Dr. Frankel, in discussing Professor Cochran's paper, stated that the subject was one of extreme importance. In Pennsylvania the sale of oleomargarine was prohibited, and, as a result, this compound and other mixtures of fats were constantly being sold as pure butter. Dr. Frankel stated that the tests used by Professor Cochran for the detection of cottonseed oil had given him satisfactory results. In reference to the use of this oil for "Butter Ripener," the results obtained on a large scale did not agree with those obtained by Professor Cochran, since there was no appreciable increase in the yield of butter. Dr. Frankel attributed this to the fact that relatively smaller quantities of cottonseed oil had been used by the manufacturer than were used by Professor Cochran.

In conclusion, Dr. Frankel stated that the microscopic examination of butter and butter compounds obtained from solutions of amyl alcohol, which Professor Cochran had made, were of interest, and hoped that subsequent work would enable the latter to work out a plan of analysis by this method.

Stated Meeting, December 20, 1898.

DIGESTIVE FERMENTS WITH ESPECIAL REFER-
ENCE TO THE EFFECTS OF FOOD
PRESERVATIVES.

BY HENRY LEFFMANN, Member of the Institute.

In strict definition an enzyme or digestive ferment is a non-living nitrogenous organic body, which has the power to transform other organic bodies without losing its own identity or exhausting its functions. In the cases that have been most thoroughly studied, one or more molecules of water are condensed in the reactions and the process is called hydrolysis. It is this phase of enzyme action that I will discuss to-night. A few enzymes are now known, and the study of biologic chemistry indicates the existence of many others. Indeed, it is not unlikely that the entire

series of phenomena that we designate collectively as "life" is governed by hydrolytic or closely analogous changes. Enzymes, themselves, have some of the characteristics of living organisms. They are restrained in their action by apparently slight influences, may recover when these influences are withdrawn or may be injured beyond recovery. When thus "killed," as we may call it, they are not seemingly decomposed, but have simply lost an activity that they once possessed. They do not multiply, and have no particulate existence, hence cannot be classed as living organisms. They seem, indeed, to stand as the connecting link between living and non-living matter, but I need not enter into this question here.

We find evidence of a belief at an early period in the existence of so-called ferments, even in inorganic chemistry. Some of the ancient metallurgists thought that the precious metals might be obtained by mingling a fermenting or converting substance with the baser material, and in modern chemistry we see some common instances. Thus, a minute amount of iodine will convert a mass of common phosphorus into red phosphorus. It has been stated on good authority that a perfectly dry mixture of carbon monoxide and oxygen will not explode by the action of an electric spark, but if a trace of water be present, the whole mixture is at once fired. The influence of manganese oxide or ferric oxide upon potassium chlorate is a familiar instance of a quasi-ferment action.

True hydrolysis, however, belongs to the domain of organic chemistry, and is the change which determines the liberation of the potential of various food articles or renders such food articles diffusible. In most cases the reactions are too little understood in detail to be represented in symbols. In no case can we indicate the exact formation of the enzyme; indeed, it is not yet sure that any enzyme has been obtained in the pure state.

Obviously a study of enzymes has an important bearing upon the chemistry of digestion. Our laboratory methods are, however, such imperfect imitations of natural methods, that we must be careful how we draw inferences from re-

sults obtained in test-tubes or flasks. Many conditions obtain in natural digestion which we can imitate only imperfectly or not at all in the laboratory. There are, for example, the kneading motion, the influence of nerve supply and the constant removal of the products of digestion by osmose.

Studies of the action of various enzymes have been made by many observers. My own experiments have been chiefly with regard to the interfering action of certain food preservatives especially on starch digestion. The food preservatives commonly used are salicylic acid, sodium benzoate, boric acid, borax, sodium fluorid, sodium silico fluorid and formaldehyde.

The experiments on starch digestion were made as far as possible under uniform conditions. A starch solution, 10 grams to the liter, was made fresh each day by the usual method. Arrow-root starch, which is especially adapted to such investigations, was generally used.

The first series of experiments was qualitative only; that is, the amount of sugar or dextrin formed was not determined, but merely the presence or absence of starch, and whether the dextrin was in its fully developed condition or only in the initial stages. These facts are determined by a solution of iodine and potassium iodide in water. This produces a red color with the dextrin first formed, a pale yellow with the fully formed dextrin, and a greenish tint with very small amounts of starch. These tests are preliminary only. Much more information is obtained by determining the amount of sugar formed, and this was done in a number of cases, as will be noted. Many experiments that are in the laboratory record are not reported, being merely duplicates or vitiated by some accidental error. All weights are in milligrams. Short tests (*e. g.*, one hour) were made at about blood heat; when the liquids were allowed to stand over night, it was at room temperature. The commercial form of the antiseptic was used unless otherwise specified. The enzymes were all in good condition. The following is a description of the enzymes used:

(1) *Malt Diastase*.—An active form obtained from Merck & Co.

(2) *Taka-diastase*.—The recently introduced enzyme; an active starch-transforming agent. It was used both in the powdered form and in active solution. Both preparations were from Parke, Davis & Co.

(3) *Pancreatic Extract*.—A solution prepared by Parke, Davis & Co.

(3) *Peptenzyme*.—A preparation in form of powder, made by Read & Carnrick, and containing all the digestive enzymes of the alimentary tract.

(5) *Carase*.—The enzyme of the papaw; the preparation used was that sold under the trade-name "caroid."

Some experiments were made with the pine-apple ferment and also with pepsin, but the results are not worth reporting.

Antiseptic.		Taka-Diastase.	Results.
None	—	II	Starch all converted.
Saccharin	10	II	Some starch present.
Saccharin	50	II	Much starch present.
Carase.			
None	—	20	Starch all converted.
Saccharin	10	20	Much starch present.
Peptenzyme.			
None	—	20	Starch all converted.
Saccharin	50	20	Much starch present.
Beta-naphthol	10	20	Starch all converted.
Taka-Diastase.			
Beta-naphthol	10	II	Starch all converted.
Formalin	3 c.c.	II	Starch all converted.
Pancreatic Solution.			
Formalin	1 c.c.	I c.c.	Much starch present.
Taka-Diastase.			
None	—	10	Starch all converted.
Artificial benzoic acid	100	10	Faint trace of starch.
Artificial benzoic acid	50	10	Starch all converted.
Natural benzoic acid	100	10	Starch all converted.
Artificial sodium benzoate	100	II	Starch all converted.
Malt Diastase.			
Benzoic acid	100	20	Much starch present.
Benzoic acid	50	20	Starch all converted.
Sodium benzoate	100	20	Starch all converted.
Boroglycide	3 c.c.	20	Starch all converted.

Pancreatic Solution.

None	—	3 c.c.	Starch all converted.
Salicylic acid	50	3 c.c.	Much starch present.
Benzoic acid	50	3 c.c.	Much starch present.
Benzoic acid	10	3 c.c.	Starch all converted.
Sodium benzoate	100	3 c.c.	Starch all converted.
Sodium carbonate	—	3 c.c.	Much starch present.
Citric acid	—	3 c.c.	Much starch present.

Carase.

Salicylic acid	10	30	Much starch present.
Benzoic acid	100	30	Starch all converted.
Sodium benzoate	100	30	Starch all converted.
Boroglycide	0.5 c.c.	30	Much starch present.

Taka-Diastase.

Boric acid	200	11	Starch all converted.
Boric acid	100	11	Starch all converted.
Boric acid	50	11	Starch all converted.
Borax	200	11	Starch present.
Borax	50	11	Trace of starch present.
Boroglycide	3 c.c.	11	Starch all converted.
Tartaric acid	25	11	Some starch present.
Citric acid	100	11	Much starch present.
Citric acid	25	11	Starch all converted.

Malt Diastase.

Borax	50	—	Much starch remaining.
Borax	25	—	
Boric acid	25	—	Much starch remaining.
Borax	25	—	

Taka-Diastase.

Boric acid	25	—	Starch all converted.
Boric acid	50	—	

Pancreatic Solution.

Borax	50	—	Starch all converted.
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Peptenzyme.

None	—	—	Trace of starch present.
Boric acid	25	—	
Borax	25	—	Much starch present.
Boric acid	20	20	Starch still present.
Borax	20	20	Starch still present.

Pancreatic Solution.

Boric acid	100	1 c.c.	Very faint trace of starch.
Boric acid	20	1 c.c.	None.
Borax	100	1 c.c.	None.
Borax	20	1 c.c.	None.
None	—	1 c.c.	Starch all converted.

		Carase.	
Boric acid	100	20	Starch present.
Boric acid	50	20	Starch converted.
Borax	10	20	Starch present.
Boric acid and borax, each	25	20	Starch present.
Boric acid and borax, each	10	20	Starch all converted.
None	—	20	Starch all converted.
Sodium silicofluorid . .	10	20	Trace of starch present.
Sodium silicofluorid . .	50	20	Much starch present.
		Malt Diastase.	
Sodium fluorid	100	20	Starch all converted.
Sodium silicofluorid . .	100	20	Starch all converted.
		Taka-Diastase.	
Sodium fluorid	25	11	Starch all converted.
Sodium silicofluorid . .	25	11	Starch all converted.
		Pancreatic Solution.	
Sodium fluorid	10	1 c.c.	{ Solution rendered perfectly clear, but starch not converted.
Sodium silicofluorid . .	25	1 c.c.	
			{ Starch solution remains cloudy.

EXPERIMENTS TO DETERMINE AMOUNT OF SUGAR FORMED.

Starch solution, 10 grams to 1 liter, 50 cubic centimeters used in each experiment, all solutions diluted to 150 after digestion.

(1) Salicylic acid	50	Taka-diastase	11
(2) Sodium benzoate	50	Taka-diastase	11
(3) Saccharin	50	Taka-diastase	11
(4) Boric acid	50	Taka-diastase	11
(5) No antiseptic	50	Taka-diastase	11

(1) Shows starch reaction strongly and only traces of sugar; 133 cubic centimeters of the solution do not reduce 10 cubic centimeters of copper solution equivalent to 0.046 dextrose.

(2) No starch present; much sugar formed.

(3) Much starch present; traces of sugar.

(4) No starch present; much sugar formed.

(5) No starch present; much sugar formed.

		Pancreatic Solution.	
(6) Salicylic acid	50	1 c.c.	No sugar formed.
(7) Sodium benzoate	50	1 c.c.	Much sugar formed.
(8) Saccharin	50	1 c.c.	No sugar formed.
(9) Boric acid	50	1 c.c.	Much sugar formed.
(10) None	—	1 c.c.	Much sugar formed.

Measured by Fehling's solution volumetrically, Nos. 7, 9 and 10 showed the same amount of sugar.

Pancreatic Solution.			
(11) Salicylic acid	50	3 c.c.	No sugar formed.
(12) Sodium benzoate . .	50	3 c.c.	Much sugar formed.
(13) Saccharin	50	3 c.c.	Trace of sugar formed.
(14) Boric acid	50	3 c.c.	Much sugar formed.
(15) None	—	3 c.c.	Much sugar formed.

Tested by Fehling's solution, Nos. 12, 14 and 15 showed the same quantities of sugar; no starch was present. Starch was abundantly present in Nos. 11 and 13; in the latter it was well liquefied, but not in the former.

EXPERIMENTS UPON DIGESTION OF PROTEIDS.

The information on this phase of the question is still very incomplete. The products of proteid digestion are much more complex than those of starch digestion, and the detection and estimation of the different substances are much more difficult. The action of pepsin is peculiar in that it requires a distinct amount of acid. Pancreatic digestion, on the other hand, is promoted by alkalies and is restrained by acids. Chittenden found that even after two weeks' continuous action of a mixture of hydrochloric acid and pepsin made in close imitation of human gastric juice, only a little more than half of the proteid was converted in peptone; that is, had been fully digested.

The general conclusions that may be drawn are:

Salicylic acid in all its forms, *i. e.*, natural, crude commercial and refined commercial, is distinctly antagonistic to most enzymes, especially those that convert starch. There seems to be no reason to believe that the natural form of the acid will be less objectionable than the artificial in this respect, even if its price does not exclude its use.

Sodium benzoate is without appreciable interfering action, and as its preservative action is undoubted and its disagreeable taste will prevent its liberal use in any food article, it seems to be well adapted for general use.

Boric acid and borax show but little interfering action with either starch or proteid digestion. Boroglycide seems also to possess but little interfering action.

Beta-naphthol interferes with the action of malt-diastrase, but not seriously with taka-diastrase or pancreatic extract.

It interferes very decidedly with peptic and pancreatic digestion of proteids.

Sodium fluorid has but little interfering action with starch transformations, but sodium silicofluorid interferes decidedly with pancreatic extract.

Salicylic acid does not interfere seriously with proteid digestion.

Concerning the effects produced upon the human system by long continued administration of small doses of common food preservatives, we have, as remarked above, but little information. Some German investigators have studied the action of salicylic acid in this respect, notably Kolbe, who discovered the synthetic method of preparing it. He found no appreciable injurious effect, but he probably used a purer article than is often found in commerce. Experiments on lower animals are numerous. Among the most recent of these is a contribution by R. A. Chittenden and W. O. Gies, of Yale University (*Amer. Jour. of Phys.*, Vol. I, No. 1), detailing an extended study of boric acid and borax on the nutritive and excretive functions of dogs. All the data are given in the report, and great care was taken in the experiments. Among the conclusions are the following:

Moderate doses of borax, up to 5 grams per day, even when continued for some time, are without influence upon proteid metabolism, and do not exert any specific nutritional changes. Under no circumstances, so far as we have been able to ascertain, does borax tend to increase body weight or to protect the proteid matter of the tissues.

Boric acid in doses up to 3 grams per day is practically without influence upon proteid metabolism and upon the general nutrition of the body.

Borax, when taken in large doses, tends to retard the assimilation of proteid and fatty foods, increasing notably the weight of the feces and their content of nitrogen and fat. With very large doses there is a tendency toward diarrhoea, an increased excretion of mucus. Boric acid, on the contrary, in doses up to 5 grams per day, is wholly without influence in these directions.

Both borax and boric acid are rapidly eliminated from

the body through the urine, twenty-four to thirty-six hours being generally sufficient for their complete removal.

In this connection I wish to read an extract from an English journal, *Food and Sanitation*, which, although representing, of course, the English point of view and methods, yet is largely applicable to the situation everywhere, and expresses, to a great extent, my own views :

"Ever since the advent of the Food and Drugs Act difficulties have arisen as to the interpretation that should be put upon certain clauses, and, despite numerous amendments, many of these difficulties still pertain.

"Of late a new phase of the question has predominated, in that attention has been directed not only to actual adulterants, but substances which are used as preservatives.

"It appears that Dr. Hill, the Birmingham Medical Officer of Health, has arrived at the conclusion that the use of chemical preservatives ought to be prohibited altogether, because they enable foods to be sold as fresh which are stale, and which have undergone such putrefactive changes as to make them frequently harmful, and sometimes actually poisonous. Secondly, whatever minor differences may exist among physiologists, Dr. Hill contends that they are agreed upon one thing, namely, that even though small doses exert apparently no serious influence upon health, the same could not be said of large doses. In short, all additions to food whose influence on health was doubtful, ought to be prohibited, and their use supplanted by refrigeration.

"These are pronouncements which involve many issues, and raise more difficulties than are apparent to the mental eye at the first glance.

"It is hard to know where we are to stop in defining what shall come under the heading of 'doubtful additions' to food. Take, for instance, boric acid in butter and saltpeter in curing hams and pickling beef.

"Niter is as much a chemical or a medicine as boric acid, but it has been used for too many years as a food preservative, to be displaced summarily. Yet if boric acid and the etceteras are to go, so must niter.

"What is more, while refrigeration is an excellent alter-

native in the abstract, it does not lend itself to local requirements, to say nothing of the expense. It may be a simple thing to enforce refrigeration and forbid the use of 'preservatives' by law, but even when a certain line of action is actually legalized, it does not follow that it is expedient.

"There is something rather too utopian about the whole idea of thus banishing from use all food ingredients that may in any possible way injure health. What will harm one will not affect another."

It seems to me that a wholesale prohibition of the use of preservatives will work much wrong. Food in an incipient state of decomposition will do bodily harm, and there is a new field for preservatives for many forms of food. I think they should be rigidly excluded from milk, because that is a food intended to be used fresh, or, if not, the sterilization of it will accomplish the needed preservation.

In permitting the use of preservatives we should endeavor to secure those which show the least interference with digestion and the least tendency to disturb the nutritive functions. From the facts at hand I believe that boric acid and sodium benzoate are most suitable from these points of view. In judging between them I would be guided by the fact that the latter contains no mineral substance foreign to the human system, and that it is essentially organic in its nature, and hence more likely to be eliminated promptly. It seems that boric acid has little disturbing effect, but the fact that it is a mineral substance not normal to the tissues is somewhat against it.

DISCUSSION.

MR. KEBLER :—In this paper the idea is expressed that a given amount of enzym will convert an infinite amount of material. That enzymes do bring about changes apparently incommensurably great, compared with the amount of enzym employed, is true, yet the results of modern research point to the fact that they do "wear out." Perhaps all enzymes, in the course of their activities, produce bodies which slow and by accumulation, ultimately stop the reaction long before the enzym is exhausted or is destroyed,

but would the absolute removal of these bodies prolong their activities infinitely?

DR. LEFFMANN:—No experiments are at hand to prove that enzymes are inexhaustible, but it seems probable that if we could remove the products of the action and add new materials without further diluting the liquid, the enzyme would maintain its efficiency. We have, for example, O'Sullivan's statement that he found that one part of invertase would invert 100,000 times its weight of cane-sugar and still be active. In the inorganic world we know that one grain of manganese dioxid might suffice to assist the decomposition of an indefinite amount of potassium chlorate and not lose its efficiency.

MR. KEBLER:—In reference to the presence or absence of free benzoic acid in such substances as pickles and catsups, when sodium benzoate is employed as a preservative, there seems to be some difference of opinion. I have always been of the opinion that the acid of the pickling medium liberates the acid from the sodium benzoate and the benzoic acid then became the preservative. Experienced men in this art hold similar views. Some practical men have told me that they use the sodium benzoate rather than the benzoic acid itself, because the former dissolves readily and can thus be easily and uniformly distributed in the things to be preserved.

DR. LEFFMANN:—In many foods benzoic acid will be set free, but I think not in all.

DR. FRANKEL, in discussing Dr. Leffmann's paper, stated that the subject was one of great importance, as the preservation of food-stuffs by means of preservatives was becoming more common daily. This practice was being carried on extensively, not only in the preservation of foods that were put up in air-tight vessels, such as canned goods and preserves, but likewise made use of in products that were exposed to the action of the air, particularly such very common food-stuffs as milk.

Naturally larger quantities of preservatives were necessary for the latter class than for the former.

It had become necessary to ascertain whether the pre-

servatives that were commercially used were injurious to health or not, and the value of Dr. Leffmann's researches was readily shown by the fact that, as a result of these, the State of Pennsylvania had prohibited the use of salicylic acid as a preservative, and had permitted the use of sodium benzoate.

Dr. Leffmann's researches were in accord with others that had been made, particularly in reference to the action of salicylic acid on the digestive processes.

There was little doubt to-day that the use of salicylic acid as a preservative should be condemned; for the reason given by Dr. Leffmann sodium benzoate would be more allowable.

COMMITTEE ON SCIENCE AND THE ARTS.

THE VENTURI METER.

Being the report of the Franklin Institute, through its Committee on Science and the Arts, on the inventions of Clemens Herschel, Frederick N. Connet and Walter W. Jackson.

HALL OF THE FRANKLIN INSTITUTE,
[No. 1,868.] PHILADELPHIA, May 4, 1898.

The Franklin Institute of the State of Pennsylvania, for the Promotion of the Mechanic Arts, acting through its Committee on Science and the Arts, investigating the merits of the "Venturi Meter," reports as follows:

The Venturi Meter is designed for the measurement of the flow of liquids in pipes of dimensions so great that the use of meters of the ordinary types, with movable parts, is impracticable.

The complete device consists of two distinct and widely different instruments, viz.: (1) the "Venturi," or meter proper, or meter tube, and (2) the registering apparatus.

The first part, *i. e.*, the meter proper, patented by Clemens Herschel, of Holyoke, Mass., April 17, 1888, No. 381,373, consists essentially of a mere constriction in the area of