydrachnid was examined, and the water-mite was found to be still alive and active. It had thus lived in a fluid containing these pancreatic ferments for quite thirty hours, while its asexual companions had long ceased to exist, as will be seen. The reagents of the experiment were as follows. The usual 10 c. c. solution of T. & A. was made up. Of this one cubic centimetre was further diluted with

four cubic centimetres of clean fresh rain-water. Four watch-glasses, labelled A., B., C. & D. were taken, and in each, in 20 drops of clean fesh rain-water, specimens of *Cordylophora* and *Carchesium* were placed. 11. 15 a. m. Of the 5 c. c. of further diluted ferment-solution there were added to A. 2 drops, to B. 4 drops, to C. 6 drops, and to D. 8 drops. Describing, first of all, the changes undergone by *Cordylophora*, 11. 26 polypes in D. contracted. 11. 53 In polypes of C. queer appearance of tentacles, thread-cells in dissolution. 12. 10 Polypes in B. contracted. 12. 20 Polypes in C. disintegrating. 12. 35 These latter now much disintegrated. 1 p. m. In A., B., C. & D. all the polypes of *Cordylophora* dead and in disintegration. It should be noted, that D., although containing more of the ferment-solution than C., had also more polypes of *Cordylophora*. Possibly this, along with the coldness of the day, accounted for the slowness of the action. The Hydrachnid or water-mite in B. was observed at the very start of the experiment endeavouring to avoid the attack of a polype of *Cordylophora*, and doing this only with difficulty. An hour later the polype made no attempt to attack the mite, which could now crawl over it with impunity. In this experiment some of the *Carchesium* were still living at 2 p. m., but in the three stronger solutions they were dead and digested by 5 p. m. The action upon *Carchesium* is given in a later experiment (no. XIV).

XIII. *Planaria lactea*, a sexual generation of a planarian worm. Temperature 16.5° C. 11. 28 a. m. A watch-glass, containing 50 drops of clean fresh rain-water and *Planaria*, to which 5 drops of the 10 c. c. dilution of T. & A. were added. All that was noted was a cessation of the tendency to crawl on the glass, and an attempt to get out of the fluid, possibly on account of the glycerin. After the animals had remained for three quarters of an hour in the fluid, they were removed alive to fresh rain-water. Three hours later they were still alive, but they made no attempts to crawl up the side of the glass.

XIV. *Nais proboscidea* and *Melicerta ringens*, two sexual generations, and *Carchesium polypinum*, an asexual generation. Temperature 15° C. Two watch-glasses were taken, A. containing 10 drops of clean fresh rain-water, and B. 50 drops, and in each glass specimens of the three animals were placed. At 11. $12^1/_2$ a. m. to each glass one drop of the 10 c. c. dilution of T. & A. was added. By 12. 25, some seventy minutes later, in both glasses numerous *Carchesium* were in disintegration, but in both here and there single "polypes" of *Carchesium* were alive and active. The action was not so marked in glass B. as in glass A. 1. 10 p. m. Practically all the *Carchesium* in A. were in disintegration, in B., although all the *Carchesium* were dead, not all the "bells" were freed from

their stalks, which were now contracted somewhat spirally. At 12. 30 p. m. numerous minute "swarm-spores" (of plants) were observed swimming actively among the débris of the *Carchesium*. On the rotifer, *Melicerta*, no action could be noted. Of the worm, *Nais*, the ferments obviously attacked and dissolved the cuticle. Apparently, owing to this action, at 1. 10 p. m. while the one individual was still alive, the other was nearly dead. At 6 p. m. both were dead and in disintegration.

XV. *Nais proboscidea* and *Carchesium polypinum*. The result in the preceding experiment, ending in the death of the *Nais*, led to the conclusion, that solutions too strong had been employed in the experiment, and that either the glycerin-menstruum, or the ferment-solution itself, was responsible. Therefore, the experiment upon *Carchesium* and *Nais* was repeated as follows, with still greater dilutions. As will be seen, with this modification the experiment was a complete success. Temperature 16° C. The stock-solution used was the same as in the preceding experiment. Five watch-glasses (A., B., C., D. & E.) containing respectively 10, 20, 30, 40 and 50 drops of clean fresh rain-water were taken. In each there were a number of "bells" of *Carchesium* and a worm, *Nais*, and to each, at 11 a. m., one drop of the 10 c. c. ferment-solution was added. Until 3 p. m. no effect upon any of the organisms was observed. At this time the fluids were removed, fresh rain-water given as before, but to each glass five drops of the ferment-solution were added. 5 p. m. In A., while the *Nais* was still alive and active, many of the *Carchesium* were dead and in disintegration. This was confirmed at 6 p. m. and 7 p. m. Next morning at 10 a. m. the experiment was seen to have been decisive. All the *Carchesium* "bells" were dead and in disintegration. All the worms, *Nais*, were alive and active. In the latter no traces of damage could be detected. In A. to E. the stalks alone represented the former "bells" of *Carchesium*, along with a débris of diatoms. Nine hours later the *Nais* were all still alive and to all appearance unhurt, and just living their ordinary life — in the fluid containing ferments — as though nothing had happened. A day later the experiment was stopped, but even the worm *Nais* in A., the glass containing most proportion of ferments, was alive and active. It had been in this solution in rain-water for more than two days.

XVI. *Actinosphaerium eichhorni*, a Heliozoan or sun-animalcule. Temperature 16° C. One cubic centimetre of the usual 10 c. c. stock-solution of ferments, freshly prepared, was further diluted with four cubic centimetres of clean fresh rain-water. To *Actinosphaerium*, an (asexual) fresh-water Heliozoan, in two drops of clean fresh rain-water, one drop of the further dilution of ferments was added at 10. 58 a. m. In less than one minute the long delicate

hairlike pseudopodia had their ends bent and somewhat thickened. 11 a. m. The hairlike pseudopodia are nearly all gone, and at 11. 2 a. m. they have ceased to exist, and the animal is evidently in disintegration. 11. 5 a. m. The animal is in dissolution, and the central capsule is escaping. 11. 27 a. m. Shockingly disintegrated. 1. 30 p. m. Contents of capsule scattered in fluid. At 11. 18 a. m. it is noted, that the addition of one drop of the further diluted ferment-solution to a drop of water containing *Actinosphaerium* causes immediate shrinking and shrivelling-up of the fine delicate pseudopodia.

XVII. *Stentor coeruleus*. Temperature 14° C. The usual stock-dilution of 10 c. c. of the ferments T. & A. was made up. Of this one cubic centimetre was diluted with four cubic centimetres of clean fresh rain-water. Five watch-glasses, each containing a number of *Stentor*, were labelled A., B., C., D. and E. In the order given these contained rain-water as follows: 18, 16, 14, 12, and 10 drops. The bulk of each was made up to 20 drops by additions of the further dilution of the ferments, or 2, 4, 6, 8, and 10 drops of the solution thus diluted. It was calculated out, that at the most the glasses would contain the following numbers of tryptic units (Roberts): 3, 6, 9, 12, and 15. The experiment began at 11. 30 a. m. 11. 40 a. m. *Stentor* in E and D mostly at rest. In C some in movement. 11. 41 In B some moving fairly quickly. In A the specimens of *Stentor* are moving as though nothing had happened. 11. 42 The animals in D and E appear to be in disintegration. The cilia are not obvious. 11. 45 The animals in A and B are still in movement. Most of those in D and E are dead. 11. 49 In E disintegration is going on rapidly, but in D a water flea, *Daphnia pulex*, is actively moving. This was seen later on, alive and active, 27 minutes after the experiment started. Afterwards it was lost sight of. The animals of *Stentor* in the same watch-glass were killed in ten minutes or less. 11. 54 In B many *Stentor* in disintegration, but some still in movement. *Stentor* in C in disintegration, no ciliary motion. 12 noon. In A and B still some movement. 12. 3 Movements in B appear to be ceasing, but not in A. 12. 4 p. m. Animals in E greatly disintegrated, many Algae freed. 12. 18 Heaps of freed Algae in D and E. 12. 20 In A still some ciliation, but in many the cilia are working feebly. 12. 25 The animals in B are now much disintegrated. 12. 32 Slow ciliation in A and all the animals are crowded together. 2 p. m. In A still the same condition of affairs, but only one animal moving cilia. At 7 p. m., when the experiment was closed, there were still some animals of *Stentor* alive in A, but in the four remaining watch-glasses all the specimens of *Stentor* were dead and in disintegration.

My acknowledgments are due, and may be expressed here, to Messrs Fairchild Bros. & Foster for the two boxes of ampoules of injections of trypsin and of amylopsin used in the experiments. All the organisms employed in the foregoing experiments were supplied by Mr. T. Bolton, 25 Balsall Heath Road, Edgbaston, Birmingham. The number of animals experimented upon would have been much greater, had all the organisms he sent survived the transit in summer. Of course, it was only possible to use organisms, which were in a healthy active condition. The seventeen experiments, hitherto carried out, have established the truth of the thesis, that living asexual generations of animals are attacked, killed, and their albumins pulled down by solutions of the pancreatic ferments, trypsin and amylopsin (Fairchild), in which sexual generations of animals go on living. The following asexual generations of animals exhibited the deadly pulling-down action of pancreatic ferments, and thus revealed the dextro-rotatory nature of their albumins: *Hydra*, *Cordylophora*, *Trichodina*, *Vorticella*, *Carchesium*, *Amoeba*, *Actinosphaerium*, and *Stentor*, eight in all[7]). The beneficent action of trypsin and amylopsin upon sexual generations of animals is to me so self-evident, that it has appeared to be almost a work of supererogation to make experiments in this direction. However, for the benefit of the sceptic, the following sexual generations of animals continued to live in solutions of these ferments, which proved to have deadly disintegrating effects upon the afore-mentioned asexual generations of animals: *Daphnia*, a Hydrachnid or water-mite, crustacean "*nauplii*"[8]), *Planaria*, *Nais*, and *Melicerta*, six in all[9]). Zoologically, the experiment (no. X) with *Hydra fusca* and *Daphnia pulex* has special interest. *Daphnia pulex* is a common prey of *Hydra*. It is impossible to keep *Daphnia* living in an aquarium containing *Hydra*. Even the individuals of *Daphnia*, which it does not catch and devour, *Hydra* quickly kills with its stinging cells. More than once I had noted, that if a number of the two forms, *Hydra* and *Daphnia*, were associated together in a small aquarium, in the space of twenty-four hours there would be no living Daphnids in the vessel. In experiment X the tables were turned, and in the presence of pancreatic ferments, trypsin and amylopsin, it was *Hydra*, which was

---

7) Eight, without mentioning the "various undetermined flagellate micro-organisms" of experiment no. VII.

8) Crustacean "*nauplii*" are not "larvae" or asexual generations. For many years, with the late Geheimrat Prof. Anton Dohrn, I have regarded them as being immature sexual generations of Crustacea. Experiment no. V proved the truth of this.

9) Six, without including the "various undetermined 'swarm-spores' of plants" of experiments nos. VII & XIV.

killed and pulled to pieces, whilst the Daphnids survived. This is possibly the first occasion, on which in close association together in nature *Hydra* was impotent to kill its prey, *Daphnia pulex*. Without doubt it is by means of a ferment that *Hydra* kills *Daphnia*. This fact answers by anticipation an objection, which may be raised, that *Daphnia* is protected from the action of trypsin and amylopsin by its chitinous covering. This latter is no protection whatever against the antithesis of trypsin, the ferment produced by the stinging cells of *Hydra*. Indeed, it is not too much to say, that the result of the experiment with *Hydra* and *Daphnia* alone would suffice to establish the existence of two categories of albumins at least, laevo-rotatory and dextro-rotatory respectively.

With Emil Fischer I maintain, that "the enzymes are quite especially valuable — as means of recognition of stereochemical differences", and that "of two molecular looking-glass image forms" — in the present case living albumins of animals — "the one is broken up by enzymes under the same conditions under which the other remains intact". His examples were the glucosides: mine the living albumins of certain animal organisms. Two examples were held by him to suffice to establish his theses: for mine more than two are adduced, and, moreover, if shown to be desirable, the number can be increased very considerably. For, in fact, the organisms employed in the actual experiments were but samples, chosen in hap-hazard fashion, of a large series of micro-organisms or developing organisms, all of which — and their name is legion — would, if identified embryologically as asexual generations, exhibit the same phenomena of death and disintegration in the presence of active pancreatic ferments. The asexual nature of the organisms experimented upon as such had been decided previously, and upon other than chemical grounds, that is, from developmental and biological data. Not a single one of the experiments failed to confirm the biological conclusion.

On the present occasion it is not my intention to examine the bearings of the facts and conclusions upon ordinary zoological problems, for to do so would carry the discussion too far. Possibly, it may now be recognisable, that the heretical preaching of antithetic alternation of generations in the wilderness in past and recent years had its fount in scientific truth. Possibly, it may become evident, that in some groups of animals, such as sponges, ctenophores, sea-anemones, and corals, as well as in *Hydra* and *Cordylophora*, the sexual generation is not represented except by the forerunners of the sexual products, eggs and sperms.

It is, however, the duty of the scientific investigator to draw the conclusions from his observations and experiments, and this I shall now proceed to do in certain interesting and obvious direc-

tions. 1) The experiments confirm the truth of the biological and embryological conclusions, that the cycle of animal life, even that of such micro-organisms as Protozoa[10]), is an antithetic alternation of asexual and sexual generations, of such a nature that the albumins of the asexual generation (dextro-rotatory) are the stereo-chemical antitheses of those of the other or sexual generation (laevo-rotatory). As I have pointed out elsewhere[11]), the conditions are reversed in plants[12]). Here it is the asexual generation, which possesses laevo-rotatory albumins and dextro-sugars. 2. All such asexual generations of animals, including all malignant tumours, are killed and pulled down in the living state by the action of active solutions of the pancreatic ferments, trypsin and amylopsin. 3. Since "Science is prevision" — to quote the words of Pasteur — and because of certain facts known to me, certain other conclusions may be drawn. As long ago as 1907 I stated[13]), that the pancreatic ferments, trypsin and amylopsin, were the natural means to be adopted for the cure of tuberculosis. This was confirmed in a single case of tuberculosis of the bowel by Dr. Margaret A. Cleaves[14]), and in various forms of surgical tuberculosis by Dr. W. Bätzner[15]). Since the latter has shown, that solutions of trypsin do not inhibit the growth of cultures of tubercle-bacilli, the favourable result in tuberculosis is seen to be due, as I had long foreseen and foretold, to the use made by the leucocytes of the ferments, trypsin and amylopsin, as weapons of attack. While

---

10) Antithetic Alternation of Generations in Protozoa. In "The Annals of Botany", V. 9, 1895, p. 446—447 and p. 468, in the course of a paper dealing with "The Phenomena of Reproduction in Animals and Plants", it will be seen, that I recognised, and postulated, the occurrence of Antithetic Alternation in the life-cycles of the unicellular organisms. In not the least brilliant of his memoirs this was first demonstrated, in the case of *Coccidium schubergi*, by that zoological genius, the late Fritz Schaudinn (vide Schaudinn, Fritz. Untersuchungen über den Generationswechsel bei Coccidien, in: Zool. Jahrb., Abt. f. Anat., Vol. 13, 1900, p. 197).

11) Beard, J. The Enzyme Treatment of Cancer, London, 1911, loc. cit., p. 159.

12) Therefore, in experiments nos VII & XIV, unlike the asexual generations of animals, such as the "various undetermined flagellate micro-organisms" of experiments nos. IV & VII, the "various undetermined 'swarm-spores' of plants" were not killed and disintegrated, but continued to live, in the presence of active pancreatic ferments, trypsin and amylopsin. The undetermined "swarm-spores" of experiments nos. VII and XIV were probably asexual organisms belonging to the Confervoid division of the Green Algae, such as *Ulothrix*.

13) Beard, J. ibid., p. 136—137.

14) Cleaves, Margaret A. The Physiological Action of the Pancreatic Enzymes etc., in: Medical Record, June 1, 1907.

15) Bätzner, W. The Trypsin in: Treatment of Surgical Tuberculosis. "The Practitioner", January, 1913. p. 203—219, 6 plates.

Dr. Bätzner has observed, that three injections of the active pancreatic ferments (Fairchild) suffice to heal a tubercular abcess, in India Captain F. W. Lambelle R. A. M. C., using the like Fairchild injections, has found, in a bad case of amoebic dysentery with abcesses in lungs and liver, that the like number of injections (three) result in the clearing-away of all the *Amoebae*, and the healing of the abcess. From these facts, from the experiments, and, more especially, from the whole course and tenour of my researches during the past twenty-four years the following additional conclusions find their scientific warrant.

Since the organisms underlying the chief tropical diseases, such as malignant malaria, trypanosomiasis, sleeping sickness, yellow fever, relapsing fever, kala-Azar, etc., are so far as these attack human beings, asexual generations, it follows, that the natural means of destroying the organisms of such tropical diseases, and of curing the patients, are the use in combination of the powerful pancreatic ferments, trypsin and amylopsin, as represented by the "1912" Fairchild injections.

A further step may, indeed, be taken. Since such tropical disorders due to parasitic micro-organisms of an asexual nature, and tuberculosis, are amenable, since the organisms of such nourish themselves, increase, and multiply at the expense of the living human organism with its characteristic laevo-rotatory albumins, and — last not least — because the greater exceeds the less, all infectious diseases, due to parasitic organisms of an asexual nature, all which possess dextro-rotatory albumins, such as pyaemia, smallpox, scarlet fever, pneumonia, leprosy, cholera asiatica, and others of a similar nature, must be, and are, curable naturally by the all-powerful ferments, trypsin and amylopsin, in combination.

In order to grasp the bearings of the facts of the present writing upon problems concerning diseases, in which unicellular organisms, bacilli, etc. play a leading part, it is needful to know something of the biology of digestion and of the relationships of extra- and intra-cellular ferments. In the unicellular animals or Protozoa, which, so far as disease is concerned, manifest themselves as asexual generations, in the asexual generations of the higher animals, in the mammalian trophoblast, and in its pathological representative any malignant tumour or cancer, digestion is intracellular, and by means of ferments acting within and upon the surface of the cell. In the sexual generations, man for example, a differentiation has taken place, of such a nature, that the production of the characteristic digestive ferments has been assigned to a certain portion of the alimentary canal, and these ferments act in an extra-cellular fashion. Not only have most of the body-cells lost the power, if they ever at any past time possessed it, of

producing trypsin and amylopsin, but a further division of labour has taken place in the original single digestive gland, its ferment-producing properties have been localised in a part of the original structure, and this part we term the pancreas-gland, while its other functions have been reserved for the portion of it, which we term the liver. I am not concerned here with the question of the production of ferments by and in the vertebrate liver. But any tryptic and amylolytic ferments contained in the liver are almost certainly formed in the pancreas-gland. The aspect of the matter concerning us here is this: owing to such division of labour the body-cells, in giving up any earlier powers possessed by them of forming trypsin and amylopsin, are placed more or less at the mercy of organisms, such as some Protozoa, bacilli, etc., which by their ravages create disease. The ferments, produced by these, being the stereochemical antitheses of those of the normal human body, when given the chance, are in this way enabled to attack the body-cells, which have as their sole immediate protectors the cells termed leucocytes. The leucocytes form the first and only real line of defence against the attacks of such micro-organisms. It was Metschnikoff[16]), who first insisted on these protective powers of the leucocytes. Notoriously, in many forms of parasitic disease, produced by a micro-organism, a bacillus, or asexual generation, such as cancer, the leucocytes are quite unable to cope with the foe. But increasing evidences go to demonstrate, that, if provided with pancreatic ferments as additional weapons of attack, the leucocytes can become highly efficient agents against such onslaughts. Moreover, it must not be forgotten, that the ferments are bodies, which do not, to any extent at all events, diffuse or pass through the walls of the alimentary canal and circulate in the blood

From the point of view of practice it may suffice to note the following. The introduction of pancreatic ferments, such as the new Fairchild preparations, into the blood is, as others have demonstrated, a perfectly harmless procedure. In such afflictions as sleeping sickness, malignant malaria, tuberculosis, etc., the organisms concerned are enabled to succeed in their attacks, because of the absence of the naturally protecting ferments, trypsin and amylopsin, but, given these circulating in the blood at the point of attack, the body — often, as in tuberculosis, aided by the leucocytes — is placed in a position not merely to resist the attack, but to defeat it utterly.

16) Metschnikoff, Elias. Untersuchungen über die intrazelluläre Verdauung bei wirbellosen Tieren, in: Arbeiten a. d. Zool. Inst. zu Wien, V. 5, p. 141 et seq., 1884.

idem. Untersuchungen über die mesodermalen Phagocyten einiger Wirbeltiere, in: Biol. Centralbl., V. 3, p. 560—565, 1883—84.

By the researches of earlier years antithetic alternation of generations as the law of the developmental cycle of animal life had been placed upon a firm basis of observation. With the facts now recorded a beginning has been made in supplying this law of antithetic alternation of generations with a foundation in stereochemistry.

Upon what foundation do the current orthodox conceptions of the nature of the above-mentioned diseases rest? Certainly, as little upon a chemical as upon a biological basis. The line of work I took up four and twenty years ago may have been — may even now be — "heretical", regarded in the light of common beliefs then and now current. But the error was, and is, in the current beliefs and theories, and not in the "true theories" or general principles, to which patient research during these years has led me irresistibly. For, as Pasteur well said, "The characteristic of erroneous theories is, that they are never able to present new facts; and every time a fact of this nature is discovered, in order to take it into account, they are obliged to graft a new hypothesis upon the old ones. The characteristic of true theories, on the contrary, is of being the expression of the facts themselves, of being commanded and dominated by them, of being able to foresee new facts certainly, because these by their nature are linked up with the former — in a word, the characteristic of these theories is fecundity[17])."

It is a long time since 1860, and the fundamental discoveries of Pasteur[18]), published in that year, discoveries, relating to what he termed "enantiomorphism", have had a curious subsequent history. While, on the one hand, it would, perhaps, not be too much to say, that their influence upon the progress of chemistry had been unbounded, their import in Physiology and allied sciences, dealing with the problems of living things, such as Embryology, Zoology, and Botany, would not appear to have been recognised hitherto. It is scarcely credible now, that so long ago as 1860 Pasteur said "I have, in fact, set up a theory of molecular asymmetry, one of the most important and wholly surprising chapters of science, which opens up a new, distant, but definite, horizon for physiology"[19]). While admiration of Pasteur's "prevision" — to use his own word — must be expressed, one cannot refrain from

---

17) Vallery-Radot, René. "La Vie de Pasteur", Paris 1901, p. 352. As elsewhere stated already, what Pasteur termed "a true theory" I identify as "a general principle".

18) Pasteur, Louis. On the Asymmetry of Naturally Occurring Organic Compounds, in: G. M. Richardson's "The Foundations of Stereochemistry, New York, American Book Company, 1901, loc. cit., p. 25.

19) Op. cit., p. 33.

astonishment, that more than fifty years, at all events, should have elapsed without a fulfilment of his prophecy.

Applying now his discoveries, the later ones of Emil Fischer, and the facts here recorded, to the problems of living things, clearly there is a General Principle of far-reaching import behind the whole. This is, that the micro-organisms, bacilli, etc., of disease are, of necessity, composed of compounds, which are stereochemical antitheses of those making up the normal human body, and that, when compared similarly with the pancreatic ferments, the like is true of the ferments, by means of which they effect their ends. Only by means of such antithetic or opposite characters of compounds and of ferments produced by them could such disease-inducing organisms bring about their ravages.

It follows naturally, irresistibly, and incontrovertibly, that the rational ways and means of meeting and coping with such ravages are the employment of the ferments produced by the organisms, to wit, mankind, who are the victims, and of these by far the most potent are the pancreatic enzymes, trypsin and amylopsin. Indeed, the final outcome of the present adventure is to demonstrate once again beyond effective contradiction, that the pancreatic ferments, trypsin and amylopsin, in combination are the most powerful agents in the whole range of organic nature.

Die rechnenden Pferde.

Von **Karl Camillo Schneider**, Wien.

Zu dem Problem der rechnenden Pferde muss jeder Tierpsychologe Stellung nehmen. Ich halte mich um so mehr dazu verpflichtet, als ich in meinem vor kurzem erschienenen tierpsychologischen Praktikum (in Dialogform, bei Veit, 1912) genauer auf den klugen Hans eingegangen bin und die Frage diskutiert habe, ob bei ihm ein wirkliches Denkvermögen vorliege oder nicht. Diese Frage verneinte ich damals. Ich verneine sie auch jetzt noch und verneine sie auch für die anderen Wunderpferde. Aber die Sache liegt doch heute für mich ganz anders als noch vor kurzem. Über Nacht gleichsam hat sich das Thema kompliziert und statt der einen, früher in Betracht kommenden Frage ist eine neue aufgetaucht, die so bedeutungsvoll ist, dass niemand mit Stillschweigen an ihr vorbei kann. Ich sehe mich einem Irrtum meinerseits gegenüber, den begangen zu haben mir außerordentlich leid tut, dem zu verfallen aber außerordentlich nahe lag. Wenn man nur einigermaßen über das tierpsychologische Gebiet hinaussah, so musste man, wie mir scheint, diesem Irrtum verfallen. Allerdings viele Tierpsychologen waren dagegen gefeit, weil sie eben weder über ihr Gebiet