expressions, the actual undiluted truth is in danger of being lost sight of." (p. 272.)

This is a vague and unmeaning sort of accusation as applied to the theory in question, but we cannot help thinking that if our author will look nearer home he may perhaps discover an undue frequency of symbolical expressions, and very great dilution of the truth. He accuses the advocates of this theory of ignoring the vitality of the blood, and maintaining that a man is a mere collection of polypes or corallines. (p. 274.) We cannot, however, perceive that the theory is in any way amenable to these censures.

On the whole, we wish Dr. Heale had not given himself the trouble of writing this book, as it appears to us to be most elaborately nothingful. We will not be so unpolite as to call it "a wind-bag;" but we suspect that Mr. Thomas Carlyle, if translated to our critical chair, might be apt to affix to it some such disrespectful designation.

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## Review VI.

1. *Archiv für Pathologische Anatomie und Physiologie und für Klinische Medicin.* Herausgegeben von R. Virchow.—1854–1859, passim.

Virchow's *Archiv.* 1854–1859.

2. *Die Cellular-pathologie in ihrer Begründung auf Physiologische und Pathologische Gewebelehre.* Von Rudolf Virchow. 1859.

*Cellular Pathology, based upon Physiological and Pathological Histology.* By R. Virchow. 1859.

3. *Journal de la Physiologie.* Publié sous la direction du Dr. E. Brown-Séquard. Nos. V., VI., VII.—1859.

Brown-Séquard's *Journal of Physiology.*

4. *An Inquiry into the Existence of Amylaceous Compounds in the Human Body.* By Dr. Bristowe and Mr. Ord. ('Transactions of the Pathological Society of London,' vol. x. p. 299.) 1859.

5. *On the Nature of the Substance found in the Amyloid Degeneration of various Organs of the Human Body.* By Francis Harris, M.D. Cantab. 1860.

If we are ever to arrive at a correct pathology, it must be by first ascertaining the symptoms and appearances of disease in relation with the particular organ affected by the light of physiological anatomy and physiology; and, secondly, by discovering those general alterations in the nutrition of the blood and tissues which give origin to what are denominated inflammations, degenerations, diatheses, and morbid growths, or in other words, to diseases of nutrition. The first part of this road to knowledge has been fairly opened up by the researches of the last ten years, but of the second part, the rough work of a few pioneers is at present all that can be found to indicate its onward direction. But though depraved nutrition and its consequences be yet most imperfectly understood, yet the advance made during the last

few years in physiology and pathology, particularly by the aid of the microscope and chemistry, may well encourage us to hope to establish ere long some principles of general pathology having equal precision with the truths of natural philosophy. A step towards so desirable an end appears to us to have been gained by the determination of the morbid condition known as amyloid degeneration, a sketch of the pathology of which formed the subject of an article in our last number (vol. xxvii. p. 442). Moreover, we deem it a subject of sufficient importance to warrant its further examination. It opens up a new field of inquiry, full of interest, and very promising to the pathological student.

The principal results arrived at in the paper quoted, were: that there is a peculiar degeneration, the expression of a general pathological state, but, at the same time, one which more particularly affects certain organs; that this degeneration may be recognised by the physical changes it induces in the tissues involved, and by certain microchemical signs; that it is due to the formation of a substance, primarily found in connexion with the capillaries and small vessels, and recognisable by its appearance, but better by the microscopic alterations it induces; that this matter is suspected by many to be of an amylaceous nature; that its accumulation is sooner or later destructive of the nutrition and function of the invaded organs; and, lastly, that it has more commonly been found associated with certain diseased states, all agreeing in this particular, that they are productive of a general depraved or cachectic state of the body.

One important matter, however, remained unconsidered, or at least was only imperfectly touched upon—viz., the chemical nature of the substance which constitutes the pathological element of amyloid degeneration. An examination of this question will constitute the leading subject of the present article; and we would gladly have followed it by a discussion of the signs or symptoms which, on the assumption that the degenerative process in question has a special character as a pathological fact, are discoverable in relation with it during life. However, we regret that there is yet so great a deficiency of material for this purpose, that an attempt to elaborate the history of amyloid degeneration as a special lesion referable to the category of ordinary diseases, is impracticable. To the minds of some, therefore, the entire subject may appear like a barren fact in pathology unavailable to the practical physician. However, such a notion would be unfortunate as well as unfair, inasmuch as the pathological change in question is yet of very recent discovery, and time is required to make out the symptoms associated with, and indicative of it during life; and inasmuch as it moreover enlightens us respecting the nature of certain otherwise obscure lesions, and affords a most valuable clue to further research.

It has been usual to distinguish two varieties of amyloid matter; one, as it exists in the form of corpuscles, very generally laminated, like starch grains, and which we may call the corpuscular variety, as found in the ependyma ventriculorum of the brain, in the pulmonary tissue, and in the follicles of the prostate; the other, as found in tissues and

organs which are in the often so-called state of waxy degeneration—for instance, in the waxy spleen, liver, and kidneys, where it is granular, and may be spoken of as granular or amorphous amyloid matter.

The chemical relations of the first, the corpuscular variety, were pretty fully discussed in the previous article quoted (pp. 443—449), and therefore will need consideration here only in their connexion with the question of the nature of the amorphous amyloid substance.

Though the presence of an amylaceous compound in animal tissue appeared on its first announcement scarcely credible, owing to the then-prevailing notion that such compounds were peculiar to vegetable structures, it is now a common-place fact, and has latterly been proved to have a very much wider signification than would have been anticipated. The existence of cellulose in the envelopes of the low grades of animal life represented by the ascidians and salpinæ, the first discovery of this class, has been followed up by the determination of the chemical alliance of chitine—the organic basis of the external skeleton of the crustacea, insects, and the like; and of tunicine, that of the envelopes of tunicata—with compounds of the amylaceous series. But this association of the allies of starch with the animal economy has been shown to be very much more extensive than is implied even in the above instances, by the discovery of the production of a substance, called indifferently glycogene, amyloid matter and zoamyline, in the process of nutrition of apparently all animals, including man; a discovery we owe to the genius and research of M. Bernard. This important fact was first promulgated in connexion with what M. Bernard concluded to be a sugar-forming (glycogenic) function peculiar to the liver. However, more recent researches, both by Bernard himself, by M. Rouget of Paris, by Dr. Pavy of Guy's Hospital, and several others, have proved that the sugar detected in the liver is not directly produced there, but owes its formation to post-mortem decomposition or to some catalytic force acting upon a true product of the economy, separable by chemical means as a white powder, and proved to be a near ally of starch;—a glycogenic substance of which the most convenient of the three names above cited seems to us to be "*zoamyline*." Moreover, the production of zoamyline is no special function of the liver, but proceeds at every part of the system, though probably attracted, so to speak, in a higher degree to the hepatic tissue.

Now the production of an amylaceous compound in the normal processes of the economy furnishes of itself an argument for the probable formation, retention, or transformation of it as an abnormal condition; and indeed, in the phenomena of diabetes mellitus we have an example of the irregular transformation of the zoamyline into sugar, and of its apparent rapid production at the expense of the tissues at large. In this instance, the zoamyline loses part of its nature as an organic compound, becomes a waste soluble material, unfit for the purposes of nutrition, and is therefore rapidly eliminated. But we may suppose a change in it in a contrary direction—that it may become more organic, more associated, whether after the laws of pure chemical

affinity or not, is of no consequence—with albuminous or nitrogenous material, and in some way less available for its normal purpose in the nutritive processes; and then, being insoluble in water, it could not be carried off like the sugar of diabetes, but would accumulate in the organs of the body, to the detriment and final destruction of their functions and normal structure. However, without pushing such conjectures further, let us examine the evidence put forward for considering the so-called amyloid degeneration due to an actual amylaceous compound, together with that which may be adduced against the hypothesis.

So far as its chemical basis is concerned, the doctrine of the degeneration of tissue into an amylaceous substance rests mainly upon the application of the common tests for starch and cellulose—viz., iodine alone or with the addition of sulphuric acid, or iodine and chloride of zinc. For besides the evidence thus furnished, whether for or against the opinion in question, we are acquainted with only one or two analyses, proximate and ultimate, which can be looked upon as in any way satisfactory or trustworthy. Carl Schmidt records two ultimate analyses undertaken by himself.* One was of a choroid plexus, rich, as it is reported, in amyloid bodies; the other was of a portion of waxy spleen: and his conclusion was that the matters thus examined were of an albuminoid nature, and contained nitrogen. This conclusion is also favoured by the only other ultimate analysis we have met with—viz., that by Friedreich and Kekulé, of which we shall have presently to speak in detail.

But to return to the tests for starchy matters, and assuming them to be satisfactory as such, there is a remarkable want of agreement in reference to the indications obtained by those tests among different observers. For instance, it is agreed on most hands that particles of tissue in waxy or amyloid degeneration assume a blue or violet colour on the addition of iodine and sulphuric acid, or of iodine and chloride of zinc—Schultze's solution, prepared according to Mr. Busk's plan.† On the other hand, however, Messrs. Bristowe and Ord failed to develop this coloured reaction;‡ the waxy matter coloured yellowish-red, melon, or deep reddish-brown by solution of iodine, and was not altered in character, excepting that its tint was after a time rendered lighter, when sulphuric acid, whether applied pure or dilute, and for a shorter or longer period, was added:

"In some cases, a bluish edge-tint was produced when the sulphuric acid was first added. This was evidently due to the precipitation of iodine in a molecular form, and almost always occurs when sulphuric acid comes in contact with iodine solution and animal matter. No tint at all approaching the starch or cellulose tint was obtained during the course of several hundred experiments. With Schultze's solution, the same colour was obtained as with iodine alone."

How are these results to be reconciled with those of every German, and, we may add, so far as our information extends, of every French, and of every other English pathologist, who all agree in stating that a blue colour tints the amyloid matter of waxy degeneration when sul-

* Annalen der Chemie und Pharmacie, Band cx. p. 250. 1859.
† Quarterly Journal of Microscopic Science, vol. ii. p. 100. 1803.
‡ Transactions of Pathological Society, vol. x. p. 301.

phuric acid and iodine are applied to it? These numerous observers cannot have been invariably deceived by the precipitation of molecular iodine around the periphery of amyloid particles; for some of them describe the blue colour as penetrating the interior, and as colouring the mass unequally. Even Friedreich and Kekulé, whose ultimate analysis of waxy spleen obliges them to decide against its amylaceous composition, describe the blue colour as appearing in the morbid matter, not only after the ordinary application of the sulphuric acid and iodine test, but also after the morbid material had been submitted to several chemical processes in the course of proximate analysis.

It might be supposed that some peculiarity in the mode of applying the test led to the different results obtained by the two English observers; but, so far as we can discover, no such peculiarity obtains. They do not, indeed, tell us of what strength their iodine solution was, but the circumstance of this differing from that employed by others surely cannot account for the divergence in the results obtained. Virchow* tells us that to demonstrate the true blue colour with the iodized sulphuric acid requires practice, because the acid soon breaks up the tissue, and then the colour grows indistinct and is at length lost. The same industrious observer also states, and on this point is supported by Paulizky, that the weaker the solution of iodine, the less the quantity of it used, and the more gradual its action, the clearer is the blue colour developed. When the iodine solution is strong, the blue or violet tint rapidly passes away, mixed with reds and browns, until at last a deep brown colour, looking almost black, succeeds.

Here, then, amid the conflicting results arrived at, scope is afforded to the students of amyloid disease to determine on which side truth lies, and to point out the circumstances which have produced the divergence. But although we advocate an extensive re-examination of the question, we are at present unprepared, in the face of so much evidence to the contrary, to range ourselves on the side of Dr. Bristowe and Mr. Ord, in denying the production of a blue colour with the cellulose tests. However, we must do those gentlemen the justice to say that they appear to have carried on their investigation in the most painstaking manner, and to those who would re-examine the question we would recommend the study of their mode of proceeding, as fully detailed in their valuable paper already quoted.

On one point, touching the effect of iodine alone on amyloid tissue, there is unanimity. It is described as peculiar and definite. Virchow has noticed this circumstance, and it is confirmed by Dr. Bristowe and Mr. Ord, as well as by Dr. F. Harris (op. cit., p. 21). The last named author writes:

> "The colour produced by iodine alone on organs which are the seat of this pathological process is perfectly distinctive. When, for example, a solution of iodine is brushed over a liver which has undergone this change, the affected parts in a few minutes assume a deep red-brown colour, very different from the colour produced by iodine on organs in any other condition—once seen, it cannot be mistaken."

* Cellular-Pathologie, p. 336.

Dr. Bristowe and Mr. Ord whilst admitting "the fact of a definite iodine-reaction belonging to the so-called waxy substance," add to it the statement that, "in diphtheritic effusion, and in the villi of a villous cancer, a colour approximating to that of the waxy liver was produced, the resemblance being far closer than that between any specimen of the waxy liver, and the true starch or cellulose colour." This approximation of colour between two sets of morbid products, we are not disposed to regard either as so important, or as in so great a degree indicative of their agreement in kind, as Messrs. Bristowe and Ord intimate. Iodine stains albuminoid matters yellow, and when used in larger quantity, yellowish brown; and the difference in colour by a few shades is surely not of much value as a distinction between such materials in general and those of the like chemical constitution, though of the class of morbid products. The immediate colouring of the amyloid matter with iodine only, is a feature distinguishing it from cellulose and from cholestearine. H. Meckel* committed himself to the statement that waxy degeneration was due to cholestearine; but the error of this hypothesis was at once pointed out by Virchow,† who showed that the reaction in colour of amyloid matter with iodine and sulphuric acid is entirely different from that of cholestearine; and that, on the other hand, tissues rich in the latter—e. g., the nervous tissue—exhibit none of the peculiar reactions of the former. The principal distinctions between the two substances stand thus:—1. Cholestearine is unchanged in colour by iodine alone. 2. The corpora amylacea dissolve in warm or boiling water. Cholestearine is insoluble in water. 3. Cholestearine melts on the application of heat; the amyloid bodies do not melt, but only dry, and still give the same reactions with iodine. 4. Cholestearine dissolves into a brown fluid on the addition of concentrated sulphuric acid; amyloid bodies swell, but do not dissolve, with a change of colour. 5. Cholestearine is soluble in ether, amyloid not. It must be stated, however, that all these differences do not hold good between every one of the varieties of amyloid substance and cholestearine. For instance, the swelling up and final solution in water is true only of the corpuscula amylacea of the brain; even the very similar and equally amylaceous granules from the prostate do not dissolve in water. Nevertheless, after admitting the existence of variations in chemical reaction, and allowing for the different results arrived at by different experimenters, sufficient evidence is furnished by the tests just considered, of the formation and accumulation of one or more peculiar matters in the tissues and organs of the body. On this point there is general concurrence; but of the chemical nature and relations of the peculiar substance opinions are varied and unsettled. Even were the iodine tests more sure and constant in their effects, they would be inadequate as proofs of a genuine amylaceous nature, and need the support of ultimate analysis to prove the non-nitrogenous nature of amyloid matter, and its conversion into sugar. To obtain these proofs is, from the nature of the case, exceed-

* Annalen der Berliner Charité krankenhäuser, and vol. xiv. p. 413 of this Review.
† Archiv, Band vi. p. 419. 1854.

ingly difficult, except with regard to the prostatic corpuscles, and to the rare occurrence of amyloid degeneration in such a high degree that the original histological elements of the tissue affected are almost entirely replaced by the morbid matter.

The corpora amylacea of the brain and spinal cord are too minute and intermingled with the surrounding tissue to be collected for ultimate analysis, or for the attempt to convert them into sugar. Carl Schmidt, indeed, undertook, as already noticed, the analysis of a choroid plexus, reported as rich in amyloid corpuscles; but we view this analysis with great scepticism. We feel very uncertain about these choroid granules having been amyloid corpuscles at all: calcareo-albuminous corpuscles are well-nigh constant in the choroid plexuses, constituting one variety of brain-sand;* but amyloid bodies are strangers in them, though common in the ependyma ventriculorum beneath. The impression, therefore, obtrudes itself on our mind that Schmidt's analysis applies to the calcareous bodies in their early or albuminoid stage, before their impregnation with earthy matter, at least in any quantity; but whatever the corpuscles examined were, the conclusion drawn was that they contained nitrogen, and were of an albuminoid composition, and did not belong to the non-nitrogenous series of hydrated carbons.

The other ultimate analysis performed by Professor Schmidt was of a portion of waxy spleen, and it led to the same result as the foregoing. The details of Schmidt's analysis are very brief, and we cannot determine how far it applied to pure amyloid substance, or to an admixture of this with the usual elements of the spleen. There is, however, a much more satisfactory analysis recorded by Friedreich and Kekulé,† of a portion of spleen so affected by amyloid degeneration that nearly every trace of primitive tissue was obliterated, and the nearest approach possible afforded to a specimen of pure amyloid matter. The altered white waxy material gave a very distinct blue reaction with iodine and sulphuric acid, and under the microscope presented the appearances detailed in our last number. (p. 451.) Having so excellent an opportunity for prosecuting a minute chemical investigation, the able pathologists who record the case proposed for solution the two following questions:—1. Does the amyloid spleen contain an unusual quantity of cholestearine, and if so, is this the cause of the iodized sulphuric-acid reaction? 2. Does the amyloid spleen contain an amylaceous substance chemically related to the starch series, to which such reaction is supposed peculiar? The investigation entered upon gave a negative reply to both these questions. The following were the chemical relations displayed. Cold and boiling water extracted only a trace of albuminous material, the mass acted upon appearing unchanged. Alcohol and ether produced no material alteration, and after their action, sulphuric acid and iodine developed the blue colour even more readily and clearly than before. By boiling fragments for a long time in very weak sulphuric acid, a clear solution was obtained, holding

* Rev. vol. xiv. p. 470.
† Virchow's Archiv, Band xvi. p. 50.

in suspension morsels of the bloodvessels from which the amyloid substance seemed to be extracted. This clear solution of amyloid matter did not reduce an alkaline solution of copper, and therefore contained no sugar; on the contrary, it gave a pale violet hue on the application of Trommer's test, behaving in this respect like an albuminous fluid. In a dilute solution of potash the substance first swelled up, then became transparent, and ultimately by boiling, or merely by long maceration at a lower heat, dissolved, with the exception of the remnants of the bloodvessels, as in the case of the sulphuric-acid solution. The addition of acids to this alkaline liquor let fall a white flocculent precipitate; and in this respect, therefore, it also behaved like a solution of albuminous matter.

Thus far the chemical examination indicated the relation of amyloid to albuminous material; but to make more certain, an ultimate analysis was next undertaken. The purest-looking amyloid was carefully removed and cut up into small pieces; the soluble albumen was extracted, and the residue boiled in dilute and absolute alcohol, and then again in ether. Little was extracted by these means, but this being separated, yielded on analysis a considerable quantity of chloride of sodium, some crystals of leucine, and cholestearine, together with some acicular crystals of fat and oil-drops.

The principal mass left after the removal of the supernatant fluid containing these matters, appeared under the microscope, after the ether had evaporated, in the shape of white granules and flakes, hyaline and formless, mingled with a few relics of bloodvessels. Sulphuric acid and iodine still produced in an equal degree the same blue colour, but it was less permanent; vanishing quickly in the smaller flakes, and in the larger changing to green and then to pale yellow. The remnants of vessels acquired a reddish-yellow hue. Having by mechanical means separated as far as practicable the vascular fragments, the white amyloid matter was next submitted to ultimate analysis, with the following results:—0·1978 parts burnt with chromate of lead, produced 0·3890 of carbonic acid, and 0·1246 of water; 0·2451 parts gave 0·5894 of ammonio-chloride of platinum, indicating 0·0369 of nitrogen. Reducing these results to their equivalents per cent., the composition stands thus: C = 53·58 : H = 7·00 N = 15·04.

Thus a parallel is established with the composition of albumen:—

*Albumen.*

| | Dumas and Cahours. | | | Lieberkühn. | | Rüling. |
|---|---|---|---|---|---|---|
| C = | 53·5 | 53·4 | 53·5 | 53·5 | ... | 53·8 |
| H = | 7·1 | 7·2 | 7·3 | 7·0 | ... | 7·1 |
| N = | 15·8 | 15·7 | 15·7 | 15·6 | ... | 15·5 |

This analysis certainly shows an almost perfect chemical identity between the substance of waxy spleen and albumen, and the very small difference in the proportion of nitrogen in the two sorts of material is certainly not sufficient to establish a different chemical alliance.

The propositions put forward by Friedreich and Kekulé are therefore thus solved:—1. Waxy spleen contains a considerable quantity of cholestearine, but this is not the cause of the reaction with iodine and

sulphuric acid. 2. Waxy spleen contains no matter allied chemically with starch or cellulose.

The pathologists just named conclude their valuable contribution by the following remarks:—That their researches apply actually to only amyloid spleen, and cannot therefore be with absolute certainty regarded as conclusive of the nature of the same matter in other organs similarly degenerated: still they render it highly probable that the condition known as amyloid degeneration, and yielding the distinctive reaction with iodized sulphuric acid, is in all cases only due to a peculiarly modified albuminous material. In farther support of this view, the observations heretofore made on the mode of development of laminated amyloid corpuscles in the pulmonic tissue from coagulated fibrine, may be cited, as well as the detection of amyloid reaction in old fibrinous layers within the sac of an hæmatocele. Although, however (they remark), compelled to refer amyloid matter to the proteine series, yet by reason of its special morphological characters, of its peculiar reaction with iodine, and of its connexion with and indication of a particular constitutional disorder of nutrition, its interest to pathologists will remain unabated, and the term "amyloid degeneration" may with advantage be still retained.

So far as we have proceeded, the weight of evidence is against the hypothesis of a starchy material constituting the basis of the so-called animal amyloid substance the product of disease. And we might on the same side advance it as a farther argument, that though iodine and sulphuric acid may afford a blue colour with cellulose as met with in plant-tissue, it cannot confidently be asserted that, because the same reagents give a similar colour with a particular morbid matter found in animals, such material is necessarily cellulose or a chemical ally of cellulose. Organic chemistry, and particularly animal chemistry, is not sufficiently advanced to enable us to predicate what slight modifications and vital admixtures of organic substances may or may not suffice to vary the effects of tests applied to them, and especially of the fluctuating and less certain colour tests. Thus, in the very instance of the amyloid matter of disease, no *à priori* argument can be raised against the hypothesis that it is an albuminous compound, and, that as such an animal product it can, equally with the cellulose of plants, develop a blue colour with iodized sulphuric acid. But the chemistry of waxy degeneration may receive some elucidation from the chemical history of the corpora amylacea of the nervous system, and of the corpuscles of the prostate gland: for it has been generally taken for granted that it is chemically the same substance in the two. On this supposition the conclusion respecting the chemical nature of the amyloid corpuscles of the brain would involve that of the material of amyloid degeneration, and *vice versâ*. Without at present discussing the truth of the above supposition, the evidence advanced in favour of the amylaceous nature of what we started by calling "corpuscular amyloid" should be here passed under review, but as this has already been done in a preceding paper in the last number of this Journal (vol. xxvi. p. 444 et seq.), very brief notes only are re-

quired. Referring to the paper quoted, it is seen that the corpuscula amylacea of the brain, and of most of those of the prostate, afford with iodine alone a blue colour, identical or almost so with that produced in starch globules; that these corpuscles have concentric laminæ and usually a hilum; that they assume a violet hue with iodine and sulphuric acid; that, according to most observers, they resemble starch granules when examined by polarized light; and more than all, that, in the case of the corpuscles of the prostate, which only are available for the experiment, sugar may be chemically produced from them, and demonstrated by Trommer's test and by fermentation.

Presuming on the accuracy of Paulizky's experiments, no doubt can therefore be raised against the conclusion that the prostatic corpuscles —those at least in the early stages of growth, are really referable to the amylaceous series of chemical compounds. There is, moreover, a general concurrence among observers, that though slight shades of difference may be noted between the "corpuscular amyloid" and both starch and cellulose, as well in physical characters as in chemical reactions, they are chemically allied.

Several eminent microscopists have in fact asserted the exact chemical identity of the corpora amylacea with starch, and Mr. Carter has, whilst indeed denying the presence of cellulose, exceeded all in claiming a universal prevalence of starch grains in the body, as well of man as of many of the lower animals. There is, too, an observation recorded by Mr. Stratford, of Toronto, Canada, of the occurrence of starch granules in the blood of an epileptic patient.*

Mr. Carter's researches appear in the 'Edinburgh Medical Journal' for 1855–56 (p. 130), and for 1857–1858 (p. 789), and the conclusions he draws from them are:

"1. That the presence of starch in the animal body is necessary for the well-being, if not for the preservation of the lives of individuals belonging to the principal groups of animals; as shown by its constant occurrence in well-marked members of those groups. 2. That the corpuscles undergo processes of development, growth, and decay, as proved by their variable dimensions, the diverse conditions of their outward wall, and the different appearances of their contents. 3. That its function is not local but general; as indicated by its tolerably equal dissemination throughout nearly the whole of the textures of the body. 4. That some of the starch found within the organism in its healthy state is apparently functionless and excrementitious; as shown by its presence in the urinary excretion and in the mucus of the bronchial tubes, &c."

This wholesale discovery of starch, as such, throughout the animal economy, implies necessarily a remarkable lack of exact observation among all previous and all contemporary microscopists in their having overlooked it; and in partial explanation of what would be so singular an occurrence, Mr. Carter suggests that many of the apparent globules supposed to be of oil, have actually been starch granules. Few observers, however, are, we believe, inclined to accept Mr. Carter's representation either of the abundance of starch corpuscles in the tissues, or of the important part it plays in the functions of life. The impression is, that he has been led into error; and with reference to

* Journal of Microscopical Science. 1855.

the solitary observation of the Canadian practitioner, neither Virchow nor other pathologists deem it of sufficient weight to enter into the discussion of the presence of amylaceous compounds in the body. It is curious to note that, by substituting zoamyline for starch, in the conclusions deduced by Mr. Carter, these might be read as conveying pretty accurately the prevailing conviction regarding the former substance and its purposes in the system. Letting this pass as a casual remark, we may go on to state that the *accidental* presence of starch corpuscles in microscopical examinations is common, and offers the best explanation of Mr. Carter's statements concerning their wide diffusion.

On this matter M. Rouget enters at considerable length in his able paper, "Des substances amyloides; et de leur rôle dans la constitution des tissus des animaux," * and cites his own experience and that of M. Balbiani. An epitome of the examination of this point is given by Dr. Harris (op. cit. p. 7), who appends his own observations, as follows:

"In examining the epithelial glycogenic papillæ of the amnion of ruminantia, M. Rouget found, when he had crushed the pulpy substance between his fingers, a considerable number of grains of starch; but he found that these grains were always on the surface, never in the substance of the epithelial layers. He suspected from this circumstance their origin; and he found that even after repeated washings, the fingers deposited grains of starch on all surfaces, especially when they were moistened. M. Balbiani found, too, that the most frequent washings could not remove the starch grains from the hands. He therefore washed one of his hands in a solution of potash, and then covered this hand with a glove; at the end of eight hours he could not discover a single grain on the hand which had been thus protected, whilst on his other hand he found the starch grains as numerous as before. M. Rouget found starch grains also in the dust on the outside of windows, on roofs, on stones, in the layer of dust deposited daily in his laboratory, on glass slides exposed to the air; in short, on almost everything to which the ordinary air had access.

"My own more limited experience (subjoins Dr. Harris) tends to confirm that of M. Rouget; for I have certainly found starch granules in the dust of books, on glass slides, and in the scrapings of my hands, but in far less numbers than I was led to suppose from M. Rouget's description. Perhaps the rarity of corn mills in London may account for the difference. In microscopical preparations, too, I have occasionally found a few starch grains, but I never could persuade myself that their presence was other than accidental. On the whole, I think it must be concluded that the presence of starch as starch in the human tissues, is a matter at present 'not proven.'"

This is the conclusion of the majority of pathologists; but it is nevertheless necessary to confirm it by a new series of observations, carried on in an unbiassed manner and with the precaution which the fact above pointed out, of the accidental introduction of the material in debate, indicates to be so necessary. However this question of the distribution of actual starch through the tissues, both in health and disease, be determined, the fact remains, that many prostatic corpuscles are members of the amylaceous series. Moreover, the

* Brown-Séquard's Journal de la Physiologie, tome ii. p. 83.

close analogy between those prostatic corpuscles which offer the amylaceous characters in the highest degree, and the corpora amylacea of the brain, renders it well nigh certain that the latter are of the same chemical nature—a point not capable of determination by the usual modes of chemical examination.

The gist of the inquiry now rests on the admission or the denial of the chemical affinity of the formless amyloid matter of waxy degeneration with that of the foregoing amylaceous corpuscles. This affinity has been universally assumed, chiefly on account of a general agreement between the two varieties of material in their reaction with iodine and sulphuric acid. But the agreement in this respect is by no means perfect, for, as already seen, iodine alone acts quite differently on the two, and when the sulphuric acid is added, there are considerable variations in the colour produced in the granular amyloid not noticed in the corpuscular form. Again: the belief in an affinity between the two is seriously shaken by the results of the proximate and ultimate analyses recorded in preceding pages.

On the other hand, the detection of zoamyline as a normal constituent of animals, renders its production in an abnormal manner a matter of the highest probability; and it may be well to notice here some of the properties of zoamyline, and of other members of the amylaceous group. Likewise, in reviewing the modifications of which starchy matters are capable, it will be instructive to refer to the history of the prostatic corpuscles in their several phases of growth, as put forward by Paulizky.

Glucogene, or zoamyline, when obtained pure, is a whitish, tasteless, inodorous, neutral, non-crystalline powder, insoluble in ether, alcohol, caustic potash, and acetic acid, but soluble in water. In its chemical properties it holds an intermediate place between starch and dextrine; it gives a rosy violet or bluish red, and at times a chesnut-brown colour with iodine; it does not reduce the alkaline copper tests, nor enter into fermentation, but if boiled with dilute mineral acids, or placed in contact with saliva, blood, pancreatic juice, or diastase, it is converted into sugar, which ferments, and reduces Barreswil's solution. When in a state of solution, alcohol and heat coagulate it, or precipitate it in a granular form.

Comparing these chemical relations with those of the amyloid matter obtained from waxy spleen by Friedreich, it will be seen that they are widely different. The latter was dissolved neither in hot nor cold water; when boiled with dilute acid no sugar was generated, nor did it reduce the copper tests; and lastly, it dissolved in liquor potassæ, not only at a boiling, but at a lower temperature. Likewise the amyloid matter obtained by Billroth from diseased lymphatic glands, is stated to have dissolved in caustic potash and in strong sulphuric acid; and, again, neither Carl Schmidt, nor Virchow, has been able to form sugar from the amyloid material of degenerated organs. Lastly, both Friedreich and Schmidt determined the presence of rather more than fifteen per cent. of nitrogen in the amyloid substance they examined.

Now, although the presence of nitrogen and the inconvertibility of amyloid matter into sugar apparently separates it from starch and its immediate allies, still there is an admitted member of the starch series—viz., chitine—which contains nitrogen, and which, moreover—and in this point it agrees with tunicine, another amylaceous compound—may be boiled with dilute acids without the production of sugar; though at the same time it must be stated that by persevering chemical processes, sugar may be formed and fermentation set up in solutions both of chitine and tunicine.

Thus far our review of the chemical relations of the material of amyloid degeneration is unfavourable to the hypothesis of its amylaceous nature. But there are two or three other points connected with the modifying effects of intermixture on the reactions of starchy substances deserving notice. Among the prostatic corpuscles are many which iodine alone does not colour blue, and others again in which this tint does not appear even after sulphuric acid has been superadded.

"As growth proceeds" (writes Paulizky),* the amyloid in the prostatic corpuscles gradually disappears; and in such of them as have advanced to the dimensions of concretions by the addition of calcareous and pigmentary matter, the starchy reaction is no longer discernible."

So again there are corpuscles the centre of which becomes blue with iodine, but the wall of a violet or reddish hue; and others there are, evidently containing albuminous matter, giving a yellow or brown colour with iodine. Thus it is common to see prostatic corpuscles coloured variously by the admixture of blue and yellow in different proportions, under the action of iodine. Moreover, Paulizky failed in his attempts to obtain the evidence of sugar in most such prostatic granules as gave a yellowish-brown colour with iodine.

If we turn to the chemical history of the hydrated carbons—starch and its allies—we notice how, with an isomeric constitution, widely they differ from each other in their behaviour with the same reagents; for example, starch gets intermingled with cellulose, and this becomes modified in a particular manner and converted into lignine, and then no longer exhibits its characteristic reactions, but acquires new chemical features. M. Rouget has pointed out the varieties of vegetable amyloid, which he reduces to two; 1, amorphous or granular, as found in cell-contents; and, 2, in the condition of cell-wall or of intercellular substance—cellulose. The former he considers to be represented in animals by zoamyline; the latter by chitine and tunicine. But besides these, he has remarked on intermediate forms, just such as occur between starch and cellulose in the vegetable kingdom, as for instance the starch of the seed-coats of chelidonium.

From the above facts it may be urged by the advocates of the amylaceous nature of the deposit in waxy degeneration, that though differing much in many of its reactions from zoamyline and other amylaceous matters, it may yet be merely another variety of them; that many of its peculiarities may be due to an intimate, possibly to a chemical

* Virchow's Archiv, Band xvi. p. 147.

mixture of amyloid with albuminous matter; that if it contain nitrogen, it has an admitted parallel among amylaceous compounds in chitine; and that if investigators have hitherto failed to convert it into sugar, it is nothing more than what happened with chitine and tunicine, until a complex process, not yet tried upon it, was invented by M. Berthelot.

With the present amount of knowledge, it is clear no absolute decision can be arrived at on the question whether the material of so-called amyloid degeneration belongs to the starch series. To recapitulate the argument;—the affirmative rests mainly on the general similarity of reaction with iodine and sulphuric acid, between the substance in dispute and cellulose; but it is strengthened by the discovery of zoamyline as an integral element in the animal constitution. On the contrary, the identity between the corpora amylacea of the nervous tissue and of the prostate, and the amyloid matter in degenerated organs, is not proved: since, therefore, the argument by analogy with proved amylaceous corpuscles in the body will not hold good, its relation to starch compounds must be separately shown. Moreover, the strongest evidence of an amylaceous nature, as afforded by iodized sulphuric acid, is *per se* quite unsatisfactory; it cannot be contended that because a certain colour is educed by the test that the substance yielding it is identical with any one or more substances which have a similar coloured reaction. The fallacy of such reasoning may be illustrated by what happens with the cupro-potassic tests (Barreswil's and Fehling's) for sugar—viz., that besides sugar or glucose, glycerine, cellulose, and choloform, though of unlike chemical composition, produce the same reactions. Since the subject was started by Virchow, the hypothesis of the amylaceous nature of waxy degeneration has been pretty extensively accepted; but it appears to us, from the details entered into, elaborated from a mass of scattered papers and essays, that the balance of evidence is against it; still, the whole subject calls for a much more complete examination than it has yet received, and we should be pleased to see it taken up by some of our fellow-countrymen, for British pathologists and chemists have hitherto, with but one or two exceptions, entirely neglected the whole subject of amyloid degeneration, both in its pathological and chemical aspects.

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## Review VII.

*Mémoires de l'Académie Impériale de Médecine.* Tome vingt-troisième, accompagné de quinze planches.—*Paris*, 1859. 4to, pp. clxviii. et 515.

*Memoirs of the Imperial Academy of Medicine.* Vol. xxiii.

Passing by an official Éloge upon M. Guéneau de Mussy from pen of M. F. Dubois, the secretary, we come to,

I. M. Trousseau's *Report on the Epidemics which prevailed in France during* 1857.—He reiterates the complaint made by all former reporters, that the insufficiency and imperfection of the materials placed