A RÉSUMÉ OF MODERN VIEWS ON GASTRIC DIGESTION.

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THE complex nature of the gastric mechanism renders the discovery of its inner workings a matter of ever-increasing toil to the experimental physiologist. To the medical man, unless his treatment is to be largely empirical and the results thereof uncertain, the need of a proper understanding and appreciation of the circumstances which control or influence the march of digestion in the normal stomach becomes each day more pressing. Fortunately, recent experience of the behaviour of the organ in health supplies him liberally with the means from which to form a rational basis for his therapeutical measures when called upon to remedy its distorted functions in disease. It is the purpose of the present article briefly to pass in review some important facts in connexion with this subject which have lately found light in the Lausanne laboratory.

Since the introduction by Pawlow of improved methods for accurately observing the phenomena of digestion on the living animal the physiology of the subject has made immense strides. The advance of knowledge has chiefly been in the direction of ascertaining how far the gastric function is influenced by the foodstuffs habitually ingested by the organism. Many years ago Schiff entered deeply into the subject of these influences, but, possessing no method of determining, even approximately, the amount of juice secreted under given conditions, his researches were necessarily restricted. For him there were but two possibilities—viz., either simple gastrotomy or infusions of the mucous membrane. The first proceeding enabled him to measure the power of the juice, as judged by the progress of digestion in the interior of the stomach; the second to measure the amount of pepsin to be found in the mucous membrane after the death of the animal. Nowadays, the classical operation of Pawlow affords a trustworthy method whereby the quantity and quality of the juice secreted under certain experimental conditions may be accurately estimated. As is well known, the operation consists in forming from the fundus of the stomach a diverticulum retaining its nerve-supply both from the vagus and sympathetic; its nerves being intact, this cul-de-sac works and rests in unison with the rest of the organ and furnishes a quantity of absolutely pure juice proportional to the extent of its surface. It is then possible, by digestions *in vitro*, to estimate the digestive capacity of juice received direct from the living animal.

Schiff's experiments and the conclusions derived by him therefrom are too well known to need recapitulation here. Those of the latter which more nearly concern our present subject may be summed up as follows. 1. That the gastric mucous membrane can, by a suitable and adequate meal, be entirely exhausted of its holding in pepsin. 2. That while certain "indifferent" foodstuffs exercise no influence whatever either upon the quantity or the quality of the juice secreted at the time of their ingestion there are others which possess in a marked degree the property of furthering the formation of pepsin. Among the 27 foodstuffs examined by him 12 proved themselves to be more or less positive in this respect; he accordingly termed them "pepsinogenes." They are as follows: (1) raw meat, (2) watery meat extract, (3) meat broth, (4) bone gelatin, (5) bread, (6) watery extract of bread, (7) dextrin, (8) certain peptones, (9) cheese, (10) watery extract of small peas, (11) watery extract of linseed, and (12) black coffee.

In contradistinction to these, the pepsin-forming substances, Pawlow's experiments on dogs have led him to the discovery of another class of substances possessing the property of calling forth the rapid and copious secretion of juice normally rich in acid, but producing no corresponding increase in the amount of pepsin; these substances are called by him juice-forming or "succagogues." Out of 16 foodstuffs examined the following eight were found to possess this property: (1) raw meat, (2) meat-juice, (3) broth, (4) meat extract (Liebig), (5) milk, (6) gelatin, (7) certain peptones, and (8) water (in large quantities).

Now, a comparison of this list with the preceding one reveals the striking fact that the majority of the substances

described by Pawlow as "succagogues" are identical with those to which Schiff ascribed pepsinogenic properties. One would thus be led to suppose that these substances (or at any rate those of them which had been examined by both observers) were possessed of the double property, pepsin-forming and juice-secreting—or, in other words, that these two properties were identical. But a closer examination of the experiments of the respective observers brings to light the fact that these two classes of substances differ in one very important respect. Whereas the "pepsinogenes" of Schiff retain their action when absorbed from the rectum, the "succagogues" of Pawlow work only when brought into actual contact with the gastric mucous membrane, their action being entirely negative when administered *per anum*. It thus appears that the "pepsinogenes" exercise their influence through the agency of the blood and the "succagogues" through that of the nervous system.

It now occurred to Herzen that there might possibly exist substances possessing entirely or in great part the one or the other property. It so happened that Schiff had never experimented with Pawlow's most active "succagogue" (Liebig's extract), nor had Pawlow tested the "succagogic" properties of Schiff's principal "pepsinogene" (dextrin). With the object, therefore, of testing these two substances equally in both directions Herzen undertook a series of comparative experiments, of which the following may be considered typical. Pawlow's operation was performed upon a young, well-conditioned dog weighing 40 kilogrammes. The operation failed, however, in this respect—that in spite of every care the stomach fibres of the vagus appeared to have suffered injury. The possibility of this accident was suggested by the observations that the animal showed no trace of psychical reflex. As it happened, the absence of the latter was a distinct advantage, since its presence would have become a considerable hindrance to the determination of the possible secretory power of the "pepsinogenes"; indeed, it would have been necessary to counteract this disadvantage by an œsophagotomy, a proceeding demanding constant and elaborate care. The dog made a rapid recovery and the gastric cul-de-sac was found to carry out its functions satisfactorily.

It would be as well to diverge at this point from the account of the experiments performed on this animal in order to emphasise the importance of certain experimental conditions necessary to be fulfilled before the experiments themselves could be of any value. The holding in pepsin of the gastric mucous membrane at a given moment obviously depends upon the amount of pepsin formed by the previous digestion and how much of it has been secreted; in other words, on how much true pepsin (not propepsin) has remained over in the mucous membrane. If, then, the observer contents himself with merely taking the animal in a fasting condition, without regard to the quantity and quality of the last intake of food, he obtains, as chance may direct, a juice of less or greater activity. Since there may be pepsin remaining over from the previous digestion, by what method may the experimenter determine how much of the quantity present in the juice is newly formed as the result of the action of the substance experimented with, or even if this substance has in any way contributed to this new formation? The value of this quantity can only be accurately determined by ensuring the apeptic condition of the mucous membrane at the time of the experiment; this has been found to be the case when, from 14 to 18 hours before the experiment, a copious preparatory meal is given to the animal, the stomach being compelled in this manner to throw out the whole quantity of pepsin formed during the digestion of the meal. In order that its stomach might be in the apeptic condition in the morning, when the experimental meal was given and the juice collected, the Lausanne dog received its preparatory meal every evening between five and six o'clock. Some idea of its appetite may be gathered from the fact that the latter meal consisted, as a rule, of 1500 grammes of horseflesh boiled in water and given to the animal together with its broth and 3000 grammes of half-liquid polenta. The dog then received nothing except fresh water until between eight and nine o'clock on the following morning (16 hours after the preparatory meal) when the experimental meal was given. Now this latter meal had to be of such a nature that its main mass was composed of an "indifferent" substance—i.e., a substance the ingestion of which provoked the secretion of juice minimal in quantity and

activity. Both Schiff and Pawlow had been in the habit of employing for this purpose boiled meat washed out in running water, or coagulated albumin; after experimenting with various foods Herzen discovered an excellent material in polenta given in a half-liquid form. To this were added 50 grammes of the substance the properties of which it was desired to determine; when occasion demanded it the latter could also be administered per anum. The juice flowing from the gastric cul-de-sac was then received into a graduated vessel. In the summer of 1900 over 100 experiments were carried out in this manner on the same dog. The following are some of the more important results.

1. *July 30th.*—The preparatory meal was given on the previous evening at five o'clock. This morning at eight o'clock the experimental meal was given, consisting of polenta alone. The beginning of secretion was at nine o'clock. 10 cubic centimetres of juice were collected at 10 o'clock; the same digested 1.5 cubic centimetres of albumin. The result was little juice and very little pepsin.

2. *August 3rd.*—The preparatory meal was given on the previous evening at five o'clock. This morning at 8.30 the experimental meal, with the addition of 50 grammes of dextrin, was given. The beginning of secretions was at 8.50 A.M. 10 cubic centimetres of juice were collected at 9.10 A.M. and 45 cubic centimetres at 10.50 A.M. Digestion of the first, 10 cubic centimetres and six cubic centimetres of albumin; that of the last, 10 cubic centimetres of albumin. The result was very much more juice and considerably more pepsin.

3. *August 4th.*—The preparatory meal was given on the previous evening at five o'clock. This morning at nine o'clock the experimental meal, of polenta alone, was given. The beginning of secretion was at 9.20 A.M. 10 cubic centimetres of juice were collected at 9.30 A.M., when an enema of 50 grammes of dextrin in 200 grammes of water was given. Further 25 cubic centimetres of juice were collected at noon. The first 10 cubic centimetres digested 2.5 cubic centimetres of albumin, the last 10 cubic centimetres digested 10 cubic centimetres of albumin. The result was less juice than in the case of No. 2, but still more pepsin.

4. *August 15th.*—The preparatory meal was given on the previous evening at five o'clock. This morning at eight o'clock the experimental meal, with the addition of 35 grammes of Liebig's extract, was given. The beginning of secretion was at 8.50 A.M. The first portion (10 cubic centimetres) of juice was collected at 9.15 A.M. At 11 o'clock a further 25 cubic centimetres had been collected. The first 10 cubic centimetres digested three cubic centimetres of albumin; the last 10 cubic centimetres digested six cubic centimetres of albumin. The result was a large quantity of juice containing a moderate holding of pepsin.

5. *August 21st.*—The preparatory meal was given on the previous evening at five o'clock. This morning at 8.30 the experimental meal, of polenta alone, was given. The beginning of secretion was at 8.45 A.M. Five cubic centimetres of juice were collected at 9.25 A.M., when an enema of 20 grammes of Liebig's extract in 200 grammes of water was given. At 11.25 A.M. a further 10 cubic centimetres of juice were collected. The first five cubic centimetres digested one cubic centimetre of albumin (10 cubic centimetres = two cubic centimetres of albumin); the last 10 cubic centimetres digested eight cubic centimetres of albumin. The result was little juice with rather high pepsin holding.

It will be apparent from these five examples of Herzen's experiments that, when given in *large doses* by the mouth, the meat extract and dextrin act both as "succagogues" and "pepsinogenes"—i.e., that the copious ingestion of either of them suffices to produce the double effect of more juice and increased pepsin holding. It is obvious, however, that the administration of a dose of Liebig's extract sufficient to ensure its action in both these directions would of itself give rise to pronounced digestive disturbances, and that, instead of being assisted, digestion would quickly become deranged by this treatment. A similar drawback attends the employment of large doses of dextrin, the disagreeable flavour of which soon becomes objectionable to the patient. In order, therefore, to avail himself successfully of this line of treatment the therapist must take advantage of a further remarkable fact brought to light by Herzen's experiments. It is found that, when given in *small doses* the pepsinogenic property of the meat extract and the secretory property of the dextrine tend to disappear; in other words, owing to the

diminished force of their converse properties, the meat extract and the dextrin tend respectively to become a true "succagogue" and a true "pepsinogene." By prescribing, therefore, small doses of one or both of these substances the therapist may modify, according to the needs of his patient, the quantity and composition of the juice secreted.

It has been mentioned earlier that the "succagogues" lose their secretory property when caused to be absorbed from the rectum. A brief glance at Experiment No. 3 in the foregoing series reveals a surprising fact in connexion with the administration of dextrin in this manner: it will there be seen that all influence in the direction of increased secretion of juice becomes lost, the pepsinogenic property of the substance being alone retained.

We have now to consider the question, Do there exist substances possessing *exclusively* the one or the other property? The latest work in the Lausanne laboratory points conclusively to a reply in the affirmative. Radzikowsky, Herzen's assistant, and Madame Mark-Schnorf, one of his pupils, have recently devoted their attention to this subject; the former has succeeded in discovering a true "succagogue" and the latter two "pepsinogenes." The work of Radzikowsky has shown that ethyl alcohol is a pure juice-expelling substance devoid of any trace of pepsin-forming properties. Experimenting in the manner above described, he finds that when the stomach has been thoroughly exhausted of its pepsin by a proper preparatory meal, the acid juice secreted by the action of alcohol is as good as pepsin-free. The alcohol, however, does not hinder the transformation of the pro-pepsin into pepsin under the influence of a pepsinogenic substance, since, when dextrin is at the same time caused to be absorbed from the rectum, the secretion of a juice rich in pepsin is obtained. It is a remarkable fact that, when administered per anum, alcohol also exercises a certain succagogic influence. This action would appear to be an elective one on the gastric mucous membrane, since, unlike pilocarpine, its administration causes no secretion from the other glandular structures of the body. In ethyl alcohol we thus have an exception to the general rule above enunciated that juice-expelling substances work only through the agency of the nervous system; it is quite possible that further research will reveal others possessing a like property. The results of Madame Mark-Schnorf show that inulin and glycogen, carbohydrates closely allied to dextrine, even when given in large doses, are pure pepsinogenes, exhibiting no trace of secretory action. Another remarkable fact gleaned from the experiments of this observer is that the white, so-called pure dextrin, exercises no influence whatever, either pepsin-forming or juice-expelling, on the gastric mucous membrane, these properties being entirely confined to the yellow dextrine of commerce.

The practical importance of these researches may be estimated from the under-mentioned examples representing the average variations in activity of the stomach under the conditions already discussed. 1. After a meal consisting of "indifferent" food-stuffs such as boiled and washed-out meat or coagulated albumin, 10 cubic centimetres of juice may be secreted by the stomach in one hour; these 10 cubic centimetres will barely digest one cubic centimetre of albumin. 2. After a similar meal to which has been added a juice-expelling substance, 50 cubic centimetres of juice are secreted in one hour. A portion of 10 cubic centimetres taken from this juice will digest one cubic centimetre of albumin; thus the whole hour's secretion digests five cubic centimetres instead of one cubic centimetre. This is already a great advantage for the digestion. 3. After a meal similar to No. 1, to which has been added a pepsinogenic substance, barely 10 cubic centimetres of juice are obtainable in one hour, but these 10 cubic centimetres digest, say, six cubic centimetres of albumin. This also is a great advantage for the digestion. 4. Finally, after a meal similar to No. 1, to which has been added both a juice-secreting and a pepsinogenic substance, 50 cubic centimetres of juice can be collected in one hour, of which each 10 cubic centimetres digests from five to six cubic centimetres of albumin—i.e., in all from 25 to 30 cubic centimetres. Here the advantage for the digestion is enormous, it being from 25 to 30 times stronger than in the first case and from four to five times stronger than in the second and third cases.

These results tend to throw some light upon the fact that the juice furnished by a normal stomach is always in sufficient quantity and contains enough pepsin to bring about the digestion of an ordinary meal. The majority of

the foodstuffs contain secretory and pepsinogenic principles sufficient to call forth the secretion of a juice adequate for their digestion; those foodstuffs which do not initially do so nevertheless furnish them during digestion by virtue of the chemical changes which they undergo within the stomach. Natural feeding thus offers ample means for putting digestion in motion. Once started, its march becomes each moment more rapid until the culmen is reached when, owing to accumulation of its products, it begins to decline. There can be no doubt, however, that without unduly fatiguing the stomach its digestive capacity may be considerably raised by the ingestion of those principles the properties of which we have been considering. The importance of this fact becomes emphasised when dealing with the diseased or functionally inactive organ. Since their action is to raise the digestive capacity of the stomach two- or three-fold the administration of these substances becomes a therapeutical measure of immense value. It is not to be imagined that the clinical importance of their results remained unrecognised by Schiff and Herzen. Though their knowledge was limited to the power of the pepsin-forming substances yet they did not fail to realise the fact that in this class alone they possessed a potent means of control over the more commonly occurring forms of gastric derangement. Indeed, the favourable influence exercised on these cases by the "pepsinogenes" was repeatedly tested and confirmed by them. They found, for instance, that in obstinate cases of hyper-acidity almost immediate relief could be afforded by restoring the normal balance of acid and pepsin in the juice by the administration of a pepsin-forming substance. Thus, the excess of hydrochloric acid, formerly causing such distressing symptoms, was utilised for the benefit of the organism.

The advantages in other directions of this control over the composition of the juice are so obvious that their recapitulation becomes almost superfluous. There seem, however, to be pathological or semi-pathological conditions in which this simple form of treatment becomes more especially indicated. An instance may be found in pyloric constriction where, on account of the suspension or deficiency of intestinal digestion, malnutrition forms a prominent and troublesome symptom. In these cases, by means of suitable stimulation, a large proportion of the work performed by the duodenum may be thrown upon the stomach and by this means the general nutrition may be correspondingly improved. Again, in the fatigued condition of the stomach during convalescence from acute diseases, when, in spite of the relative integrity of the digestive function, the work of the stomach is not carried out with sufficient energy to maintain the increased metabolism demanded by the enfeebled system, the organ may be stimulated to increased exertion and, by its initiative, may incite the other factors in the digestive cycle to renewed activity. Further, relief may be obtained in obstinate cases of infantile dyspepsia due to the interruption or perversion of natural means of nutrition, with consequent emaciation of the child; in a large percentage of such cases malnutrition is the result of a resort to artificial feeding. The treatment of the acute dyspepsia arising from this cause by the simple means of mixing broth with the child's milk has long been known as an empirical preventive measure; but its *rationale* becomes apparent only when it is known that meat broth, by virtue of its activity in the double sense of pepsin-forming and juice-secreting, has the property of promoting the rapid and copious secretion of a juice rich in pepsin.

The simple and even nourishing nature of the substances which may be employed to further the production either of juice or pepsin is a great consideration in favour of their use under the circumstances above enumerated. Nature is, so to speak, assisted through the agency of her own materials; food is necessary for the maintenance of life, and it should be the aim of the therapist to remedy the cause of disordered digestion through the natural channel offered by alimentation rather than by the more artificial, but in no way more scientific, resources of pharmacodynamics. Further, owing to the facility attending the administration of these pepsinogenic substances per rectum the stomach does not become surcharged with materials which can be equally well absorbed elsewhere; by this means also the whole energy of the remedial agents is secured to the performance of its allotted task, no part of it being held back by the process of digestion. Personally I have seen nothing but good result from this line of treatment. The combination of dextrin and Liebig's

extract or of dextrin and alcohol is especially to be recommended. The efficacy of dextrin alone in cases of insufficient production of pepsin is surprising and in no case has its administration been known to produce unpleasant results. A very large proportion of the knowledge derived from these researches should, however, be applied in avoiding harmful modes of nourishment in those cases where the cause of the trouble is already recognised by the medical man. It is perfectly obvious, for instance, that in cases of hyper-acidity no substance known to be "succagogue" should be ordered to be taken, since the symptoms of the patient would only be aggravated thereby. By the observance of rules such as this a rational line of treatment can be marked out to suit the requirements of almost any type of gastric disorder.

Lausanne.

A DILATED SUPERFICIAL ABDOMINAL VEIN WITH A SUGGESTIVE HISTORY.

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THE accompanying illustration is reproduced from the photograph of a mentally deficient girl who attended the out-patient department of the Bristol Children's Hospital under my care. A large superficial vein was found running upwards over the right half of the abdomen. The history of its appearance is interesting and may be considered to lend some support to one of the theories of the causation of infantile hemiplegia. At the age of one year and seven months the child was seized with convulsions and remained unconscious for about a week, but no loss of power in either arm or leg was apparently present.¹ Towards the end of the week the right leg and thigh were swollen and the dilated abdominal vein was noticed to have appeared. The girl is said to have been bright and intelligent at the time of the attack and to have been able to say a few words. After recovery of consciousness no attempt was made to speak for more than two years and the girl, now 10 years of age, is still unable to read. She is of cheerful disposition and on good terms with her brothers and sisters, but has not sufficient intelligence to be entrusted by her mother with the most simple errand. No indication of weakness of either side of the face is present and there is no defect of sight or hearing. There is no weakness of either arm or leg and the knee- and elbow-jerks and reflexes are equal on the two sides. The vein seen in the illustration runs upwards from the centre of the right groin to the costal margin, where it divides into several branches which spread over the front of the right half of the chest, some reaching nearly as high as the clavicle. Below the point of division the vein nearly equals an ordinary penholder in diameter. The blood in it flows upwards. When emptied from above it remains empty, but it immediately fills on removing the pressure of the finger. The girl has five brothers and sisters, two of whom have attended the hospital as out-patients. One boy has had empyema following pneumonia, but mentally and physically they present no defect. In this girl also the head is well-shaped and she is tall rather than short for her age. There is nothing to suggest congenital syphilis. A further detail in the history may be worthy of mention. The mother attributes the attack of convulsions to the falling of the child into a dirty stream about three weeks before their onset. The child was nearly drowned, and after being pulled out she vomited a considerable quantity of water which had been swallowed.

In this case there has obviously been blockage of the

¹ Recently in going through my notes I discovered that this girl had been seen by me in August, 1896. The history then given by the mother in the main is the same as that recorded here, but a few additional facts of importance are mentioned. At the onset of the unconsciousness there are said to have been twitchings of the right side of the face and the mouth was drawn to the right side. Jerking movements were also present in the right arm and the right leg. The child could not walk for five or six weeks after the attack and then limped on the right side. At the time she attended the out-patient department she was said to be using the left hand in preference to the right, but no weakness of the grasp of the right hand could be detected. She was then commencing to say a few words, but was said to have been able to speak better before the attack, since which more than three years had elapsed.