International Health Exhibition,
LONDON, 1884.

THE

ADULTERATION OF FOOD.

CONFERENCES BY THE INSTITUTE OF CHEMISTRY ON MONDAY and TUESDAY, JULY 14th and 15th.

FOOD ADULTERATION AND ANALYSIS

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INSTITUTE OF CHEMISTRY.

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Professor W. ODLING, M.A., F.R.S., President of the Institute, in the Chair.

THE CHAIRMAN said the Executive Council of the Exhibition had invited the Institute of Chemistry to hold a conference on the very important subject of the adulteration of food, and the modes of analysing it, and he hoped that having before them a subject of this kind, to which so much attention had been paid by so many eminently qualified, a discussion of considerable interest must arise, and that some good in the way of increase of knowledge and increase of agreement as to the points desirable to attain in future must be arrived at.

FOOD ADULTERATION AND ANALYSIS.

By Dr. JAMES BELL, F.R.S.

ADULTERATION, in its widest sense, may be described as the act of debasing articles for pecuniary profit by intentionally adding thereto an inferior substance, or by taking therefrom some valuable constituent; and it may also be said to include the falsification of inferior articles by imparting to them the known appearance of commodities of superior quality.

The evils of adulteration may be viewed either from a sanitary, moral, or pecuniary standpoint, and it is no doubt chiefly in its relation to the health of the people that the subject of Food Adulteration and Analysis has been chosen for a Conference in connection with this Exhibition.

Of the sanitary evils of the adulteration of food there cannot be the faintest doubt, and even on this ground alone the practice merits the severest condemnation. This is the case when the substance added merely reduces the nutritive value or characteristic property of the food, but the offence becomes highly criminal when the adulterant also possesses properties injurious to health.

The moral aspect of this question should never be lost sight of. No man can continuously practise deception without losing self-respect, and, also, when detected and exposed, the respect of his fellow-citizens. Moreover, in such circumstances, a feeling of uncertainty on the part of the buyer is created, and his first idea on the receipt of a commodity of somewhat lower quality than usual is that it must be adulterated. The honest vendor thus shares with the dishonest one the general penalty of suspicion, and the transactions of nearly all dealers in articles of food are viewed with distrust.

But it is from the pecuniary standpoint that the question is most often viewed by the general public, for the primary cause of adulteration is a desire for unjust gain to be obtained, either at the expense of consumers, or by taking unfair advantage of competitors in trade.

If the adulterated article is sold at the ordinary price of the genuine commodity, the consumer is robbed of the amount represented by the diminished value; whereas, if it be sold as genuine, though at a proportionate reduction in price, the unfair competition tends either to seriously injure their honestly-disposed rivals in trade, or, what is but too often the case, to drive them into a similar course. Attempts have sometimes been made to estimate roughly the amount of pecuniary loss suffered by consumers owing to the adulteration of different articles of food, but, for my part, I have never been able to see that any reliable data were obtainable upon which to form even the rudest approximate estimate.

The practice of adulteration is by no means of modern date, but has existed, more or less, from time immemorial. There is evidence that it was practised by the Greeks and Romans, and it has probably been co-existent with the development of commerce.

The earliest enactments in this country in reference to food appear to have had a much wider scope than those of recent years, for they embraced the quality as well as the genuineness of the article, and dealers in foods or drinks which, from whatever cause, were considered as unwholesome, were fined once or oftener, and then, if found incorrigible, were condemned to bodily punishment. The first enactment on the Statute Book is the 56 Henry III., cap. 6, passed in 1266. Under this and subsequent statutes or "Assizes," the baker was to be punished if he sold bread light in weight, or made from unsound wheat, or at too high a price in relation to that of wheat; the brewer if he was not sufficiently liberal with his malt in proportion to the price of barley; the beer-retailer if he sold ale drugged or short in measure; the vintner, if his wine was drugged, corrupted or unwholesome; and the butcher, if he sold diseased meat.

When we consider the difficulty which at the present time we experience even with increased knowledge and appliances in suppressing adulteration, it is not to be wondered at that the machinery of those days failed to put an end to the evils complained of.

With the exception of one or two Acts relating to the adulteration of bread, all the legislation upon articles of food from the time of George I. to the year 1860, had reference to the protection of the revenue, and therefore only indirectly guarded the health or pocket of the consumer. The Acts within this period related principally to tea, coffee, beer and porter; and, if we are to place any reliance upon the words of an Act of Parliament, the adulteration of tea a hundred years ago must have attained very alarming proportions. The Act, 17 Geo. III., cap. 11, states that great quantities of sloe leaves, and leaves of ash, elder, and other trees and shrubs were then being manufactured and sold in imitation of tea, to the injury and destruction of great quantities of timber, woods, and underwoods.

In the year 1851 there was considerable agitation amongst planters and others interested in the production and sale of coffee, in consequence of the falling off in the consumption of that article caused by its wholesale admixture, as permitted by Treasury Minute, with chicory. Petitions were presented to both Houses of Parliament on the subject, and it was perhaps the general attention directed at that time to this matter which induced the proprietors of the *Lancet* to perform a public service of the highest value. In 1851 and several following years, at their own expense, they instituted an extensive inquiry into the character of the food, drink, and drugs sold in London, and engaged chemical and microscopical analysts for that purpose. The results showed that adulteration prevailed to an alarming extent, and that in many cases the adulterants were of a nature highly injurious to health. The Editor of the *Lancet* showed his confidence in the analysts employed by publishing in that journal the results of the analyses, whether favourable or otherwise, together with the name and address of the vendor. The increased public attention thus caused, resulted in an inquiry by a Select Committee of the House of Commons, in 1855, which reported that adulteration of food, drink, and drugs was very prevalent, and that some of the adulterants used were of a poisonous nature. Following upon that report, and as a consequence thereof, the first general Act in this country was passed in the year 1860. This Act may have exercised to some extent a deterrent effect, but beyond this the practical outcome of it was but small, for the appointment of analysts was permissive, and the obtaining of samples for analysis was left to private purchasers. Another Act was passed in 1872, extending the right of appointing analysts to boroughs having separate police establishments, but still left such appointments optional. A most important provision, however, was made for the purchase of samples by local officials, and the right was given to private purchasers to have samples analysed on payment of a small fee.

The adoption of the Acts of 1860 and 1872 was by no means general, but was principally confined to London and the large towns; and even where adopted, the action taken was often of a very restricted character. The prosecutions which ensued, however, were sufficiently numerous to cause a general outcry from tradesmen about alleged miscarriages of justice; and in answer to petitions from most of the large towns, the Government decided to appoint another Select Committee of the House of Commons to enquire into the working of these Acts. This Committee reported that while the Acts had done much good, they had likewise done considerable injury, as many heavy and undeserved penalties had been inflicted upon respectable tradesmen, and that such injury had arisen partly from the want of a clear understanding as to what constitutes adulteration, and partly from the conflicting opinions and inexperience of the analysts employed, some of whom appeared to have evinced a great want of discretion. It was recommended that the Acts of 1860 and 1872 should be repealed, and that a new, extended, and compulsory Act should be substituted for them. The chief amendments suggested were the inclusion of the fraudulent abstraction of an important property of any commodity, such as the removal of cream from milk, as a punishable offence; the examination of tea on importation; better regulations for obtaining samples, and for securing the appointment of qualified food analysts. To meet an important want provision was also made for obtaining an independent analysis in case of dispute.

A great improvement had evidently taken place since the previous Parliamentary Committee had sat in 1855, especially in regard to the deleterious nature of adulterants used, for this Committee concluded their Report by expressing their belief that it will afford some consolation to the public that in the matter of adulteration, they are *cheated* rather than *poisoned;* and that if deleterious substances are occasionally used for the purposes of adulteration, they are used in such minute quantities as to be comparatively harmless. Further, as a matter of policy, they pointed out that they did not consider that Parliament desired needlessly to hamper or fetter trade, still less to interfere between the buyer and seller with the view of regulating prices, or attempting to assist the consumer in ascertaining the real money value of any marketable commodity.

Upon the lines indicated in this Report was framed the Bill which passed into law as the Sale of Food and Drugs Act, 1875, and which is the Act now in force, though amended in some respects by the Sale of Food and Drugs Amendment Act, 1879. I shall now pass on to consider 1st, the object of these Acts; 2nd, the machinery provided for attaining that object; 3rd, how far the Acts have succeeded; and 4th, analysis in relation to adulteration.

The title of the Act of 1875 states that it is "to make better provision for the Sale of Food and Drugs in a pure state." Although expressly intended to suppress adulteration in food, drink, and drugs, the word "adulterant" or "adulteration" does not occur in any of the clauses, for the reason, I believe, that no definition of these terms could be framed to meet all practical requirements. The sale of mixtures is freely allowed, provided that the nature of the commodity sold is brought to the notice of the purchaser before the sale is completed, so that if necessary it may be declined, and that no ingredient has been added so as to render the article injurious to health.

The fundamental idea of the Act is found in Section 6, which enacts that "no person shall sell to the prejudice of the purchaser any article of food, or any drug, which is not of the nature, substance, and quality, of the article demanded by such purchaser." Here is a clause capable of a very wide definition, but I think the spirit of the section is fairly expressed by Mr. Justice Mellor in delivering judgment in the Appeal Case of Hoyle *v.* Hitchman, when he says, "The offence intended to be prevented by the Act was the fraudulent sale of articles adulterated by the admixture of foreign substances which would necessarily be to the prejudice of the purchaser, and those words were inserted only to require that such adulteration should be shown to have been made;" and further, "if the purchaser asks for a certain article, and gets an article, which by reason of some admixture of a foreign article, is not of the nature or quality of the article he asks for, he is necessarily prejudiced."

It would thus appear that for a purchaser to be prejudiced within the meaning of this clause, it is necessary that the article sold should contain some admixture of a foreign substance not specified at the time of sale; and therefore that the purchaser is not legally prejudiced when the article sold is of low quality but genuine. This view will be found confirmed in the twelfth Report of the Local Government Board, in which it is stated that "the Sale of Food and Drugs Acts are not designed to prevent the sale of poor articles, but that of adulterated articles." It has been urged that samples should be judged by those of average quality, which the purchaser might reasonably expect to get; but this was evidently not the view of our legislators, for Parliament deliberately abstained from fixing limits of quality for natural products, whether in a raw or prepared state.

I come now to the means provided for suppressing the adulteration of food. The Local Authorities of each city, metropolitan district, county or borough, throughout the United Kingdom, have now the power to appoint inspectors and duly qualified analysts for the purchase and analysis of samples, and should they not appoint an analyst voluntarily, they are required by the Act to do so when called upon by the Local Government Board in England, or a corresponding authority in Scotland and Ireland. When any sample purchased, according to the provisions of the Act, is found adulterated, the vendor can be summoned before a magistrate, and on conviction fined in a sum not exceeding £20 where the adulteration is simply to the prejudice of the purchaser. When, however, the adulterant renders the article injurious to health, the maximum penalty is £50 for a first offence, and six months' imprisonment on subsequent convictions.

On payment of a fee not exceeding 10*s.* 6*d.* a private purchaser may have any article analysed by the public analyst, and, if found adulterated, the vendor, if the provisions of the Act have been complied with, may be prosecuted and fined as if the purchase had been made by the inspector. The requisite official machinery has not been provided in all places, and the Local Government Board do not appear to have power to enforce the appointment of inspectors, nor the purchase of a sufficient number of samples to ensure the efficient working of the Act.

I find, on inquiry, that though analysts have been appointed for most places in England and Wales, there were no fewer than sixty-three boroughs and three counties in which no samples whatever were analysed during the year 1883, and in many other places the number analysed was very small.

In Scotland, out of thirty-two counties only seven have yet appointed analysts, and of these two have had no samples examined for six years, while a third has only had one sample, and a fourth only three samples analysed during the last three years. Of 167 royal and police boroughs, thirty have appointed analysts, thus showing only thirty-seven appointments for the whole of Scotland out of a possible total of 199, or about one in five.

In striking contrast to Scotland is Ireland, where an analyst has been appointed for every place except one borough and one county.

In considering some of the general results which have been obtained by the working of these Acts, it would manifestly be unfair to institute a comparison between the years prior and subsequent to the Act of 1879, which laid down minimum strengths for spirits, so I confine my statistics to the last three years for which returns have been issued by the Local Government Board. I regret that I have been unable to obtain complete returns for Scotland and Ireland, so the following data for the years 1880, 1881 and 1882, showing the total number of samples analysed in each year, with the percentage of samples reported as adulterated, refer to England and Wales only.

Year.	Total Number of Samples Analysed.	Percentage Reported Adulterated.
1880	17,673	15·7
1881	17,823	14·6
1882	19,439	15·0

The percentage of samples found adulterated varies, as might be expected, somewhat from year to year in the various commodities; but on the whole, and so far as these returns show, it is practically stationary.

These are the only data available, so far as I know; and valuable as they are for comparison from year to year, there are several reasons why they afford only a roughly approximate idea of the extent to which adulteration is practised in this country. On the one hand, the samples are nearly all purchased by inspectors, many of whom are personally known to the tradesmen,—the object for which the purchases are made being perfectly well understood;—whilst some districts throughout the country are inadequately, if at all, represented. On the other hand, a large number of samples are returned as adulterated where the amount is so small that no proceedings are instituted; and to these may be added samples of which adequate notice of admixture had been given at the time of purchase, and also samples of impure well-waters, which are sometimes classed as adulterated. I may also mention that of 528 samples purchased by private individuals in one year, the percentage found adulterated was 25, as compared with only 14·5 per cent. in the samples purchased by the official inspectors during the same year; but this may partly be accounted for by the fact that a private purchaser has generally good grounds for suspecting adulteration before going to the trouble and expense of having the article analysed. The small number of samples submitted for analysis by private purchasers has been more than once commented upon by the Local Government Board, and shows, I think, that the expense of the analysis, together with the trouble involved in the event of a prosecution, are more than private individuals are willing to bear. Perhaps this is not surprising when it is considered how small an amount individually they have at stake, and how readily they can, when dissatisfied, change their tradesmen.

The working classes, especially, who form the bulk of the population, and are the greatest sufferers from adulteration, can hardly be expected to take action on their own account if only by reason of the expense; but there is often the further impediment of the analyst being many miles away, and doubtless in such cases his name and address are not always generally known.

It is much to be regretted that an evident unwillingness has been found on the part of some local authorities to bring these Adulteration Acts into operation. The Acts are practically a dead letter in some districts even where nominally complied with, owing to the small number of samples purchased, or the conditions under which the purchases are made. In the twelfth Report of the Local Government Board it is stated, that in some cases "scarcely any attempt is made to conceal the official character of the buyers, or the purpose for which they are buying;" and the Board add, what must be perfectly obvious, "that unless the samples obtained by the inspector are of the quality ordinarily sold to the public, the object of the purchase is frustrated."

In some districts the local authorities have been much discouraged by the small fines imposed by the magistrates, even when the offence has been committed more than once. There can be little inducement for them to carry out these Acts energetically when they find that after going to all the expense and trouble of the purchase and analysis of samples, and taking the necessary legal proceedings against a fraudulent tradesman, the heinousness of his offence is assessed by the magistrates at such a trifling sum as cannot in any view be held to be a deterrent penalty, but one readily covered by the illegitimate profits of a few days.

The tendency in recent years has been to place increased discretionary power in the hands of magistrates. For many years prior to 1879, their discretion in matters of fines in Revenue cases was limited to reducing penalties to not less than one-fourth of the amount named in the Act. By the Summary Jurisdiction Act of 1879, however, they were given full discretionary power in first offences, but the former restriction remains in force for second and subsequent offences. Some such regulation may be found desirable under the Sale of Food and Drugs Acts, especially in cases where the vendor is the actual adulterator.

In discussing the relation of analysis to adulteration, it is not my intention to review the various methods of analysis, but merely to refer briefly to some of the analytical difficulties experienced in dealing with the subject. When the adulterant differs chemically or microscopically from the article to which it is added, as when alum is added to flour or bread, or wheat flour to mustard, the detection of the adulterant is only dependent upon the skill and experience of the analyst. But when the adulterant is similar in character to, or identical with, one of the constituents of the article to which it is added, we are met at the outset with a formidable obstacle in the fact that natural products of all kinds vary greatly both in composition and quality, and the problem presented for solution is then whether lowness of quality is due to natural poverty or to adulteration.

There are butters, for instance, so rich in quality that they would admit of a large addition of foreign fat, and still yield analytical results within the limits of genuine, but poor, butter. Again, it is well known that the milk yielded by some cows is of so low a quality as not to be equal to that from other cows with a large proportion of added water. Further, there are some teas which, regarded from whatever test of quality we may apply, are so rich that they will bear a considerable admixture of partially exhausted tea-leaves and still yield results equal to those from other poorer, but yet genuine, teas. This is the difficulty which, more than all others of a scientific nature, stands, and I fear will continue to stand, in the way of the entire suppression of adulteration.

Unfortunately, the history of food analysis shows that this difficulty in dealing with natural products has been increased to some extent by the adoption of different processes of analysis, which, in the hands of various chemists, have yielded results differing so materially as to lead to contrary opinions upon the same sample. To my mind, it is therefore most important that whatever analytical process is used, it should yield absolute, and not comparative, results.

There are, however, occasions on which differences of opinion between analysts may be expected to arise, as, for instance, when the microscope has to be depended upon for the detection and estimation of the adulterant. Any want of concord between analysts in respect to their estimate of the proportion of adulteration in such cases as the presence of barley-meal in oatmeal, or rice flour in ground ginger, should not be made too much of, as the certain proof of admixture is the main thing to be desired, and it can make but little difference whether the percentage of the adulterant be returned, say, as 15 or 20 per cent.

It is frequently urged that certain "limits," founded upon the analyses of samples of average quality, should be laid down and legalised for natural products, below which such products should be deemed to be not "of the nature, substance, or quality of the article demanded," but the adoption of such "limits" might lead to grave difficulties. It is the opinion of practical men that it would be unwise to adopt any legislative measure with respect to limits of quality which would tend to discourage production, and diminish the supply of any article of food. It would manifestly be an economic blunder, if, for instance, in order to raise the quality of milk by one half of 1 per cent. on the non-fatty solids, the actual production were to be diminished by 10 per cent. in quantity.

Following these views, it may be of interest to particularise some of the principal articles of food, and the results of the analyses of samples under the Adulteration Acts of 1875 and 1879. I have taken the data from the Local Government Board's Reports, founded upon Returns made by the Public Analysts, and of which an able Summary for the five years, 1878 to 1882, will be found in a valuable 'Handbook on the Law of Adulteration,' by Thomas Herbert, published by Knight and Co., of Fleet Street.

Milk.—Beginning with milk, we find that it differs from most other natural food products in that it is sold to the public, and, as a rule, consumed, in its natural state; also in that it is difficult, from a general inspection of its appearance, or from its taste or smell, to form a fair idea of its quality; and further, in that within the same town or district it is mostly sold at a uniform price, except in special cases for nursery purposes.

The judging of the quality of milk may therefore be considered to be largely dependent on analysis, and having regard to the facility with which it can be adulterated, the public require a greater amount of assistance in order to secure a supply of genuine milk, than they do in the case of almost any other article of food. I have little doubt that in course of time, with the increasing means of education, the public will become more skilful in judging of the quality of milk and other commodities, and will be able frequently to detect those instances of gross adulteration which may now pass unobserved.

The range of quality in the milks obtained from healthy and well-fed cows is very considerable. Taking the non-fatty solids of the milk as a criterion of value, I have found in common with others that the percentage varies—with a few exceptions on either extreme—from 8·2 to 10·8 per cent. It is evident that a milk of the higher value might be subjected to a good deal of watering—about 25 per cent.—and still yield the results obtained from the poorer, but still genuine, milk.

This opening to sophistication which the differences in the quality of milk permit, is not less, but even exceeded in the case of butter, owing to the greater range in its quality, a point I shall shortly have to notice.

For a long time it was contended that cows which gave milk containing less than 9 per cent. of non-fatty solids were either diseased or starved, but this notion may now be said to be dispelled, for the more the matter has been investigated the more has such a position been found untenable.

Milk yields very variable proportions of fat. The percentage is sometimes as low as 2·2, and occasionally rises to as high as 6. This great range of difference affords facilities in some instances for the abstraction of part of the cream, and unfortunately renders the analysis in such cases of but little value in protecting the public against this species of fraud—a circumstance much to be regretted when the high value attached to the fat of milk is considered.

As to the necessary groundwork of milk analysis, chemists are universally agreed. The data sought for are the percentages of fat, non-fatty solids, and ash; but, in order that the results of one analyst may compare with those of another, the processes employed for determining these data require to be uniform, and the methods themselves must be such as will yield accurate results.

As proceedings under the Adulteration Acts are of the nature of a criminal prosecution, it is essential that the analysis should not indicate mere comparative results, but that the constituents relied upon for forming an opinion should be expressed by those weights or percentages which shall set forth the true quantity in the substance analysed, as absolutely as the most skilful analysis can provide.

About 6,300 samples of milk are analysed yearly in England, of which 20 per cent. are returned as adulterated. The offences are practically confined to addition of water and abstraction of cream, but occasionally preservatives, such as boracic acid, designed to prevent the milk from turning sour, have been found, and also, but still more rarely, sugar and colouring matters.

While admitting that in some districts the milk-sellers may be adequately sampled, yet, taking the country as a whole, the total number of samples analysed appears to me to be insufficient to show to what extent adulteration is generally practised, or to act as an effective bar to the practice.

Butter.—The supply of good, wholesome, and genuine butter for the public use is a desideratum. Fortunately, however, in this they are able in a great measure to become their own judges. They can readily distinguish between what is sweet and rancid, and can discover a butter which is heavily loaded with salt, and often detect the presence of an excessive amount of water. In fact, the public can practically protect themselves against most forms of butter adulteration, except that arising from the admixture of foreign fat.

Butter is another illustration of the difficulty with which chemists have to contend, arising from the wide variation in the composition of the article in a pure state; and, as in the case of milk, it is essential that, in order to avoid differences in results, and contrary opinions, the method of analysis adopted should be such as to effect a complete and accurate separation of what is termed the soluble and insoluble fatty acids. It is now generally admitted that the percentage of fixed fatty acids found in genuine butters varies from 85·5 to nearly 90·0 per cent., so that the addition of something like 40 per cent. of a carefully selected foreign fat to the richest butter, would still leave the percentage of insoluble fatty acids within the range of a genuine butter.

As in the case of milk, chemists are agreed upon the lines to be followed for the determination of the genuineness of butter, and differences can only arise from variations in processes followed for the attainment of the necessary data.

About 1200 samples of butter are analysed yearly, of which 15 per cent. are reported against. The adulteration consists in the substitution or admixture of foreign fats, and occasionally in the introduction of an excessive amount of water.

In connection with this subject, I may mention that the manufacture of artificial butter compounds from animal and vegetable fats has, in recent years, attained enormous proportions in the United States of America. These compounds, known as butterine, oleomargarine, suine, &c., are in the opinion of high authorities legitimate articles of commerce, if sold under names which properly indicate their origin and composition.

If manufactured in a cleanly manner from sound fats, they are perfectly wholesome, and afford the poor a cheap and useful substitute for butter, especially during the winter months, when good butter is both scarce and dear. I see, however, that the Legislature of the State of New York has, at the instigation of the farming interest, resolved to suppress the manufacture and sale of such compounds within the bounds of that State.

This decision was based upon the evidence given in what is said to have been a very one-sided investigation, and in which it was stated that such compounds contained deadly germs; that the workmen engaged in their manufacture were subject to loathsome diseases; and that by their use the death-rate of New York had increased at an alarming pace. Putting aside such undoubtedly exaggerated statements, it is highly probable that with the increased demand there may have been less care exercised in the manufacture than at first, and that in some cases impure or decomposed fats may have been used, but these are grounds rather for sanitary supervision than for the suppression of the trade.

Cheese.—It is considered that the consumer can in a great measure protect himself in his purchases of cheese. The range of prices plainly shows him the different qualities, and he can exercise his judgment in selecting the kind best adapted to his taste and pocket. I am not aware of any instance in which an adulteration of cheese has been reported. Colouring matter is about the only foreign ingredient employed in its manufacture, but this is a necessity to satisfy the public taste as regards colour.

The successful manufacture of factitious butter from animal and vegetable fats has naturally suggested their substitution for milk fat in cheese, but there is no evidence that "butterine cheese" has yet found its way into the English market. When it does, there are adequate chemical tests to distinguish it from the genuine article.

Bread.—About 1100 samples of bread are analysed annually, of which, on the average, 6 per cent. are shown as adulterated. The principal adulterant is alum, which was reported in one case as being present to the almost incredible amount of 1305 grains, or nearly 3 ounces to the quartern loaf. I do not think it would be questioned that so large an addition of alum must be injurious to the health of the consumer. The amount usually added, however, is comparatively small, being only about 30 to 40 grains in the 4-pound loaf, and whether then injurious to health or not is a matter in dispute, there being both chemists and medical men who take opposite views on this subject. When the objects for which alum is added are considered, that it is either to enable unsound flour to be used, or to cause the bread to appear to have been made from better flour than has really been the case, its use should be strongly deprecated, and its presence treated as an adulteration.

Tea.—The number of samples of tea analysed by public analysts is small, and the cases are very rare in which adulteration is reported. This, no doubt, in part, arises from the scrutiny which tea undergoes on importation, which has had the effect of discouraging, in great measure, the trade in adulterated teas.

The manufacture in this country of spurious teas from the leaves of other plants, or from exhausted tea-leaves, is extinct; for the low price at which genuine tea can now be sold holds out but small inducement for the increased risk under the present adulteration Acts, of manufacturing and selling a spurious article. The methods of analysis adopted for the detection of the adulteration of tea are fairly effective, and the only form of sophistication which could be practised with any chance of success is the admixture by the Chinese of partially exhausted tea-leaves.

Coffee.—About 1250 samples of coffee are yearly analysed, of which 18 per cent. are reported as adulterated. With rare exceptions the sole adulterant found is chicory, which, it may be mentioned, is the only substance that can legally be added to coffee without requiring the payment of a further tax in the form of a stamp duty.

The adulterants of coffee all consist of vegetable matter, and allowing that the analyst is acquainted with the structure of the different vegetable tissues, their detection by the microscope becomes a matter of certainty.

In connection with coffee it may be noticed, and the remark applies equally to all substances on which a Revenue duty is imposed, that the interests of the public are largely though indirectly protected by the constant supervision and inspection which such commodities undergo, either in their manufacture or sale, so that before such articles in the adulterated state can come into the hands of the public analyst they must have evaded those safeguards which the restrictions of the Revenue Acts provide.

That such a result is brought about receives confirmation from the fact that it is seldom that a prosecution arises under the Food and Drugs Act, for the adulteration of a dutiable article with a marketable commodity not liable to duty.

Spirits.—Whisky, gin, rum and brandy are the only articles under these Acts which are required to be sold at not less than a specified strength, unless otherwise declared at the time of sale.

These spirituous liquors are in a different position to natural products, for being in all cases mixtures of manufactured spirit and water, the relative proportions of which are readily ascertainable, it was not unreasonable for Parliament to fix a minimum proportion for the essential constituent alcohol (defined in terms of proof spirit), below which the retail purchaser was to be considered "prejudiced," unless made aware of the fact at the time of sale. It is true that the percentage of alcohol is but one factor in determining the commercial value of spirits, and that a purchaser may receive better value for money in a well-matured spirit below the minimum strength, than if he were supplied with a less-matured article at or above that strength. The alcoholic value, however, is the only one which can be accurately estimated, and about which, therefore, analysts may fairly be expected to agree.

About 2000 samples of spirits are annually analysed, of which 25 per cent. are reported as adulterated, but only in very isolated cases has any other adulterant than water been found. This is a striking refutation of the opinion, so frequently expressed, that most of the evils of spirit drinking are due to adulteration, and no better illustration could be afforded of the frequency with which inferiority of quality is confounded with adulteration. On several occasions samples of whisky have been sent to me from districts where the people were said to have been injuriously affected by drinking the spirit, and I have never met with an adulterated sample, but the spirit was invariably of a raw and immature character. The changes that take place in the maturing of spirit whereby it loses its fiery character, and the deleterious traces of fusel oil, become changed into comparatively harmless flavouring ethers, are not well understood, and it is impossible by any mode of analysis at present known to separate spirits into the two clearly defined classes, of those which are new and deleterious, and those which are sufficientiy matured as to be harmless, this being rendered all the more difficult by the common practice of blending spirits of various ages and flavours in order to get a mixture having a certain recognised character.

In some measure, to meet this difficulty, an effort was made a few years ago by a well-known Irish member of the House of Commons, an effort which is now being renewed, to move the legislature to enact that whisky before being sent out for consumption must have been kept in warehouse for at least one year. This attempt, however, did not succeed, through the trade difficulties which were found to beset such a plan.

The obstacles in the way of controlling the quality or genuineness of brandy are even greater than in the case of whisky, as its production is carried on outside this country, and the practice of adding a certain proportion of plain spirit and a mixture of sugar and flavouring matter to real brandy, has become fully recognised in the trade, and is allowed for in the purchase and sale of this article.

This addition of saccharine matter has a marked tendency to obscure the naturally harsh character of brandy, and to cause its coarse and immature nature to pass unnoticed by the public generally, while whisky being free from sugar at once appeals to the palate in cases where the spirit is of a new or fiery character.

That the circumstances indicated create formidable difficulties in the application of chemical tests to brandy suspected to contain added spirit is clearly evidenced from the fact that there does not appear to have been any successful prosecution under this head in connection with the Food and Drugs Act.

Beer.—This, from its position as the national beverage of this country, is of especial interest and importance in its relation to analysis and adulteration. Prior to 1847 beer could be accurately and legally defined as a fermented beverage prepared from malt and hops, but in that year sugar was allowed to be used. Fifteen years later, namely, in 1862, the hop duty was abolished, and revenue interference with the use of hop substitutes ceased; then, in 1880, the malt duty was removed, and brewers were allowed by the Beer Act of that year to use any materials whatever capable of being used in brewing. There is no legal limitation as to the strength or original gravity of beer, nor as to the degree to which it shall be fermented, or, in other words, the proportion of alcohol it shall contain. It is, therefore, impossible to give a clear and concise definition of what beer ought legally to be. The former definition and still popular idea, that it is a fermented beverage prepared exclusively from malt and hops, is neither supported by revenue law nor by present trade practice, for there may now be legal beer without either one or the other, or even without both.

Under what circumstances then can a purchaser of beer be deemed to be prejudiced? The Local Government Board have stated that "it would seem to follow from decisions in the High Court of Justice that a purchaser in demanding beer must be held to mean the article ordinarily sold under that name, and that it would be to his prejudice to sell him, as beer, an article not of the nature, substance, and quality of that ordinarily sold as such, whether containing ingredients injurious to health or not." It is not easy to fix a basis or standard of quality for the article ordinarily sold as beer, for it is my experience, as well as that of other analysts, that even in the same town the money value of beer sold under the same name, and at the same price, differs by as much as 50 per cent. from whatever point of view its value may be considered. Suggestions have been made that, as in the case of spirits, minimum limits of strength, based upon original gravity, should be laid down by Parliament for the several well-recognised sorts of beer; but there would be many objections to such a course, more especially where the value of the beer depends more upon its character or flavour than upon its stength.

An Association has been formed to cause the ingredients from which the beer has been made to be declared, but I fear that those who expect analysts to be able to prove or disprove the truth of such declarations rather overrate the present capabilities of chemical science.

A popular notion has long prevailed that no article is more manipulated than beer, and it is therefore satisfactory to find that there have been comparatively few prosecutions for the adulteration of beer, and, so far as I know, the only adulterant found has been common salt. Now the amount of common salt naturally present in beers varies widely, some of those containing the largest proportions being held by the public in high repute. As salt is added as an antiseptic, and really increases the keeping properties of some beers, it has been contended that the public cannot have been much prejudiced in those cases where a small quantity has been added, but where the total amount present is within the limits of a genuine beer held by them in high estimation.

It was my intention to discuss in detail several other subjects of interest, including wine, but it appeared to me that if I did so, the paper would prove too lengthy and tedious for the opening of a Conference.

I may say, however, that in most articles of food there has been a very great improvement in recent years as regards adulteration, and that the gross and deleterious forms of sophistication which are stated to have been extensively carried on at one time are now practically abandoned.

For example, the only substances which are now found in cocoa are sugar and starch, and in mustard, flour and turmeric, and these additions are not considered as adulterants so long as the preparations are not sold as pure or unmixed articles.

Again, in the manufacture of confectionery, not only has the use of earthy substances been discontinued, but the employment of pernicious colouring materials has practically disappeared, and harmless, vegetable colours are now almost universally employed.

Even in pickles and preserved vegetables it is now rare to find the colour heightened by the addition of a salt of copper, and the colour of cayenne pepper is no longer improved by the use of red lead.

In fact, in whatever direction we look, the same improvement is observable, judging from the Reports of the Public Analysts to the Local Government Board, and the absence of prosecutions.

Before concluding, I desire to express my opinion that the machinery provided by the legislature for the suppression of adulteration is fairly efficient, and only requires to be vigorously worked by the various local authorities in order to be productive of great good to the community. I trust that this Conference will be the means of stimulating these authorities to a more zealous administration of these Acts, and particularly of directing their attention to the advisability of obtaining samples for analysis from every part of their district, and with such precautions as will insure the purchase of articles in the state in which they are ordinarily supplied to the general public.

I cannot conclude, however, without expressing my sense of the efficiency of the work which has been, and is now being done by public analysts, not only in their official capacities, but in regard to their contributions to analytical science, of which their works on bread, milk, and butter may be cited as well known examples. It has been the least pleasant part of my duty to have to differ from them, as sometimes they have differed among themselves, at one time on actual results of analysis, and at another on the deductions to be drawn from practically similar results, but such instances should not affect the confidence with which the general ability and high services of public analysts ought to be regarded.

DISCUSSION.

The CHAIRMAN having thanked Dr. Bell for his very complete, interesting, and fair account, said he thought there would be pretty general agreement in several of the statements he had put forward. In particular he might take upon himself to declare how very largely the public was indebted to the labours of those many gentlemen who undertook very ably the office of public analysts, and how largely pure science was indebted to them for their labours. It was gratifying to hear from Dr. Bell that there had been so large an improvement in recent years in regard to adulteration, and that the gross and deleterious forms of sophistication which were stated to have been extensively carried on at one time were now practically abandoned. So far, therefore, the Adulteration Act may be regarded as a success. It must further be said that there could not be any doubt as to the sanitary evils resulting from the adulteration of food, and, therefore, in connection with the Exhibition they might congratulate themselves on the means of adding to the public health which had resulted from the working of the Act referred to. It would be admitted that, on the whole, the Acts had worked well; but a question arose whether they might not be made to work better, whether indeed in some particulars they did not imperatively call for amendment. If the question before the Conference was simply the repression of adulteration, it was quite obvious that the Acts might very considerably be amended in respect to their efficiency; but other conditions had to be borne in mind as well, and they could not conceal from themselves that to a small extent in some places, and to a larger extent in others, Acts of this kind were more or less prejudical to trade and invention. All were interested in the supply of pure and honest food, but they were all interested also in not interfering with its abundant and cheap supply, or with the improvements in the mode of manufacture and productions of those articles of food which were more or less of an artificial character. He feared if the Act had been in force some forty years ago, what Dr. Bell had told them with regard to beer would have had no foundation, and that the supply and quality and cheapness of beer might have been very seriously interfered with by any very stringent and legislative enactment with regard to the materials from which it must be produced. But it was not for him to express his own view on any of these points, but rather to invite the opinion of others; but he must refer to one or two points with regard to the possibilities of an amendment of the Act, with the view of inviting those with most experience of the subject to say how far they thought it necessary that it should be altered in certain respects, and how far it was necessary to amend it so as to insure its general applicability, because at the present time there were considerable portions of the country where it was not actually applied at all. If the Act were really doing good, it seemed a pity that it should not be doing so over the largest possible area. It appeared that the Local Government Board had power to enforce the application of the Act so far as the appointment of analysts was concerned, but not to insist on the appointment of inspectors, nor, on the other hand, to insure that a sufficient or indeed any number of samples should be analysed. In many cases, although the Act was to a certain extent in force, the number of samples examined was so small as really to have no influence on the character of the supply of the district. Another point hinted at by Dr. Bell was how far it was possible to secure that the articles submitted to the analyst were the actual articles supplied to the public in the neighbourhood. Here of course came the question how far the services of the inspector were neutralised by the publicity of his office, and how far it was desirable that samples purchased by private consumers should be analysed. Then again there was another point, whether the punishments inflicted on offenders were adequate, and whether the same limitation to the reduction of the fine as applied in the case of offences against the Revenue Laws should not also apply to repeated convictions under this Act. Another point which naturally suggested itself was, how far the Act should be increased or diminished in stringency; for instance, as Dr. Bell told them, beer was qualified only by this definition, that it must be the article ordinarily sold under that name, and the question was whether matters should be left in that state with regard to beer, and if so, whether it might not be desirable to leave them in the same open state with regard to other articles of a more or less manufactured nature. It might or might not be right in the case of beer, but if it were, the question arose, why should it not be right for butter or for cheese? If a tradesman were allowed to sell as beer anything which was held to be the article ordinarily sold under that name, why were butter and cheese not to be equally the articles ordinarily sold under that name? It might be desirable to put these latter articles on the same footing as beer, or, on the other hand, it might be desirable to put beer on the same footing as them. Another question was, how far the use of chemical agents as preservatives was allowable. They knew that beer of very high repute did contain the chemical substance called bi-sulphite of lime, and he did not know that any brewer had been interfered with for using that article, but, on the other hand, they knew that dealers in milk had been interfered with for using boracic acid, which seemed to be an anomaly. In the same way with regard to bread. At one time an artificial powder made of tartaric acid and bi-carbonate of soda was largely used in making bread, and afterwards bi-sulphate of lime was used as a substitute for the tartaric acid; and at one time bread was made largely in the neighbourhood of Manchester, in which carbonic acid gas was made by the introduction of pure super-sulphate of lime and carbonate of soda. It was a question whether chemical agents of this kind should be allowable and to what extent. Another poin which he would venture to put forward was, how far the Adulteration Act might be extended so as to include food for cattle, and how far, moreover, the work of public analysts might not be directed to a considerable number of articles of food which were rarely, if ever, now examined ; such, for instance, as syrups and fruit essences, many of which were made from artificial chemical products, and, again, the class of mineral waters. Another point of some delicacy, but of considerable importance, was how far the mode of settling differences of opinion or differences of statement between analysts was altogether satisfactory, or how far it might be possible or desirable to improve it. The mode adopted of referring these matters to the Inland Revenue Chemical Department was no doubt a very unusual method ; in most other cases a chemist on one side, and a chemist on the other set forth their different opinions, and a judge or jury had somehow or other to decide the matter between them. Occasionally these opposite views were referred to some particular expert to act as referee, but it was only done by the consent of both parties. In the case of adulteration of food there was an official referee, and on the whole they would all feel that he had done his spiriting very gently. Then came the very important point raised by Dr. Bell, as to the desirability or not of fixing the limits of quality in such articles as milk and butter, which though genuine were susceptible of very great variations in quality, so that putting aside the idea of legal prejudice, a customer might really be more prejudiced by buying an inferior genuine article than he might be by buying articles of high quality subjected to a greater or less amount of adulteration. Dr. Bell had already intimated his view on this point, that the adoption of limits of quality might lead to some difficulties, but other persons might have a different opinion. A question would arise, how far any regulation of this kind would limit the supply if, as had been suggested, the rise of $\frac{1}{2}$ per cent. in the non-fatty solids of milk would really have the effect of reducing the supply by 10 per cent. ; no doubt they would all agree that it was very undesirable to do so, but opinions might differ whether or not it would necessarily have that effect, and whether the inferior qualities of milk might not be made use of in some similar way to what was called the mingling of brands in other articles. No doubt Dr. Voelcker would be able to give some idea if a limit of quality were fixed, whether it would interfere with the abundance of supply. Then would come another question, how far it would affect the average result. It might reduce the highest qualities of milk to the lower standard, but even if that undesirable effect resulted, the influence might on the whole be good by improving the general average. At the same time it might be possible to have in the market more than one quality of milk; they might even perhaps suppose that milk dealers would sell milk guaranteed to be of a certain quality with a certain percentage of non-fatty solids, a certain amount of cream, and so on. Then came another point also raised by Dr. Bell, the difficulty of analysis by reason of the variety of natural substances, and the question, what should be the standard taken in the case of milk and in the case of butter. They all knew that very considerable differences of opinion had arisen, and had led to some rather warm discussions with regard to what should be the standard which should serve as the means of expressing the proportion of water added to any particular milk. Then came the question of different modes of analysis, and it would be for the meeting to decide whether that subject should be discussed; but they might certainly consider the point whether it was desirable, in all cases where practicable, to obtain results which were expressible in exact percentages and not rely on mere comparative results. Another point was that some of these adulterants were added with the object and result of improving, as a marketable and eatable article, the materials of the food to which they were added, and a question of considerable importance, how far these effects might be produced without the aid of adulteration; for instance, in the case of bread, they all knew that alum aided in producing a much more presentable loaf than could be obtained without it, but the question was how far could that appearance be obtained without the use of such an objectionable adulterant.

Dr. VOELCKER said it was impossible to discuss the many points to which the Chairman had alluded, though they all needed discussion before any amended Act could usefully be brought in. On the general point he would venture to express the opinion that a very great deal of good could be done if the adulteration of cattle food were included, for no one could have an idea of the extent to which the adulteration of cattle food was systematically practiced in England, more especially linseed cakes, which were so largely used for the production of milk and fattening of cattle. It was true that in late years, owing to the Royal Agricultural Society of England, who had taken a very bold step in some cases of publishing the names of offenders, the adulteration of cattle food had somewhat diminished, but it still existed to a great extent. Taking linseed, rape, and other cakes of a definite character, leaving out mixed cakes, which were professedly sold as mixed, a very large proportion were adulterated. In the same way, feeding meal, such as refuse from rice mills, Indian corn flour, and the refuse of starch manufactories, was very greatly adulterated, and a deal of harm was done to cattle. Every year he got a great many samples of rice meal, adulterated with gypsum and bran and pollard, which was sold for feeding pigs, and of course filled them. A good many cows, too, were yearly poisoned by adulterated rape cake ; one-half of the linseed cakes, even those which professed to be pure, were not genuine pure cakes. At the same time there was no difficulty in obtaining reasonably, commercially pure linseed, containing not more than 5 per cent. of foreign matter, such as small bits of sand or seeds. A few years ago there were a few mills which produced pure linseed cake, but at present they were more numerous, still a great deal of good would be done if the Act were extended to cattle food. In his capacity as Assistant in Chemistry to the late Professor Johnston, of Edinburgh, subsequently to an experience of fourteen years at the Royal Agricultural College at Cirencester, and his experience as Consulting Chemist for twenty-six years to the Royal Agricultural Society of England, had brought him in close contact with all matters in connection with dairy farming and the production of butter and cheese, and he would therefore say a few words on the production of milk. It had been stated that it would be a great advantage to fix a definite standard quality for milk, and in some measure it would be, provided it were fixed high enough, and that standard were fixed on a reasonable and sound basis, not, as had been done, on questionable analyses and experience. The present standard by the public analyist was too low, and he was of opinion that from one-half to three-quarters of the milk sold in London and other towns was partly skim milk, not the natural substance as the cow furnished it, especially in the strawberry season, when garden parties were common, because a good deal of the cream was taken off. At the present time very reasonably good milk might be expected, not of course such rich milk as that furnished by Jerseys and Alderneys, which often contained a much higher percentage of fat than the maximum mentioned by Dr. Bell; but of course you could not expect to get that at 4*d.* or even 5*d.* a quart. A large percentage, however, of pure milk was partially skimmed, owing to the fact that public analysts had fixed the standard, which they had published or made known amongst the trade, at 2½ per cent. of fat; on the other hand, 9 per cent. of solids, not fatty, was too high, and this figure had been fixed on the basis of an imperfectly dried milk residue. Of course, if the water were not all driven out, the residue would be larger than it would be if it were dried perfectly. The difficulty of fixing any standard arose from the fact that milk was subject to such great variations. At certain times of the year milk was poorer than at others; for instance, in the spring of the year when the fresh grass was coming in, being very watery, it would not produce such rich milk. Still, with all these variations, a certain minimum quality ought to be insisted upon, and he thought that 3 per cent. of pure butter fat and 8 per cent. of solids not fat, would be a very good standard, and few dairymen would find fault with it. Another danger in fixing a standard was that dealers would work up to it. He one day asked the dealer why he did not give more cream, and the reply was that he was compelled by competition in the trade; that he could give milk with 3 per cent. of cream, but the others did not do so, and therefore they kept it to the standard. One man said they could not go on with the business if they did not keep a chemist on the premises. He was by no means unfriendly towards his own professional brethren, but he could not see the necessity of having an analytical chemist employed to work up to the standard required by public analysts, and thought it would be much better to have the milk pure. As a rule, milk dealers took care of themselves, and did not supply the public with richer milk than they were compelled to. He did not think Dr. Bell was quite accurate in saying that no cheese partially made with butterine had as yet found its way into the market. He was sorry to say a good deal did so, and the exportation from America of oleomargarine cheese was very considerable and increasing. There was something to be said for this cheese; he had himself tested it, and as long as it was sold for what it was there was no great objection to it. The same with regard to the oleomargarine used in the manufacture of Dutch butter; about 100 tons were exported every year to Holland, manufactured there, and came back to England as the best Dutch butter. So long as an article of food was sold for what it was, and the materials employed were of a wholesome and inviting character, he did not see any objection. A great deal of cheese in England was unsaleable, especially that made in localities where there was no sale for the milk. There was great trouble in disposing of the skim-milk, and skim-milk cheese only fetched from 3½*d.* to 4*d.* a lb., but with the addition of oleomargarine it could be made into cheese which could be sold for 8*d.*, which was certainly a more profitable way of disposing of it, and perhaps no great injury was inflicted on the public. The great desideratum was that the thing should be sold under its right name. In conclusion, he would offer a word of caution to analysts, who he had no doubt had been doing a great deal of good. The adulteration of food had certainly greatly diminished, owing to their exertions, and their duties were more and more recognised by those in authority. It was from no wish to find fault with them that he remarked that perhaps a little more caution would sometimes be desirable; that they should not jump to a conclusion simply because they found a certain reaction was produced, that a certain thing was present which had really nothing whatever to do with the character and value of the article under consideration. Only a few days ago a sample of cream had been referred to him which had been pronounced by the public analyst to be adulterated with starch, and of course his impression was that starch in the shape of a thick paste might have been used with the view of making the cream look thick. He tested it in the usual way with tincture of iodine, and found that the quantity was so small that he knew at once no starch could possibly have been added to the alleged adulterated cream. Taking several portions, in some he found traces of starch, and in others he did not, and examining it under a microscope, he found that where he got a starch reaction there was a solid starch granule or so, and it struck him there could not possibly be any appreciable quantity of starch, and that possibly it might be due to the fact that the cream had been strained through a linen cloth, and on further inquiries he was confirmed in his opinion that that was the right explanation. In another case which recently came under his notice, a gentleman sent him some cream which he said threw down a purple colour, and he thought something dreadful had happened. However, under the microscope and subsequent chemical tests, he readily found out that there was some aniline dye present, and, writing for further information, it turned out that the dairymaid had strained the milk through a red-coloured calico. In such cases, to jump to the conclusion that some frightful thing had been practised on the cream would be totally wrong. At the same time he did not say that the use of red-coloured calico was not objectionable.

Mrs. SEDDON asked if there was any society for the purpose of paying the expense of analyses for poor people who could not afford to do so, and also if there was a public analyst at Ramsgate.

The CHAIRMAN said there was a public analyst for Ramsgate, who lived at Canterbury. There was no society for the object named.

Dr. DUPRÉ said that public analysts had so rarely the opportunity of bringing their case before the general public that he gladly availed himself of this opportunity of setting forth their side of the question, and he hoped there might be present both manufacturers and dealers who would give their opinion from the opposite side. There was no doubt that adulteration had greatly diminished, more particularly in such articles as came more under the operation of the Act, such as bread, milk, spirits, and coffee, &c., but the effect of the Act had not been anything like as great as it might have been, for various reasons. First and foremost was the apathy of the general public. The Act was passed primarily for the protection of the general public, and secondly for the protection of the honest trader, to protect him against unscrupulous rivalry; but unfortunately this primary object of the Act seemed to be forgotten by many persons, and public analysts as a rule received no support whatever from the general public, either by having samples brought to them to be analysed or by an expression of opinion in favour of a proper carrying out of the Act. The result was that the analyst found himself opposed by those who practised adulteration, not by any means a small class, and also by certain associations, some old and some new, which ought to look on the analyst as the greatest benefactor, his object being to suppress adulteration, but they did not seem to do so, and consequently, whenever any one of a particular trade was attacked, they went in with counsel and witnesses and all the machinery of the law to stop the prosecution, and the public analyst, not having any support, often failed. His real position was often misunderstood by the public and by the tradesmen directly interested. His sole function was to analyse any article of food, drink, or drug brought to him by either an inspector or by any one appointed under the Act, or by any one of the general public who complied with the provisions of the Act, which were to the effect that, at the time of purchase, he must tell the dealer that the article was to be analysed, and must offer to divide it into three portions. The public analyst had nothing whatever to do with buying the article, or with any subsequent prosecutions; he simply gave his certificate, and, if necessary, he must be ready to give evidence as to the truth of the certificate in the witness-box. He had nothing to do with any prosecution, and in fact occupied a position of absolute neutrality. The second cause why the Adulteration Act was not as effective as it might be was on account of the low fines frequently inflicted. He could not illustrate this better than by referring to milk, which was an article of primary importance, on which depended the lives of thousands of children, yet it was one of the most largely adulterated, owing partly to the ease with which a man might go to the pump or water-tap. This only seemed to him to render it desirable that, if adulteration of milk were proved, the fraudulent dealer ought to be punished severely. But what did they find? If a man added only 10 or 20 per cent. of water, he was fined 5*s*. or perhaps 10*s*. What was the meaning of the fine of 5*s*.? it meant simply the sale of 12 quarts of water in the shape of milk, so that, if he added 10 per cent. of water, the sale of 15 gallons of adulterated milk would pay the fine. Now, in the nature of things, it would be quite impossible to frequently analyse the milk of the same dealer; it would be scouted as persecution, and the result was that, before the milk inspector came round again, the fraudulent dealer had long ago recovered his fine, so that such a low fine, instead of a deterrent, was actually a premium on adulteration. To show what might be done if the public took more interest in the matter, he might say further, that in his district inspectors used to be in the habit of going round, and when he had been, in two successive weeks the milk used to come up to a very good standard. It was once suggested that they should go on the Sunday, and the result was that the adulteration of milk, which on week days was one in six for several years, turned out on the Sunday to be six in seven ; almost every sample bought on the Sunday was adulterated. Next Sunday every sample obtained was genuine. He had not the slightest doubt that if the public would occasionally bring samples to the analyst for examination, this adulteration would be considerably checked. With regard to the standard, the society of public analysts had never fixed a standard, they had fixed a limit below which no milk should be considered genuine. There was no question about it that the fixing of such a limit was a great difficulty ; milk did undoubtedly vary within tolerably wide limits, but this variation was confined to a very few animals. You might occasionally find the milk of a single cow which fell very much below the limit, whether the cow was in a state of health or not, or had been properly fed, he would not say. But was it right that the general public should be deprived of their proper quality of milk because sometimes a single cow gave a milk which fell below that standard. If it were the case with a single cow, it was never the case with a whole dairy. He desired to speak with the highest respect of the officials of Somerset House, who did a difficult work with remarkable ability, and, on the whole, with considerable success ; but on the question of milk he could not help thinking they had made a mistake, and that it would be a great injustice if Londoners were restricted from getting their milk up to the standard of 9 per cent. Another point was this, the word "adulteration" was not mentioned in the Act, it simply said the article should be of the nature, quality, and substance demanded, and it would be well if the Act throughout kept to that definition, and did not require of the analyst an impossibility ; but, unfortunately, the schedule appended to the Act, which gave the form of certificate which must be used by the analyst (and must be literally followed, for if a single word were left out it might lead to objections being taken and a failure of prosecution), said the analyst must certify that such and such a foreign ingredient was present in such and such a proportion. Now, he might say, without fear of contradiction, that though it was often possible to state that a substance was not of the nature, quality, and substance demanded, it was perfectly impossible to state what was the nature of the ingredient added, and still less to say what was the absolute quantity added. He thought, therefore, the Act should be amended in that respect, and that the analyst should have the option of stating that the article submitted to him was not of the nature and quality demanded, but that he was not able to state the exact nature and absolute quantity of the article added. Take the case of wine ; it was comparatively not a difficult matter to say whether the colour of red wine was genuine or not, but is was nearly almost impossible to say what was the nature of the colouring matter added; in some cases it could be done, but in others it could not, and therefore, in such a case the only option the analyst had was to pass over such an article, for if he varied from the form of certificate, the prosecution would fail. A great many articles had to be passed simply because the analyst was unable to state what was the quantity of the adulterant. There was no doubt the present form of certificate was a great stimulant to research, because no one liked to fail, and every one was anxious to devise methods which would enable him to state what was the exact nature and absolute quantity of the adulterant. But as long as that was not possible, he did not think the law ought to ask them to state what was really an impossibility. Dr. Voelcker thought public analysts had raised the standard of milk too high in one respect, and too low in the other, namely, in the cream ; but why had they done so? Because they were not sufficiently supported by the public, and if the unfortunate analyst gave a certificate that milk containing 2·5 or a little cream was adulterated, down came some association and a number of witnesses, to prove clearly that that was all matter of necessity or of accident, and that if you went on taking milk from the top of the churn, you naturally went on skimming it, and if you came to the bottom, the cream must have been removed. It might not have been removed fraudulently, but still it had been removed, and the result was that the public had to take bad milk. Everybody could skim milk, but it need not be done, and if a dealer were thoroughly honest he could easily mix his milk before the sample was taken.

He had made many experiments, showing that if you had milk with as much as 5 per cent. of cream, you could go on dealing out four or five gallons without reducing the cream. With regard to the question of whether anything should be added to preserve articles of food, at first sight it seemed quite right to allow it, but on a little further consideration grave doubts would be engendered, whether in the case of milk that was right or not. Milk was fortunately an article which had to be handled and treated with very great care, and unless the dealer were cleanly in all his apparatus and business, the milk would all turn sour. But if he were allowed to use anything to keep the milk, the public would lose to some extent that safeguard, and business might be conducted in a slovenly manner, and the milk kept in dirty rooms, without showing it, by turning bad. He thought this property of milk was very fortunate, and one of the great safeguards; for if you had milk which kept a reasonable time, it was an indication that it came from fairly healthy cows, and had been properly dealt with. In the second place, the milk dealer could not skim much cream unless he used a centrifugal machine for making the milk turn, and he noticed in his district that whenever they had milk with a sufficiently low proportion of cream, there was generally boracic acid in it. He had no doubt that had been added in order to allow of the milk being kept standing sufficiently long to skim it without running the risk of its turning sour. With regard to spirits, it was often said that young spirits were injurious to health, because they contained fusel oil, but there was absolutely no evidence to support it. Nobody had ever yet proved by analysis that young spirit contained more of this supposed deleterious ingredient than the old. Some years ago he had to analyse some Cape Smoke and Sanchou from China, which played great havoc with the English sailors there; the idea was that these deleterious effects were due to an improper proportion of fusel oil, but it turned out that it contained a smaller proportion than English whisky. Some years ago there was some considerable discussion on this point in Sweden. The Swedes seemed to be given to a great extent to brandy drinking, and it was stated in public that the many injurious effects were due to drinking fresh spirit with fusel oil in it. A commission was appointed to examine into the matter, but there was no evidence to prove that it was due to fusel oil, but that as a rule the young spirit was so much liked by the populace that they drank considerably more of it than they did of the old, and therefore the injurious effects were due to the increased quantity taken rather than to the bad quality. He hoped this Conference would to some extent arouse the interest of the general public on this question, for he was firmly convinced that it was only by a fair co-operation of the public with the public analyst that adulteration could ever be suppressed.

Mr. WIGNER (President of the Society of Public Analysts) said his own opinion was that Dr. Bell had taken rather too favourable a view of the action of the Act up to the present, and although he agreed with him that it had done a considerable amount of good, he did not look on the amount of good yet done as being nearly sufficient for the machinery put into play. It was something very little short of a disgrace to a country like England, after having an Adulteration Act at work for eight or nine years, to find the average of adulterated articles sold should be 17, 18, or 19 per cent., varying a little with the class of goods. Dr. Bell had quoted from the statistics given in a recent book of Mr. Herbert's, but he was sorry to say those statistics were not so full as was desirable, and in some respects they were not by any means accurate. He had a few other statistics which would illustrate that point. Taking the seven years from 1875 to 1881, the reduction in the percentage of adulteration had only been 18·1 to 16·6, a very unsatisfactory result for seven years' work. Taking, again, the adulteration of milk, it had increased since 1879 by nearly 3 per cent., and grocery, the next important article, only showed a reduction of 2 per cent. It was clear therefore that an alteration in the Act was wanted, and he very strongly advocated that alteration, taking the form of schedules, or standards of purity, of such a character that the very inferior articles, such as some speakers had referred to, should be excluded, even at the risk of a little inconvenience. For instance, there was just as much reason for excluding from retail sale milk which had only 8 per cent. of solids, not fat, if produced by an underfed or badly kept cow, as if produced by the actual admixture of water. If the cow were incapable of producing better milk, then she ought to be sent to the knackers, rather than be used as a milk-producing machine. He thought they might learn something from other countries. England took the lead with the Act of 1875, but that was the result of a compromise, when the effect produced by the Act of 1872 had been too severely felt by tradesmen. It was said that that Act acted harshly, and no doubt it did in some instances ; a Committee of the House of Commons was appointed, and the result was the Act of 1875 ; but it was introduced with this remarkable clause, that if any article sold was sold in accordance with the usage or custom of the trade, the vendor should not be proceeded against. That, which was struck out in Committee, was the basis of the whole Act, and was the reason why no standards or limits were introduced into it. Amendments were gradually introduced during the passage of the Bill through the House, and an effort was made, not only to introduce standards, but also to extend the Act to cattle foods, but this was defeated by the agricultural party. More than two-thirds of the United States were under Adulteration Acts, and they were all based on an uniform draft. There was in addition a national law, and, with two exceptions, all those States had limits, and, with one or two exceptions, all of those limits were those laid down by the Society of Public Analysts, so that throughout more than one-half of the United States it was illegal to sell milk that contained less than 9 per cent. of solids not fat, or with less than 2·5 per cent. of fat. Granting that Dr. Voelcker was correct, and that the fat standard might be raised, he had heard no complaints from America with regard to it. Inferior milk was no doubt used to make inferior cheese, and the public were, he believed, fairly supplied. Now, turning to France, the Parisian Act was a municipal one, much more stringent than ours, and much more thoroughly enforced, but the same standards had been adopted. Although that Act had been in operation for about five years, he had not heard of any case in which a successful appeal had been made against the conviction, which showed that in Paris the matter was looked upon more seriously than it was here. In that city, with a population less than half of that of London, there were twenty-four inspectors, who did nothing else than take samples. Their course of procedure was to go in couples to every shop, to examine every canister, jar, and package in the shop, selecting that which they thought fit, and taking it to the laboratory, and leaving the others; and the number of samples examined was from 800 to 900 a month, or about 10,000 every year, while in London we were content with 1200 or 1400 in the same time. The result of that on milk was, that in Paris the average of the adulteration was only 2 to 3 per cent.; while the average adulteration at the present day in London was 17 per cent. adulterated with water, and at least 17 per cent. by skimming; or, adding the two together, 34 per cent. of milk was adulterated in one way or the other. That formed the strongest reason for suggesting the use of a limit, and that it should be higher than the one adopted by Dr. Bell, who had adopted his limit on the basis of poor cows being legitimate machines for manufacturing milk. He thought most decidedly the other way, and that proper milk should be the milk of healthy fairly well-fed cows. The section which provided for the examination of tea in bond had certainly been of service, and the adulteration of one or two other things had been entirely suppressed. The effect of the change made in 1879, by which spirits had a fixed limit, had also produced an improvement. Passing to the important mode in which the Act was enforced, he would remark that the Local Government Board had power to appoint analysts, if the Local Authority refused to do so, but they had no power of enforcing any penalty if the Local Authority did not appoint; and, after they had appointed an analyst, they had no power to pay him any salary, and therefore the Local Authority could, and did, snap their fingers at the Central Board, and the consequence was that analysts were not appointed, because their appointments would be mere sinecures, as they would have neither work nor pay. The same thing applied to the number of samples which were purchased. It had been put forward several times by the Local Government Board that one sample per 1000 of population ought to be purchased every year—certainly a very moderate estimate —but that was something like sevenfold the actual number. The certificate of analysis was unquestionably a most complicated and cumbrous document. It was originally worse, but it was slightly improved in its passage through the House; but, unfortunately, that certificate was not made incumbent on the chemists at Somerset House, when giving reference certificates, and, as the result of that, differences had arisen in many cases. The Public Analyst, for instance, was compelled to state whether any change had taken place in the character of the sample which would interfere with that analysis, and it was notorious to everyone that, in nine cases out of ten, samples of milk became decomposed when sent for reference analysis. That fact ought to be put in the certificate, because it had an important bearing on a second point that that certificate had to say—not as they did now, that the analysis could, or could not, be confirmed, but to say, in many cases, there was nothing to show whether the analysis was right or wrong. He believed Dr. Bell would agree with him, that many cases occurred where they were utterly unable to say the Public Analyst was right, but were equally unable to say that he was wrong; and if that were the case, the weight of evidence should certainly go in favour of the analysis made when the article was fresh, and the conviction should stand, rather than a man who, in all probability had been guilty of watering the milk, should escape. The question had been raised as to the limitation of supply which would arise from raising the standard, and his feeling was that that limitation would be very small. It was quite true that some of the milk used in country districts—particularly at a great distance from London—which was used for manufacturing condensed milk and for cheese, would be withdrawn for those purposes. But the milk could just as well come as an imported article; and if the area from which the milk supply of London was drawn were enlarged by a very few miles—and it already extended to an average distance of thirty-eight miles from the outskirts—it would give the supply required to sell all genuine milk, instead of part genuine and part water. The sale of genuine milk was larger than was supposed, because the sale of high-priced milk was larger than was generally thought to be the case. He was sorry to hear Dr. Voelcker's remarks with reference to the necessity for more care on the part of the public analysts, especially bearing in mind that in the two cases which he cited—only one of which was the case of a public analyst—it would clearly have been the duty of the analyst to have condemned the cream. In the first case it was true it contained only a trace of starch, and the supposition was no doubt correct that it was derived from an unwashed piece of cloth or calico used to strain the cream; but if the dairyman had allowed a piece of calico dressed with starch, or other impurities, to be used to strain the cream, he deserved to be convicted under the Adulteration Act, and, if it were not wide enough to catch him in one way, it ought to be wide enough to catch him in another; and the same thing was certainly true in the case in which linen coloured with aniline had been used. His feeling was that they should pass some resolution which should strengthen the hands of those who would have to take it in hand, if an amendment of the law were considered desirable or feasible.

Professor ATTFIELD, F.R.S., said he should address himself to one only of the points mentioned by the Chairman, and that was as to the proportion of articles of food and drink which were said to be adulterated. The public drew rough conclusions from what was said at Conferences like that, and one very rough conclusion they would draw was that of any articles of food and drink which they had to consume, 15, 16, or 17 per cent. were adulterated. Now, he should not like it to go forth to the public that that was true; the truth was, that of the articles which had been examined by the officials under the Adulteration Act, 15, 16, or 17 per cent. were simply said to be adulterated. Now, taking the number of different articles placed on our breakfast, dinner, and tea tables, he thought they might say there would be 20 or 30 different articles so presented in the course of the day, and in the course of a year many thousands of distinct purchases were made for the household. Now, was it to be assumed that of those thousands of articles, 17 per cent. were adulterated? As a chemist, having had 25 years' experience of analyses of articles of food and drink, he protested against any such assertion. He had examined vast numbers of articles of food and drink, and a still larger number of drugs, and his deliberate conviction was that not one in 1000 was adulterated, and he could give, not only his experience, but statistics to support it. For the last ten or twelve years he had been the chemical adviser of a body of traders who were liable to be charged with adulteration, and he consented to advise them whenever they might be threatened with a prosecution.

In some 25 cases in which they had been so threatened he had advised that about 20 should be defended, and in the course of defending the actions in these 20 cases, where the matter had been brought before the various impartial tribunals to which such matters were referred, the prosecution of 19 had been dismissed. In several of those cases it had been a matter in which the local officials on the one side had been put into the witness box, and himself on the other (but he had to give no evidence at all), in which a few questions put by the counsel for the defendant to the witness for the prosecution had been sufficient to upset the case. He made no charges against any man, but at the same time no man was perfect. It was quite possible in those 19 out of 20 cases there might have been wrongful adulteration, but he could only say that the independent tribunals had said it was not so. Now, if out of 25 cases brought before him he was able to succeed, so that in four-fifths of them the prosecution would be upset, and that practically in the whole of those cases the defendants were found not to be in the wrong, if one were to draw an inference, it would be that out of 15 per cent. of cases of alleged adulteration you ought to take off about 12, leaving 1 or 2 per cent. of possible cases of adulterated food. He would not, however, make any such inference, for he questioned the wisdom of drawing any conclusion whatever from these figures.

Mr. HEHNER said, after the somewhat vigorous remarks of the last speaker, it would not do for public analysts to let the matter stand without some reply; for although Professor Attfield had disclaimed the idea of bringing charges against public analysts, yet with the fact that every year something like 16,000 to 18,000 samples were analysed, and something like one-fifth or one-sixth were declared to be adulterated, if they were told that only 1 in 1000 was so, the implication upon public analysts was a somewhat heavy one. This Act had been in operation about 10 years, and every year 16,000 to 18,000 analyses had been made, making a total of close on 200,000; of those 200,000 something like 30,000 were declared to be adulterated, on which prosecutions took place, and according to the hypothesis now put forward, wholesale injustice must have been inflicted. It was notorious that statistics could prove anything, but these analyses were not made to produce statistics. The aim of those who bought samples and submitted them for analysis was to do the greatest amount of public good for the least amount of money, and therefore the aim of inspectors was to catch as many adulterating tradesmen as possible. If the inspector went about, and only bought the best samples of food, and the analysts reported that out of every 100 samples he received 100 were genuine, the public would be misled, and the authorities would soon direct that no further operations should be undertaken under the Act. Therefore the inspector in his district did not endeavour in buying samples to get an average number of adulterations, but he tried with the small amount of money allotted to carrying out the Act to do the greatest amount of public good, and that was only to be done by trying to get at those who adulterated, not at those who notoriously did not. Professor Attfield seemed to be exceedingly fortunate. Of course he accepted what he said, that he only got 1 sample out of 1000 adulterated, but considering that there were something like 100 public analysts, and many thousand samples were examined, nobody with any fairness of mind would for one minute admit that this wholesale injustice had been committed over so many years; and therefore it only followed that if Professor Attfield had been so fortunate as to escape getting adulterated samples, someone else must have had them in an increased degree. That was specially the case with the poor people who bought their goods in pennyworths, or small quantities. It would be as easy to buy 100 genuine samples as to buy 100 adulterated, and therefore he admitted the statistics did not go for much; they only showed that out of so many samples examined 16 per cent. were found to be impure. Again, although it was shown that the adulteration had not greatly diminished in percentage, yet every public analyst had noticed the decrease in the amount of adulteration. Five or ten years ago, samples of milk were frequently met with containing from 25 to 50 per cent. of water ; but now it was exceedingly rare to get anything which contained 20 per cent.—10 to 12 per cent. was much nearer the average amount of adulteration. On the whole, adulteration in our days meant something quite different to what it did ten years ago. Fifteen years ago, vermilion, chromate of lead, and other poisonous substances were frequently used, but in our days poisons were no longer met with ; in fact, as had been said, only cheating and not poisoning now took place, and if that was not an improvement effected by the Food and Drugs Sale Act, he did not know what could be. It was notorious that altough the Local Government Board could insist that an analyst should be appointed, there was no power to insist on samples being purchased for analysis, and there was a very considerable portion of the country in which no samples were examined. In one town that he knew the Act was not enforced, whilst in the country all round it was. In the country no adulterated articles would be sold, but as soon as the milkman passed the borough boundary, he could put his can under the nearest tap, because he knew there was no inspector about. In that respect the omission of compulsion in the Act did a great deal of harm. It should be made compulsory, not only as to the appointment of analysts, but in the purchase of samples, and in the proportion of samples to be purchased. It was not sufficient to get about ten samples a year, and even that was more than was done in some places. It must not be left entirely to the governing bodies, whose interest it frequently was not to have any samples analysed at all. He could mention a number of boroughs where there were a majority of people in the Town Council who dealt in food and drugs, and although an honest dealer might not mind having his articles analysed in some boroughs, the Act was not very strictly enforced. Dr. Bell had been extremely complimentary to public analysts, and on the other side he must acknowledge the amount of consideration which had been shown by the Appeal Court to which their cases were referred, and he was happy to say that there was a very considerable agreement between that Court of Appeal and Public Analysts, more so even than appeared. Every year, out of 25 or 30 cases referred to Somerset House, the analyses in only about half had been contradicted, but small as that proportion was, it was in reality much smaller, because it was frequently not a question of fact at all which was in dispute between the Public Analyst and the Court of Appeal, but simply a question of opinion. Nearly all cases in which disputes took place had been those of adulterated milk, and it frequently happened that the analyses of the analyst agreed entirely with that of Somerset House, only he came to a different conclusion from the figures. Of course, with so many thousand analyses there might be mistakes. Analysts were quite as fallible as other people, and perhaps more so, but the proportion of mistakes were very small, and there was this slight grievance, that they had to refer their analyses to a court of appeal, which really had far less experience in that particular kind of work than they had themselves, seeing that they analysed every year about 6000 samples of milk, whilst the Court of Appeal perhaps only analysed 600 altogether.

Professor DE CHAUMONT thought they might congratulate themselves, in spite of the partial failure of the Adulteration Act, that so much had really been attained. He could not take the roseate view which had been taken by one speaker, and say that in one article out of a thousand submitted to him for analysis there was no adulteration proved. In milk alone the experience of any analyst would have proved that the proportion [was larger than had been stated. With regard to the question of how they should deal with cases of alleged adulteration, he quite agreed with what had been suggested by more than one speaker, that a great deal of loose statement was made with regard to the presence in articles of commerce of adulterants. For instance, in his own neighbourhood, Netley, he had been told that a good deal of the beer sold was adulterated with tobacco, but although he analysed seven samples, he had been unable to detect the presence of tobacco, except in one case, and in this instance he proved conclusively that it got in through the man carrying some tobacco in his pocket. One important point to consider was, whether they should deal with articles as avowedly prepared articles of commerce, as was understood to be done in the case of beer, or whether they should deal with them as articles that ought to be provided in a pure state. As a great number of articles were allowed to be used in the manufacture of beer, it was hardly possible to lay down any possible standard of what beer ought to contain, but this did not apply to butter or cheese. Milk ought to be sold as it came from the cow. At a Milk Conference that he attended at Gloucester, one gentleman suggested that milk should be taken as an article of commerce at a certain standard, and he considered it very hard if he had some cows yielding a particularly rich quality of milk that he was not allowed to take the cream off and sell the milk, which would then be equal to the usual standard. No doubt this would be very convenient for the trade, but exceedingly dangerous to the customers, as they had no security with regard to the means adopted, because water might be taken from the most polluted well in the country. As to butter and cheese, he thought they should be sold as pure articles. The Adulteration Act might be amended in this way, that no mixtures whatsoever with articles which could be provided as pure articles ought to be allowed at all. If coffee was sold under the name of coffee, it ought to be sold as pure coffee, and if people desired to use chicory, by all means let them buy it, and mix it themselves. The same principle might be applied to other things. The difficulties which the Adulteration Act had met with were many, and no doubt in earlier times one of the difficulties was the different modes of analysis, the uncertainty of the application of the guess made, and the necessary inexperience of analysts. All those were stumbling-blocks in the earlier days, but these for the greater part had now been got over. The Adulteration Act was above the standard of morality of the nation of the present time, in fact it was too respectable an act for general outward application. He said this advisedly, for there were many tradesmen who would certainly scruple to put their hands into a person's pocket and take out sixpence or a shilling, who had no hesitation in putting water into milk or chicory into coffee. The immorality of the act was the same, but the public did not seem to think so, and magistrates seemed to look upon it as the custom of the trade to cheat, and that therefore the public ought to be content to be cheated. If a man were fined for adulterating milk one day, and again brought up a day or two afterwards, it was looked upon as persecution ; but supposing a man was punished for picking pockets, and he immediately resorted to the same practice, it would not be considered persecution if the police again took him into custody. Until they reached the point at which they could make it felt generally that adulteration was a distinct wrong against society, and not only a wrong, but a disgraceful wrong, there was not much chance of getting the Adulteration Act carried out to its full extent. In Paris and other parts of the Continent the Act was carried out in a more rigid way than in England. If public opinion could only be educated up this point, that a man who had been convicted of adulteration was publicly disgraced, then and not till then would adulteration be put a stop to.

The Conference then adjourned.

Conference on July 15, 1884.

The Conference resumed at 2 o'clock.

Dr. MUTER said, in renewing this discussion he should not descend into the personalities or the contentious matter which had been brought up in the course of the discussion by those speakers who seemed to wish to run down the public analysts. Without going through the whole of the heads mentioned by the Chairman, he proposed to inquire first of all whether adulteration really existed to a marked extent before the passing of the Act of 1872, and whether that had been checked to any extent by the passing of that Act; secondly, he would inquire whether the Act, as it at present stood, ought to be amended, and in what direction, and whether standards and limits should be adopted; and lastly, he would reply briefly to the remarks made by one or two gentlemen yesterday. In the first place, on the question whether adulteration existed before 1872, and was that adulteration deleterious or merely commercial adulteration. Dr. Bell had already commented on the reports of the Lancet Commission and other instances in support of the contention that adulteration did exist. Now he was one of the two or three remaining living analysts who really trained themselves to food analysis before the passing of the Act, and who had had practical experience in connection with a commission similar to that of the Lancet, viz., the Food Journal Commission. Looking back to the figures of 1870 and 1871, he found that out of twenty-three samples of coloured sweets then examined all over London by the editor of the Food Journal, thirteen were coloured by a coating of chromate of lead, and three contained streaks of vermilion as well. As regarded mere commercial immorality, out of forty-seven samples of coffee bought as pure in that year, thirty-one were more or less mixed with chicory, whilst in seventeen cases the chicory itself was mixed with something else. He mentioned these facts to show that these things really existed—it was not mere hearsay, and he also asserted that the passing of the Act had produced a very great improvement; whereas in the districts in which he held appointments during the first few years after the passing of the Act, they could still get hold of these tainted sweets, they could not now do anything of the kind. For the past four years, out of many hundreds of samples he had examined, not one contained any deleterious colouring matter. He would even go the length of saying that the Act had entirely stamped out all deleterious adulteration, and that what now took place was rather in the nature of commercial immorality. In looking over the books of the South London Public Laboratory, where the business was done for seven districts and boroughs, he found that since 1872 they had examined over 10,000 samples of food; out of those 10,000 they had had occasion to bring a certificate into court over 1000 times, and in every case, except one, that certificate had been supported. That was a practical answer to one of the speakers yesterday, who, having announced himself as an analyst to a Defence Association, stated that it was all very well to quote the published reports of the Local Government Board, that those were only the reports of the analysts; but if they were taken into court before an independent tribunal, as he had said, out of twenty cases in which he had advised a defence, nineteen were successfully defended. Unfortunately, the exception in that case only proved the rule, but he would defer dealing with that point until afterwards, when he would show why those nineteen had failed. It was not long ago since he happened to be speaking to a very eminent foreign man of science, who told him he was astonished, seeing how many public analysts there were in England, how they went on year after year making so few mistakes.

No one was infallible, all make mistakes; but the mistakes made by public analysts were wonderfully few considering the enormous number of samples which passed through their hands. With regard to the Act of the present time, he found that in 1872, taking two of his districts, Lambeth and Wandsworth, in Wandsworth they prosecuted 25 per cent. of cases showing a large amount of adulteration, for he did not mean only adulteration on the analysts' report, but adulteration proved to exist by convictions. In Lambeth also there was the same proportion; last year the percentage in Wandsworth had come down to 6½, and in Lambeth to 12. This was a direct proof of the benefit of the Act.

In Wandsworth especially, the Act was carried out in a most intelligent and excellent manner. One man was set apart whose whole duty was to perambulate the parish, and try to get hold of bad articles, but he could only find 6 per cent. But ought they to be satisfied with the Act as it now stood? He thought not; there was no reason why what was done in one parish should not be done in another. Still, limiting himself to his own experience, he found that in one district, where the inspection was very complete, and the number of samples taken annually was never less than 400, the percentage of adulteration had been reduced from 25 to 6½; in the next district, where the inspection was not quite so complete, where only 300 samples were taken, it had only been reduced from 25 to 12; and going again to another district, where the inspection was very incomplete, and where probably he did not get more than 20 or 30 samples in the year, he found every one of them bad. Then he came at last to two districts, one of them, that of Newington, where the Act had never been put in force at all. What the state of matters was there he had no means of saying, as it was not his business to go and collect samples; but he thought if some of the newspaper editors would undertake to make an examination of those districts, rather an astonishing revelation would be made. What, then, were the points on which the Act required amendment? In the first place, there ought to be a compulsory appointment of inspectors. The Local Government Board could make it compulsory on a Local Board to appoint an analyst, but as they were not bound to appoint an inspector, the analyst would have nothing to examine. Inspectors also ought be appointed compulsorily, and it ought to be compulsory that the number of samples purchased for examination in the course of the year should bear some reasonable ratio to the number of dealers within the district. It might be too much to expect, but he certainly thought every dealer ought to be visited at least once a year, so as to see who were honest men and who were not; particular dealers ought not to be singled out, but a regular system ought to be adopted, and one sample, at least, taken from every dealer. If he understood Dr. Bell rightly as far as he expressed an opinion, it was not desirable to have too many limits and standards, but his opinion was that the true reform required was that the Act should be assimilated in many respects to the New Zealand Sale of Food and Drugs Act, and that there should be certain limits fixed, below which articles should be deemed adulterated. This point came very prominently forward in the case of milk, with regard to which Dr. Bell seemed to think that if such a course were adopted it would restrict the out-put. He did not think it would have that result, and it seemed to him that where you had a variable article like milk, the lowest possible honest milk should be the limit below which the dealer should not go, though he might go as much above it as he liked.

It would leave every man perfectly free to take his own view of his own business, and the man who sold the best milk would get the most business. Why should a reasonably low limit restrict the trade at all? In order to arrive at a limit, there should be a permanent Commission appointed, consisting of one eminent chemist appointed by the Government, such as Dr. Bell, another appointed by the Public Analysts, and a third who should represent the Chamber of Trade. It should be the duty of the Commission to examine in turn every commercial article of food, and to lay down a limit, beneath which that article should not sink, and when that Commission made its report, an Order in Council should be sufficient to give effect to the standard. That would put an end to all heart-burnings, because the traders themselves having a voice in the Commission, as well as scientific men, every one would feel that the matter was fairly dealt with. This was not a chimerical scheme, for it was already adopted in New Zealand, and during last year the schedules of standards had been commenced which would be added to from time to time on the recommendation of the Commission of Experts. With regard to the question of milk generally, he had rather radical views, and he thought the great mistake made by everybody, including analysts was, that they had been too anxious to draw a hard and fast limit, based on one particular quality of milk, when it seemed to him there ought to be a sliding scale. Supposing they adopted the figure of 9 per cent. solids not fat, as the standard, it had been his experience, extending over some 6,000 analyses of milk, that wherever the solids not fat were very low, there was invariably an increase of fat in the milk, and he, from the first, had made it a practice never to condemn the milk where the solids not fat fell to 8·3, or 8·5, if that milk had an excess of cream, because he found that when you lowered the one you gained in the other. Therefore, he thought the standard should be so fixed that if the fat were over a certain limit, it would not matter if the solids not fat were rather lower. On the other hand, if the fat were below a certain limit, plainly showing that skimming had taken place, then the solids not fat ought to be calculated on a higher standard, because taking away the fat from the milk by skimming increased the proportion of solids not fat. He hoped that before many years a Commission would be appointed which would have the power to make these standards, and that a sliding scale in this case would be adopted.

He had been asked by some of his colleagues to refer briefly to some remarks made yesterday. In the first place, Dr. Voelcker, for whom they all had a great esteem, made rather an unfortunate slip in giving what he called some advice to public analysts, which was not to be too hasty in jumping to conclusions. It was certainly very good advice, and he did not object to any one advising him, but the question arose, Did they require that advice, and was Dr. Voelcker entitled to give it? That gentleman, to show some ground for the advice he gave, mentioned a certain case in which a sample of cream contained starch, which on investigation he ascertained to have arisen from its being strained through a new cloth. But then this difficulty arose: if Dr. Voelcker had been in the position of a public analyst, and the cream had been brought to him by an inspector, he would not know where it came from, and would have no opportunity of making inquiries about the cloth or anything else. He was bound by the law to state either that the cream was pure, or that it had something in it. What was the analyst to do but to state that the cream did contain starch, and leave it to the other party to explain how the starch got there. Then Professor Attfield had spoken to twenty prosecutions, nineteen of which failed, and the inference would naturally be that in those cases adulteration did not exist at all. He would give one or two cases in point to explain the matter. There was a public analyst who had to examine some scammony—rather an expensive drug—in which he found chalk, and it effervesced in hydrochloric acid. The analyst, referring to the notes about scammony in the Pharmacopœia, found it specially mentioned that it ought not to effervesce in hydrochloric acid. At all events, he felt bound to give a certificate that that scammony did contain chalk. Then the case came into court, and the Defence Association and Professor Attfield came forward and explained that that chalk must not be taken notice of at all, it was not an adulteration, and that the scammony-root grew in a chalky soil, that the gum was obtained by making little incisions in the root and by putting in little shells in which it collected, and what was more natural than for the innocent natives to put a little chalk upon it to keep the scammony from sticking to the shell. Of course the analyst was laughed out of court, and the chalk was pronounced to be not an adulteration but a mere accident. But that did not show the analyst was wrong. He was bound to say exactly what he found there, or else say the article was pure, which in that case he could not. He could not go into an explanation of this story about the niggers and the chalk, which the defendant could and did so successfully. All these nineteen prosecutions were of a similar nature. To take another instance, an analyst had brought to him an article which was called milk of sulphur, and on analysis he found it contained so much sulphur and so much sulphate of lime, and the authorities took the case into court. He should remark here that the analyst had nothing to do with taking the cases into court; he simply said what the article contained, and it was for the authorities to decide whether proceedings should be taken. When this case came into court, the other side came forward and showed that it was quite a common thing to put sulphate of lime with sulphur; that in fact the public liked sulphur mixed with sulphate of lime, and that for some complaints it was far better, and in point of fact it was quite a legal thing to sell. He was not going to dispute the decision that it was legal, but it was not anything against the analyst, whose report was not in any way impugned. Both in that case and in the case of the scammony the decision did not affect the analyst. It was a mere settlement of the legal question, whether scammony should naturally contain chalk, and whether sulphur should naturally contain sulphate of lime. It was settled that they should, and those were things that had to be brought before the Court to settle, for there was no other way of settling them. Another case was referred to by Dr. Voelcker, in which milk threw up a purple cream, and on examination he found it contained aniline. Of course, not being a public analyst, he did not jump to a conclusion, but made inquiries, and found the milk had been filtered through a red cloth. He assumed that, had he been a public analyst, he would have jumped to a conclusion.

What else could he have done? He could not have said the cream was pure, and must have stated that it contained aniline. It was not his province to inquire how the aniline got there. After this explanation he hoped that the position of public analysts would be more fairly understood in future.

The following communication was then read by the Secretary from Mr. Bannister, of the Chemical Department, Somerset House, who was unable to be present:—

Dr. Dupré, and other public analysts who spoke yesterday, attempted to draw a great distinction between the standard or limit of the public analysts, viz., 9·0 for solids not fat, and 2·5 of fat, and that of Somerset House. In this statement the fact is altogether overlooked, that the methods of analysis are different, and therefore the results are not concordant. The method of obtaining the amount of solids not fat laid down by the public analysts is to dry the solids not fat for three hours only, and not continue to dry till the weight is constant. In our laboratory the "solids not fat" and "fat" also are dried till the weight is constant, and from experience we know that 9·0 per cent. of solids not fat, as determined by the method followed by the public analysts, is only equal to about 8·5 per cent. when dried to a constant weight. Many of the analysts are alive to the unsatisfactory results obtained by the Society's method, and Mr. Hehner, who spoke yesterday, says of it ('The Analyst,' vol. vii. No. 73, April, 1882):—

"It appears to me that as much more concordant results are obtained when the solids are dried to constant weight than for three hours only, it would be well to discard the old plan, and accordingly to lower the limits of 'solids not fat' from 9·0 to 8·5 per cent."

It is therefore not a matter of difference of standards, but of the methods of working, and it is unfair to try to lead the public to believe that we have lowered the standard for milk simply, because we work in a way which gives constant results. We gave the three hours' drying method a fair trial, but as it was not reliable we abandoned it many years ago for the one we now employ.

With regard to the admission that milk varies in composition, it is pleasant to know that this fact is now conceded, for I remember very well when many analysts held that milk did not vary in composition, but only in the quantity given by different cows, and that it was childish to suppose that any cow could give milk containing less than 9 per cent. of solids not fat.

In construing the Food and Drugs Act, we must bear in mind what was the deliberate intention of the Legislature in placing it on the Statute Book, and this intention is well expressed in the report of the Select Committee of 1874 in the following words :—

"Too high and rigid a standard has been fixed by some analysts, and no sufficient allowances have been made for natural variations in milk. Ten per cent. of milk solids may be more difficult to obtain under certain unfavourable conditions than 12 or 14 per cent. under a more generous diet, a warmer atmosphere, and a comfortable lodging. . . . Allowances should therefore be made for these natural variations, which some purely scientific chemists seem to have occasionally overlooked."

It is evident from this quotation that the Legislature could not agree with the views of the analysts, and it is equally evident to me that if more stringent regulations are to be enforced, we must get further powers in a new Adulteration Act.

The following communication was then read from Dr. Wallace, of Glasgow :—

With regard to the question of the possibility of having a standard for milk, I think it would do very well to have a standard not too low, say, 8·5 solids not fat, and 2·5 of fat, or 8·75 and 2·75 respectively, and that in any case when the quantities came below these standards, the milkman should have the privilege of proving his innocence by having the cow or cows milked in presence of the inspector or the analyst. In the case of a man having, say, a dozen cows, it should be no defence for him to show that one of his cows gives milk of unusually low quality.

In any future Act it should be made compulsory for all towns and local authorities to appoint both analysts and inspectors, and the analyst should be paid not by fees, but by a fixed salary, at the rate of *not less* than £1 for every 1000 inhabitants; and the inspector should be obliged to supply to the analyst *not fewer* than one sample per annum for every 500 inhabitants.

There should also be a provision for employing, under the instructions of the inspector, working people, in their everyday apparel, to take samples, as it is useless to attempt to get correct samples by employing ordinary inspectors, who are frequently police sergeants, and who, at all events, are well known to the dairymen and shopkeepers.

Mr. GEO. BARHAM said they had been all much instructed by Dr. Bell's able Paper; a discussion on the adulteration of food was very important, and it was pleasant to see so many public analysts taking part in it, but he must express his regret to see so few of the other side present. What was wanted at such Conferences was not to hear one man's ideas, or one set of men's theories, but to endeavour as far as possible to insure the supply of pure food to the public. Instead of public analysts setting themselves apart from traders, and looking upon them as their natural enemies, and speaking in a sneering tone of commercial morality, he thought it would be better if they occasionally called in the leaders of the various trades to aid them in carrying these Acts into operation. Having given evidence in the year 1884 before a Committee of the House of Commons, which inquired into the working of the adulteration Act of 1872, and representing 300 dairy farmers, and being deputed by the Metropolitan Dairymen's Society to be present at this meeting, he thought he was entitled to say a few words. He had the greatest respect for public analysts, but as there were dairymen and dairymen, so there were public analysts and public analysts, and those gentlemen who were members of the society knew very much better where to draw the distinction than he did. Professor de Chaumont had spoken on the previous day about commercial morality, and said they could never stop adulteration until the scale of morality was higher, and that was no doubt correct. Why should a dairyman be asked to supply milk without water, when he had to buy beer with 50 per cent. of water, to buy bread with a certain proportion of alum ; as to drugs, he was not quite sure about them, and even taking professional men, like lawyers, did they not skim their milk ; did they not set it for years and skim it every two or three months, or as often as they could get a cheque. If he went to a horse repository to buy a horse, did he find honesty there? and it was said that cattle jobbers were even worse than horse dealers. If he bought a piece of furniture he was assured that it was solid mahogany when it was only veneered ; or if he went into a linendraper's to buy flannel or cloth, and purchased what was warranted to be all wool, it would probably be found to contain more or less cotton. What protection had he in all these cases ; and why should dairymen, therefore, be expected to be the only honest people in the world. Of course they ought all to be honest, but they ought not to be attacked as if there were none honest among them. Dr. Voelcker had spoken of cream being extracted in the strawberry season, but he should like him to be apprenticed to the trade for a few weeks, and he was quite sure he would be satisfied that in such a season it was quite impossible to take off the cream and sell the remainder after standing for twelve or twenty-four hours as fresh milk. With regard to the use of boracic acid and bi-sulphite of lime, and so on, in his opinion they should be forbidden. As one of the public, he had no right to have his children dosed with boracic acid day after day for the purpose of enabling the dealer to save his milk ; and if he bought beer he did not want bi-sulphite of lime. All such preparations should be forbidden ; no doubt it would entail a certain amount of waste, but the public must pay for it, and they had better do that and have the article pure. He had no desire to be personal, but if he were inclined to be so, he should take exception to a public analyst occupying a very high position, writing sensational articles in the paper with reference to milk which had been purchased by his own officials, and then writing a letter to be advertised in the public prints, to one dairy firm two or three days afterwards, saying that the milk supplied by the said firm was perfectly pure. He thought that was highly objectionable, and he wondered that the Society of Public Analysts had not a certain amount of *esprit de corps* and professional pride which should prevent such things being done. Dr. Dupré spoke with reference to the adulteration of milk, and the quality he found on Sunday mornings and other days, but it seemed to him that he had named his own remedy, he had only to send every other Sunday for samples, and the milk would always be pure. Then Mr. Hehner said the Adulteration Act had worked great benefit, for whereas milk used to be adulterated with 50 per cent. of water, they now rarely found 20 per cent., and in the majority of cases it was only 10 per cent. He was pleased to hear it, and he believed it was perfectly true; but what did Mr. Wigner say? that within the last four or five years the percentage had increased, and if that were the case the only inference to be drawn was, that the analysts and inspectors and all this great expense was of no earthly use. Another gentleman referred to the Paris supply, and he had often noticed that Englishmen disparaged themselves more than any one else, and always thought that things were done very much better abroad. For instance, he once heard the secretary of the Royal Agricultural Society say he would not drink a drop of English milk, and would not allow a pound of English butter to come into his house—a most extraordinary statement for such a man to make—because he found everything was done so much better abroad. Why was that? It was simply because he had gone abroad as secretary of the Royal Agricultural Society; he had been taken to show places, and everything had been made nice and smooth for him, the same as we should do here if the secretary of some great society abroad should come, sending a letter beforehand to say when he was to be expected. He had made the supply of milk to Paris a particular study, and had seen the whole process from beginning to end. In the first place, the morning milk was boiled, it was cooked milk, the night's milk was put with it, a thing unheard of amongst dairymen in England, and those two milks mixed together were sent in to Paris next morning. They only had a supply once a day, and on a hot summer's day it was impossible to get a drop of sweet milk at one o'clock in Paris. He had tried to do so, saying it was wanted for a sick child, but he could not get it; he was told they had a little milk just on the turn, which would be all right with a teaspoonful of bicarbonate of soda stirred up with it, but that was the best he could obtain. There was no town in the world supplied with better milk than London. He must say he was very much pleased with Dr. Muter's careful speech; he said he would have no water put into milk, and there he agreed with him; but this was his difficult point, which he could not reconcile his commercial morality to: the analyst went into Court and swore that a given sample contained added water. Now, had he found the added water? No, he knew he had not; he had found a certain amount of solids, and if he were to go into Court and say that he had only found a certain amount of solids, and inferred that there must be added water, the case would be dismissed. He acted entirely by the amount of fat, and no fatty solids, and he went deliberately and told the magistrate and signed the certificate that he found a certain amount of added water, and in the result the dairyman was convicted of fraud. It was said that eels got used to being skinned, and some people seemed to think that dairymen paid the fines with a great amount of pleasure. But there were dairymen who would scorn to be convicted of fraudulently deceiving the public. Professor de Chaumont, speaking of commercial morality, said these men would scorn to put their hands into his pocket and take out *6d.*, but they would not hesitate to defraud him by adulterating his goods, which in reality was the same thing. You were convicting that man of picking another man's pocket—in fact, of robbery, for there was no other term for it. As to paying the fine, it was comparatively nothing. As Shakespeare said :—

> "Who steals my purse steals trash;
> But he that filches from me my good name,
> Robs me of that which not enriches him,
> And makes me poor indeed."

And many traders were under the same impression. When this Act was first passed, the Society he represented invited the public analysts to meet them with the view of fixing standards, but that was declined. What they wanted analysts to do was to give them a ready means of detecting added water. He did not mean water digested by the cow, but raw water added, and if they could do that he would guarantee it would do more to stop adulteration than all the fines in the world. With regard to the standard, a cow had been called a machine for making milk, and so she was, but unfortunately they could not control her like a steam engine, and though you gave a cow good food, she might take it into her head to produce a large amount of fatty solids, and a small proportion of non-fatty solids, and if they sold that to the public they might be convicted of selling watered milk. 9 per cent. was adopted as the standard for non-fatty solids, and at that point the public analysts did not give a certificate that the milk was adulterated, but if it should only come up to 8·5, 8·6, or 8·7, did they say that the difference between 8·7 and 9 represented the amount of adulteration? No! They raised the standard then to 9·3. Was that just and right? Were they not deceiving the magistrates, the public, and everybody else, if it were so? Now, with regard to this standard, he would quote a few figures. There was a dairy show held annually in London, and one of the most useful classes was the class for milking cows, in which the prize was given for the animal which gave the most milk of the richest quality. It was the duty of every exhibitor to feed his cows as well as he could, and to get the very highest quality of milk. The figures he was going to read would be found in the report of the British Dairy Farmers' Association, the samples being taken in the presence of four or five judges, and analysed by Dr. Voelcker. The following were the figures of the milk of some of the short-horn cows :—

Non-fatty solids	.. 8·5	Fatty	4·1
" "	.. 8·8	"	3·7
" "	.. 8·4	"	4
" "	.. 8·8	"	4·7
" "	.. 8·8	"	3·1
" "	.. 7·8	"	3·9

Was it to be said that these animals were to be sent to the butcher as being unfit to produce milk? Out of 23 short-horn cows 12 gave less than 9 per cent. of solids not fat, the average being 8·9, and 3·7 of fat. Taking Jerseys and Guernseys, which gave the richest milk in the world, one gave 8·8, another 8·5, and another 8. Again, taking the Dutch cows, the average of total solids was 11·8, the fat being nearly 3, so that the average of the whole of the cows was less than 9. Were all these animals to be sent to the slaughterhouse? He could tell them how they could be sure of having pure milk, and that was to make up their minds never to pay less than 5*d.* a quart for it; dairymen would then get a fair profit, would be afraid to lose their custom, and would always supply pure milk. If they were working like brewers and did as Dr. Richardson said they ought to, for he contended that drawing milk from a cow was a barbarism, that the component parts ought to be mixed together without the trouble of going to the cow for it, and when they could prepare milk like that, then would be the time to fix a standard. You could not go to a butcher's shop and always find the meat containing the same quantity of fatty and non-fatty solids. If a standard were fixed, it must be low enough to cover the poorer samples, and then people would have to depend on the repute of the firm with which they traded. With regard to the butter-fats, that was a most difficult thing. There ought to be 3 per cent., but if that was always insisted upon, any dairyman might be fined or punished. An alteration was constantly going on in milk; if it were set in a can at night, by the next morning the cream would be at the top, and the heavier portion at the bottom, and that change went on not only in the dairyman's shop, but in the cow's udder. Some Sunday morning, when the inspector went to get samples, the dairyman's man might have overslept himself, and instead of finishing milking the cows would scamp them, the consequence of which would be that there might be only 2 per cent. of fat in the milk. Then, again, milk which came 150 miles, as some of it did, might be partially churned; he had seen globules of fat floating on the surface, which would take off ½ of 1 per cent. of the fat. Then, again, the milk stood in the cans in the shop, and samples taken later in the day would not be so good as those taken earlier. With regard to altering the Act, he should certainly like to see it altered. Dairymen were not an influential body of men, but some two or three years ago they did go to Parliament and got the Act altered to a slight extent; there was a little Act brought in, saying that milk should be sampled at the railway stations, because unless the sources of any article were kept pure it was impossible to have it distributed pure, and in some cases it was alleged that the milk was sent up from the country in an adulterated state. The Act was therefore altered, giving power to the inspectors to obtain samples at the railway stations, but perhaps some gentlemen present could tell him at how many stations this was carried out.

Dr. MUTER said it was carried out in Lambeth and Wandsworth.

Mr. BARHAM said it was carried out in St. Pancras and Paddington and the districts named by Dr. Muter, but he believed in no others in London, although the proper authorities had been asked to do so. Then, again, Clause 14 said, the inspector, when purchasing a sample should offer to divide it into three parts. Now those words, "shall offer," ought to be taken out, and it should be compulsory on the inspector to divide the sample. Another point was with regard to the written warranties; these traders were told they should buy their goods with a written warranty; they were probably aware that a dairyman purchased his milk twice a day, and if he agreed with a farmer or a wholesale man to supply him with milk warranted pure for a twelvemonth at a given price, they would suppose that was a written warranty, but it was nothing of the kind. It had been decided that a dairyman must have a written warranty with every consignment, which of course was utterly impracticable. What farmer would get up at four o'clock in the morning to write a warranty to put on a can of milk? Then, again, the Act provided that in the certificate the analyst should say if the milk had undergone any change. He thought it would be better to provide that the summons should be issued within a week which would allow plenty of time for the analysis to be made, and if necessary the remainder of the sample could be tested while it was comparatively fresh. If the Act were to be carried out properly it should be made to people's interest to carry it out. There was more heartburning over one honest man convicted unjustly, and more prejudice excited against the Adulteration Act, than by 500 just convictions.

Dr. STEVENSON said he had no intention of replying to Mr. Barham, who represented a large and important interest, but he could not help feeling that if they could get at his own private opinion he would be inclined to fix a higher standard for milk than he had admitted in his speech. He was unwilling to fix any absolute standard, and was rather inclined to agree with Dr. Muter, that when milk was rich in cream, or butter-fat, some allowance might be made for solids not fat. At the same time, he must enter a protest against the adoption of any such standard as had been proposed by Dr. Voelcker. He was quite sure that although the milk supply in London was greatly improved, it was not what it should be, and if that standard were adopted they would have a depreciation of the quality of milk very likely to the extent of 10 or 12 per cent. Mr. Barham said that analysts swore that milk contained so much added water, but though he had signed some thousands of certificates under the Act, he was not aware that he had made any such declaration. The form of certificate was that the analyst expressed an *opinion* that there was so much added water. He wished to impress on the general public, a good many of whom he believed were present, that public analysts were desirous of having more assistance from them in carrying out the Act. It was quite astonishing the few samples which were sent to them in this way. In the case of public institutions especially, he had had from time to time to examine the drugs supplied to hospitals, infirmaries, and so on, and he had been astonished to find what inferior articles, as a rule, were supplied, compared with those supplied to the general public. It was, of course, said that the manufacturers contracted at a figure for which the articles could not be supplied, and possibly that was so in many instances; but still that did not exonerate the trader from promising to supply a genuine article at a price at which he knew it could not be legitimately sold, and then supplying an inferior article. It would be well if analysts directed their attention more to drugs, and he mentioned this because he noticed there were many gentlemen present connected with pharmacy. He had examined many articles supplied by pharmacists, and he could vouch for many of them, that they were supplied with a care and precision of quality which left nothing whatever to be desired; but, on the other hand, there were certain classes of traders supplying at a cheap rate to medical men and public institutions drugs of a very inferior class. To give an instance recently brought before him, though not officially, in a compound senna mixture he found that its virtues depended on the presence of an enormous excess of Epsom salts, which was a legitimate constituent; but the senna was conspicuous by its absence, and the very much cheaper sulphate of magnesia was substituted. He did not mean to speak disparagingly of pharmacists as a body, for he thought no class of the community, as a rule, supplied better articles, but there were many who did not. With regard to the question of articles of an inferior character being sophisticated by the addition of something which gave them a good appearance, such as the addition of alum to bread, he should have liked that point to have been discussed by those best competent to form an opinion how far it was legitimate to utilise inferior articles in this way. It was well known that there were certain classes of flours which were not what was called in a sound state, and out of which a good presentable loaf could not be made, yet by the addition of alum it could. He was of opinion that if you took an unsound flour and added alum to it, and made a presentable loaf, the purchaser had a more wholesome article than if no alum were added to the unsound flour; but that did not quite settle the question. If the purchaser were told that alum was mixed with the bread, it would be right enough, but he did not understand the morality of giving to this originally inferior article a better appearance, and making it more like a good article ; and this was only typical of several other things that were treated in the same way.

Mr. EASTON (who described himself as a dairyman and editor of a paper connected with the dairy trade) said dairymen had no antipathy whatever against analysts as individuals, but they had an antipathy to incapable analysts who were not quite fit for the position they occupied, and whose certificates had been the means of partially ruining many honest traders. The statement had been made, that out of a thousand cases taken into court, only one had been lost, but the question was how many of them had been contested. There were hundreds of cases where the defendants did not attempt any opposition. He knew a case where a man was fined for the addition of 4 per cent. of water, and he got the case adjourned, and sent the sample to Somerset House, and he was happy to say they gave a righteous decision, and the case was dismissed. One gentleman, who spoke yesterday, intimated that public analysts were better fitted to give an opinion than the chemists at Somerset House, because they analyse every year 6000 samples, whilst at Somerset House they did not perhaps analyse more than 600 altogether. But had the Public Analysts any evidence of the identity of the samples which they analysed, and if not how could they pronounce any of them adulterated. Did they obtain samples produced under all the different circumstances? or had they obtained them indiscriminately, and formed a general average? According to one gentleman, the adulteration of milk had dropped from 50 per cent. to 6 per cent., and the adulteration of articles of food had been going on from time immemorial. Now, as the Adulteration Act had only been in existence since 1872, it was quite within the range of possibility adulteration might become extinct, and then the occupation of the Public Analyst would be gone.

Mr. HELM (Somerset House) said Dr. Bell's paper was so cordially received that it was scarcely necessary for any one from the department over which he presided to address the meeting, were it not that in the course of the speeches a serious charge was made against him and his colleagues in their capacity of referees. Two gentlemen of position amongst public analysts had made the very serious charge that in adopting the standard they had at Somerset House they had taken as their standard either diseased or improperly fed cows. Now they could have no motive for doing so, and they had done nothing of the kind. They sought London round, and went as far north as Derbyshire, and as far west as Somerset, in order to get fair representative samples. Those two gentlemen said that the limits adopted by the Society of Public Analysts were 9 per cent. of solids not fat, and 2·5 per cent. of fat, but to-day he had been pleased to hear a past President of the Society say that he himself would pass a milk with 8 per cent. of solids not fat, provided the fat was fairly high; and yet because Somerset House adopted something like 8·5 or 8·4, they were told that their cows were diseased or badly fed. As Mr. Barham had said, it was not usual to exhibit badly fed or diseased cows at dairy shows. Dr. Dupré had on many occasions opposed the referees at Somerset House on account of their not adopting the limits laid down by the Society of Public Analysts, and said they were encouraging adulteration of milk by taking poorly fed and diseased cows as the standard; yesterday he was rather more moderate, for he said that occasionally a single cow might give less than 9 per cent., though whether such cows were diseased or improperly fed he was not prepared to say, but the mixed milk of a dairy was never so low. Now he happened to have with him the analyses referred to by Mr. Barham of the milk given by the cows exhibited at Islington. Those analyses were not made at Somerset House, but by a man of probably greater experience on this matter than any one in the country, namely, Dr. Voelcker, who found that in five years, from 1879 to 1883, out of twenty-three shorthorn cows thirteen gave a milk below the Society's standard; whilst out of nineteen Jerseys three gave milk below the standard; and out of sixteen Guernseys four gave milk below the standard; and out of six Dutch four were below the standard. Then it was said that the milk from a whole dairy would never give milk below the standard; but if the milk fiom the whole of the shorthorns exhibited had been mixed and tested, it would have been pronounced adulterated according to their standard. At Somerset House they sent round the whole of the country, and out of 238 single cows the milk of 184 would have been pronounced adulterated according to the Society's standard, being below nine. And out of twenty-four dairies eleven fell below the standard. What were they to think of Dr. Muter, who had passed a sample at 8 if the fat was high; and Dr. Stevenson congratulated him, and said he followed a somewhat similar course, while at the same time the referees, who did not belong to the Society, were to be opposed, because they had thought proper to act upon the results of their own investigation. There was nothing in Dr. Bell's paper which could give any offence to public analysts, but Dr. Dupré said how glad he was to have an opportunity of stating their grievances, one of which was, of course, that Somerset House had been the means of upsetting many of their certificates by not adopting their standard. He could assure him that the chemists at Somerset House were equally glad to have that opportunity of explaining their position, but the letter which had been read from Mr. Bannister had forestalled a great deal of what he had intended to say, The Society of Public Analysts adopted their standard on a basis suggested by Mr. Wanklyn, one point of which was to dry the milk for three hours only, then to take the fat out of it, and the difference was put to non-fatty solids. Now, of course, if any water were left in the milk, it would go to swell the non-fatty solids; and in a paper which had been read by Mr. Hehner, he had shown that, by weighing the non-fatty solids dried, 8·5 was equivalent to something like 9, as usually estimated. How then could it be said that the cows must have been diseased or badly fed from which the Somerset House referees drew their figures, if 8·5 fully dried was equal to 9? And, as Dr. Bell had pointed out, it was far better in chemical analysis not to have any partial and comparative results, but to deal only with actual results, which any other chemist could deal with. He could assure all analysts present that there was no work done at Somerset House which gave so much anxiety as the reference samples, and they were always glad when their results agreed with those of the Public Analysts. The great question was what could be done to make the Act more effective. Unfortunately it was very inefficiently worked throughout the country. Theoretically the machinery provided was effective, but it was not carried out. Dr. Dupré had suggested that inspectors should be compulsorily appointed, and that a certain percentage of samples should be purchased; and that no doubt would be very good. But what would be the use of appointing an inspector, and insisting on his making purchases, if he always went about in a policeman's uniform. He thought the Local Government Board should be empowered, where there was reason to think the Act was not properly carried out, to work it themselves in some way or other, which he would leave to others to devise, but he feared the Act never would be efficiently worked without some further pressure from head quarters.

Mr. ANGELL said this was the first opportunity the public analysts had had of speaking at such a meeting before men eminent in the chemical world, and before the representatives of what he might call the Upper House who were set over them. One of the earliest grievances of the public analysts was that they had certain gentlemen set over them in an upper chamber whom they could not approach. He was also glad to have come face to face with those who seemed to look upon public analysts as if they had something like the other side to play. One gentleman spoke of it as if it was a game with two sides, and seemed to think that two blacks made a white, by showing that many other people besides dairymen were to blame. He also seemed to have misunderstood some of the previous remarks, and to have mixed up a statement made by one gentleman, that the percentage of cases of milk adulteration had increased, with the statement of another, that the percentage of water had decreased. The two facts were, however, by no means inconsistent. He also said they could not tell added water from other water, and that was the same complaint he had heard made once before when lecturing before a body of farmers in Hampshire. He had taken some pains to show why it was reasonable to suppose that such a secretion as milk might be expected to be somewhat constant in its nature, and to show by experiments that that was really the case, as it was within certain limits. One of the farmers present then wanted to know whether he could tell added water from other water, and having admitted that he could not, he was told that he was no use, and he might sit down. He did not, of course, accuse Somerset House of having specially prepared cows, though one of the gentlemen seemed to intimate that they were, and if it were the case it might give rise to some difference in the results.

Mr. EASTON said what he meant to say was that at Somerset House they investigated the variations which occur in genuine milk under all circumstances.

Mr. ANGELL said one speaker had referred to the difficulty of deciding as to what might be passed as beer, and it frequently happened that the authorities in various districts took upon themselves, in a fit of indignation as to the quality of the beer in their neighbourhood, to send him a great many samples, and in consequence of the fact that there was no formula laid down for the composition of that beverage, he was bound, unless he found something absolutely injurious to health, to certify that the beer was genuine, which no doubt sometimes produced considerable astonishment. He thought he could see a way out of the difficulty. If the only alternative was to suppress that very large and very reasonable form of commerce which consisted in making up various kinds of tonic drinks and selling them under the name of beer, or to leave them alone, he should say leave them alone ; but he thought it might very reasonably be laid down, that if a man asked for a glass of beer he should have nothing but malt and hops, but in order to meet the difficulty of not suppressing a good wholesome article—not beer—it should be sold as ale. He would suggest that under the name of ale anything might be sold in the shape of bitter and wholesome beverage made from what source it might, but if a man asked for beer he should have malt and hops only supplied. As Professor Attfield was not present, he should not say as much in reply to him as he had intended, but he certainly thought such statements as he had made should be put forward with extreme caution, and he claimed for public analysts a much more independent position than Professor Attfield held with regard to any prosecutions he had been connected with. He had spoken of some 20 cases, and in two or three of these he appeared on one side and Professor Attfield on the other. Now, which of the two were to be considered the more interested parties, the gentleman who held a high reputation as a distinctly qualified man, the representative of a powerful trade union, which came down with its counsel and its legal pleaders, and chemical pleader in some cases, with a vast number of pharmacopœias piled up (and if one did not cover the case another did), or the public analyst? If the analyst ventured to say that the article was set down in the British Pharmacopœia and that it did not answer the tests there prescribed, then they did not believe in the pharmacopœia at all; but if, on the other hand, there was some other pharmacopœia which could be taken out from the British Museum which would answer their purpose, it was brought out and paraded, and if the case was dismissed, they were told they must look upon it as if an error had been detected. Of couıse there were such things as differences of opinion, but it was decidedly incorrect to speak of these cases in which prosecutions had been dismissed as if they arose from errors of the analyst. He had intended to have referred to several instances in which Professor Attfield was concerned, in one of which he actually found, where others could not, a very fine trace of soda carbonate in the presence of a considerable quantity of sulphate of lime in so-called soda water, by some extraordinary method which he had kept secret up to the present time, but as he was not present he would not go into details.

Professor REDWOOD said he had listened with considerable interest to the discussion which had taken place, but what had been said by several previous speakers had superseded the necessity of his saying much upon the subject. He almost entirely agreed with what had been said by Dr. Muter, and he might say also with reference to the very spirited remarks of Mr. Barham, that all who heard him must congratulate themselves on having heard a very able defence of the dairymen. But there were two points which had not been thoroughly disposed of, upon which he would make a few remarks. First, in reference to the statement made yesterday, that the Adulteration Act had not accomplished all that was expected from it, or even much that could be satisfactorily referred to, because it was found on reference to statistics that the proportion of adulterated articles continued very much what it was in the first instance. No doubt that argument would have weight with many persons unless some explanation were given of it. Now it appeared to him that that arose mainly from the circumstance that a very considerable change had taken place in the nature of the substances collected by the inspectors for analysis as compared with what was the case some years ago. He had been a public analyst almost from the commencement, and had had very considerable experience, and he should say that when this work commenced the inspectors were in the habit of collecting a very large number of samples of different kinds, but in process of time it was ascertained that a large number of these articles which they had been in the habit of collecting were found practically never to be adulterated, and latterly the inspectors had confined themselves to a limited number of articles, such as were most liable to adulteration—such, for instance, as milk, butter, coffee, mustard, and a few other articles—those, in fact, referred to by Dr. Bell as being the articles which were alone found to be to any general extent subject to adulteration. Seeing that the articles now collected were only those liable to adulteration, it would naturally follow that the proportion of adulterated specimens amongst them should be greater in relation to the aggregate than where a larger number of different classes of articles were examined. This was the principal cause of the continuance of the same percentage of adulteration as occurred some years ago. There were other causes certainly, amongst which might be named the imperfect manner in which the Act was carried out, for in those districts where it had been most regularly and systematically enforced, there had been a very considerable improvement. In one of the two Metropolitan districts with which he was connected, there had been a very large improvement in this respect; whereas in others the case was quite otherwise, those being districts where the inspectors only now and then purchased samples for analysis; the result of which was that certain traders got into the irregular habit of supplying adulterated articles. He should be glad to hear from Dr. Bell whether, when he referred to cocoa and mustard, he intended to indicate that he did not consider the addition of flour, starch, or sugar an adulteration. The view which he acted upon was this: he certainly considered the substance sold to the public under the name of cocoa was well understood, unless there were some special explanations given, to be cocoa mixed with starch and sugar, but, nevertheless, if he found a sample with an undue proportion of those additions, he should look upon it as an adulteration. The same with reference to mustard; from the commencement he had considered that the addition of a little flour to mustard improved its quality, where it was used for dietetic purposes, but if he found more than 8 or 10 per cent. of starch, he should certainly also look upon that as an adulteration. Of course, if mustard were intended to be used for medical purposes, it should be in a state of purity; but when only used for dietetic purposes, he did not consider that in those cases in which the starch was intentionally omitted it was really any better in quality than it would be if there were a certain portion of starch present in it.

Mr. CHESHIRE said he was very glad that he had taken the trouble to come from Hastings to attend the Conference which had been very interesting. It was stated that the percentage of adulteration was probably very much higher than the reports gave, on account of tradesmen often knowing the inspectors, especially when they were in uniform; but he would draw attention to the fact that there was another side to that question, in his district certainly. There the inspector only procured samples when he had reason to suppose he should find them adulterated, and yet they found that only about 15 per cent. were adulterated. Means were taken by the inspector to prevent suspected persons knowing him, by sending other persons, or by asking for articles from special canisters, and he might say that in the case of about half-a-dozen samples which had been sent to him for analysis by private persons he had not found one adulterated. One reason why small fines were sometimes imposed was, that they did not always fall on the really guilty party; the small dealer often bought from the wholesale man without a written warranty, in which case he had to suffer, and the plea was often made, in the Hastings

Court, that they had sold the articles as they bought them. With regard to the amount of adulteration, he had always made it a practice only to certify to such an amount as he could feel sure of, but if a very small amount only were stated, so as to be quite safe, sometimes the magistrate would remark upon it to the effect that there must be some mistake, for it could not be worth the while of the tradesman to run the risk of detection for such a small advantage. With regard to the necessity of giving quantities in the certificate, he was in favour of keeping things as they were. He thought an analyst ought to be bound to say something about quantity, for though it had been very fairly remarked that it was very difficult in some cases to give the quantity at all accurately, he for one always put the word "about" in, which was quite sufficient to cover any slight margin. Only recently he had a case in which he had certified that a sample of raspberry jam contained about 50 per cent. of apple jam; he believed it was really more, but that word "about" was never objected to. With regard to the improvement in the percentage, he might refer to another district, Rye, which was one of those places in which they went for three or four years without taking any samples, and then made a grand rush. He would have a letter from the Town Clerk, stating that some samples were going to be brought to him, and shortly he would have a number of samples of milk, one from each dealer, nearly half of which turned out to be adulterated. The Town Clerk also said that next week he was going to send him samples of butter, but he told him afterwards that he could hardly find any butter in Rye, that it was all butterine. That showed how much more careful tradesmen were when they knew the Act was going to be put into force. The Chairman had referred to the question of beer, and said there seemed to be no definition of it. Now, he took it, it must be a fermented liquor containing spirit and a wholesome bitter, and that was the definition he had gone by. As regards the use of chemical re-agents, he adopted the practice that if they had been used reasonably, and with good effect, he passed them, but he thought there ought to be some precise understanding about these things. If a chemical re-agent looked at all suspicious, and was in any way unhealthy, he should certify against it at once. With regard to milk, it appeared that a majority of the low standard milks were analysed by Dr. Voelcker, and he thought it was quite clear that he adopted some different plan for drying the solids to that generally followed. In his own case, he adopted the usual plan of drying for three hours, and in every case—except where the fats were high, when if the solids were a little low, it had been passed—if it fell below 9 he had certified against it, and he never had an appeal to Somerset House, which appeared to show that the milkmen, in those cases, admitted the adulteration. As regards any alteration in the Act, it was quite true the word "adulteration" was not mentioned, but in their reports they had to state that a certain number of samples were genuine, and a certain number adulterated. With regard to that, a question had been raised whether skimmed milk could be said to be adulterated, and he thought perhaps "sophisticated" would be a better word. He had intended to have made some remarks on what fell from Professor Attfield, but after what had been already said, it was not necessary.

Mr. LLOYD said he thought the great object of the Food and Drugs Act was to ensure health, and that the public analyst was required rather to protect the public from any ill-effects of their food than to ensure that it should come up to certain standards. That was the difficulty he found in coming to any conclusion as to standards, especially in regard to milk, because that had proved of all articles of food the one which was most likely to produce disease. If the very best milk had water added to it, you enormously increased the liability to disease. There was also, he understood, a large amount of condensed milk mixed with water being sold as milk, and, if there were one practice more than another likely to prove detrimental, that was it. The liability to disease from even minute quantities of water getting into milk had been very great, and therefore the danger would be much greater if condensed milk were to be made up to the strength of ordinary milk, and sold as such. If the milk were condensed with sugar, the analyst could detect it, but some condensed milk was made without sugar, and he did not exactly see how that was to be dealt with. It was said the Act was largely a failure, owing to inspectors not being able to obtain samples, but that was provided against by the public being enabled to take samples. The difficulty, however, arose owing to a fee of 10*s*. being required, because no one could be expected to buy a shilling's worth of food and pay 10*s*. in order to prove whether it was pure. It was the duty of the State to protect the public; how that was to be done he was not prepared to say, beyond suggesting that, where there was any suspicion aroused, the public should be invited to apply to the inspector. After all, the great thing was to educate the public more upon this question. You could not expect a poor man to pay 1*s*. 6*d*. for coffee without chicory in preference to paying 1*s*. for coffee with chicory; and until they could educate the public to see the effect of pure food, the Act would never receive that public support which, after all, it mostly needed. He did not think it necessary to extend the Act to agricultural substances. The reason why analysis of food should be made at the expense of the State was because the food cost comparatively little compared to the cost of the analysis. But that was not the case with cattle food, and if you included feeding cakes which the farmer bought in large quantities, and with regard to which he could afford to protect himself, and was assisted by Farmers' Clubs in doing so, he did not see where you could stop. If it held good for cattle food, why should it not hold good for the manure with which he grew his crops, and the principle would have to be extended to analysis of woollen cloth and everything else.

Dr. VEITCH said that almost all the speakers who had addressed the Conference had referred principally to the question of milk adulteration. It was a question deserving of the great attention paid to it, because milk was an article of food not only in daily use, but one on which the younger part of the population almost entirely depended. He had devoted the last eight years exclusively to analytical work in connection with milk and milk products, and in the laboratory which had been under his charge for the last four years some 50 to 60 samples of milk were analysed daily. That there were some difficulties in connection with milk analysis and milk adulteration he thought was sufficiently proved by the animated debates which ensued whenever the subject was made a matter of discussion. The variations in the natural composition and the alterations caused by the tendency of the fat in milk to separate in the form of cream made it difficult to ensure the supply to the general public of an article in no way tampered with, and at the same time not to do wrong to the honest dealer. The liability to speedy decomposition very often made it difficult to prove a suspected, and confirm an alleged adulteration. Bearing in mind the fact that milk naturally varied to a great extent, a prosecution for adulterated milk would be almost impossible unless some standard or better limit were fixed. The question of how the limit should be fixed was a difficult one, and in his opinion could not be solved satisfactorily as long as the milk of individual cows and dairy milk was treated in the same way. Milk of individual cows sometimes came down very low as far as composition was concerned, and he could see no reason why dealers should not be compelled to sell such a milk labelled accordingly, and a lower standard should be applied to it. Dairy milk, which was the milk of a number of cows mixed, was much more uniform in character, although it might vary a great deal. The special gravity of milk could easily be ascertained by means of a small lactometer, and if only every small milk dealer who had no other means of protecting himself, and every householder who liked to have pure milk for himself and his offspring, would use this instrument, a great deal of watered milk would be banished from the streets of London in the shortest time ; but as it was impossible to detect adulteration in every case by this means, there would still be a great deal of the work left to the analyst. Where to fix the limit was a question of analytical method ;

if the total solids were given, the fat and non-fatty solids compensated one another. If by one method the fat was exhausted to the last trace, the solids not fat would be proportionately low; if, on the other hand, a particular method left about $\frac{1}{5}$ per cent. of fat in the non-fatty solids, the latter would be so much increased. How much of fat and non-fatty solids one might be allowed to expect in milk must be found out by statistical investigation, and he thought there existed plenty of material nowadays to settle the question at once. If out of 100 farmers 99 were able to produce milk of a certain standard, the 100th should be able to do the same, and if he fed his cows so poorly, or watered the milk through the cow, his milk should be excluded from the market. In his opinion, the standard applied by the Society of Public Analysts at present was quite fair and just to both parties. The tendency of the fat to rise in the form of cream must not be lost sight of, and he thought it was only right in the case of milk falling below the fixed limit, it should not be returned as watered or skimmed, but as not of the nature, quality, and substance of the article demanded, and public analysts should not be obliged to make statements which they could not prove, viz., that the addition or depreciation extended to such and such a percentage. As to decisions in the cases of disputed analyses, he thought it utterly impossible to put an analysis of an old and decomposed sample of milk against one made of the milk while it was sweet. As soon as decomposition had proceeded to a certain point, in his opinion, it was almost waste of time to analyse it.

Dr. BELL, in reply, said it was very satisfactory to find that hardly any exception had been taken to the contents of his Paper, and very few criticisms had been passed upon it. Dr. Dupré rather questioned the potency of fusel oil in whisky, but he still adhered to the statement he had made, and thought experience bore him out. It was a very common saying in Scotland, "You will not find a headache in a hogshead of that whisky," the reason being it was a matured and mellowed whisky, the fusel oil having been entirely changed into harmless compounds. Distillers might entirely dispense with all the trouble and expense of maturing spirits in bond if it were not for the deleterious character of the fusel oil present in new whisky. With regard to the question of cocoa and mustard, put by Dr. Redwood, he had stated, "That the only substances now found in cocoa were sugar and starch, and in mustard flour and turmeric, and these additions are not considered as adulterants so long as the preparations are not sold as pure or unmixed articles." It was not his province to decide what quantity should be present in cocoa or mustard to constitute adulteration; that was for the Justices, but if he found a greater quantity of flour in either article than is usually present in ordinary commercial samples, he should feel it his duty if that question formed part of the reference, to indicate that fact in his certificate. The great bone of contention throughout the discussion had been "milk;" and their position at Somerset House seemed to have been largely misunderstood with respect to that article; and he was glad to have this opportunity of explaining it. In the paper written by Mr. Bannister a paragraph was quoted from the report made by a Parliamentary Committee in 1874, which stated that cows yielded milk of different qualities; and indicating that proper allowances should be made for variations in quality. Parliament was aware of that, and laid down no limits of quality, and fixed no standard, but imposed on the Public Analysts and the Reference Department the duty of saying what was watered and what was not, and this was a serious responsibility in the face of the now admitted fact that milk does vary greatly in composition. Mr. Hehner said that when samples were sent to Somerset House, we often said we could not confirm the analyst's statement that water had been added. That was undoubtedly true, but as a matter of fact the public analyst was exactly in the same position, and the well known principle of English Law was that if there were any doubt in a case, the defendant should have the benefit of it; therefore, if they could not say that water had been added, although they could not say it had not, they gave the defendant the benefit of the doubt. That, he believed, was the clear intention of Parliament in imposing those important duties upon them. He did not oppose the fixing of standards, or limits, but it was for the public analysts and the trade to arrange as to standards of quality, and not for him to do so; his duty was simply to do justice between two parties. He had no objection to any standard of quality being laid down, provided it was laid down legally, but he could not lay it down, nor could the public analyst. With regard to the variations in the composition of milk, he was pleased to hear Dr. Muter state so honestly and fairly his views on the subject, and he hoped other analysts would follow in the same line, for it was the first time that any public analyst had publicly stated so clearly the truth of the matter. He did not say they were prepared to pronounce milk containing 8·6 or 8·7 of solids not fat not adulterated; if they found evidence sufficient to satisfy their minds from other data connected with the analysis that it was adulterated; but if they had not sufficient evidence from the data obtained, they could not conscientiously pronounce it adulterated, and they gave the defendant the benefit of the doubt. He was not prepared to go down to a very low limit, but was much disposed to agree largely with Dr. Wallace's suggestion, that if the milk went below a certain point, the seller should be called upon for an explanation, and if he could not satisfy the local authorities that his milk was genuine, then he should be called upon to satisfy the Justices. He thought that was the fair and proper way in which the Act should be applied to an article like milk. The desire of all should be to avoid inflicting any injury on honest tradesmen, for, as Mr. Barham had pointed out, it was a most serious thing for a tradesman to be fined for adulterating an article if he were innocent. With regard to the last speaker's remarks on the subject of the analysis of sour milk, it will, in my opinion, suffice for me to say that I entertain entirely different views on the matter. In conclusion, he begged to propose a vote of thanks to the Chairman for the very able and fair way in which he had conducted the Conference.

Dr. MUTER seconded the resolution, which was carried unanimously.

The CHAIRMAN said he thought they must make it a joint concern, and congratulate one another on having had a very good discussion. He only hoped that from the various opinions put forth by the public analysts on the one side, and by the representatives of Somerset House on the other, there would result a greater concensus of opinion and more good feeling one towards the other.

APPENDIX.

LACTIC ACID AND THE LACTATES AS FOOD PRODUCTS.

By Prof. William Ripley Nichols,

of Boston, Mass., U.S.A.

In asking your attention for a few moments to the manufacture of lactic acid and of the lactates on the large scale, I desire to say that I am not personally interested in a pecuniary way either in the manufacture or sale of these products. The application of the process which I have to describe was due to a friend of mine, Mr. Charles E. Avery, of Boston, and when the matter was brought to the attention of certain capitalists I was requested to examine and report upon the process, which is, certainly, of considerable interest to the chemist, and to the sanitarian as well.

When milk becomes sour, spontaneously as we say, the sourness is due to the presence of *lactic acid*, which was first extracted from sour milk by Scheele in 1780. The sugar of the milk has undergone a chemical change, as a result of which this acid has been formed. It is not alone from milk, however, that lactic acid may be obtained, for the fermentation of many vegetable substances gives rise to the formation of the same acid; thus, it is found in sauerkraut, in the fermented juice of the beet, and may be produced from almost any saccharine or amylaceous substance. When we say that milk becomes sour spontaneously, we speak from a microscopic standpoint: if we examine the matter microscopically, we find that the change is accompanied by the appearance and development of a multitude of minute organisms belonging to that order of beings which we speak of collectively as *bacteria*. The organisms which bring about this peculiar change we speak of as the lactic ferment.

Lactic acid is no new substance, and certain lactates,—as the lactate of soda, the lactate of lime, the lactate of zinc, &c.—have been prepared on the small scale and have been used to some extent in medicine. The method hitherto employed for the production of these substances has been one giving rise to the extremely offensive odours which accompany the decay of a mixed mass of animal and vegetable substances. In fact, the operation was hardly fit to be carried out in any ordinary laboratory. In the new process the material employed is clean Indian meal, that is, the meal obtained by grinding Indian corn, or maize, and, if the process be properly conducted, the only odour which is perceived is agreeable rather than otherwise. I will attempt to describe the process briefly.

The first point is the preparation of the ferment. The minute details of the procedure being of the nature of a trade secret. I am not myself familiar with them: in principle, however, it consists in the application of the method of cultivation which has proved so fruitful in the hands of the eminent specialist, M. Pasteur. As we know, the air about us contains the germs of many different sorts of organisms, among them those which, if they fall into proper liquids, are capable of bringing about the lactic fermentation. These are not, however, the only organisms which would fall into a vessel of milk if it were exposed to the air. The alcoholic, the acetic, the butyric ferments, or their germs, are present as well, and will also bring about their respective fermentations under favourable circumstances. The principle of the method now under consideration consists in the cultivation of the lactic ferment to the exclusion of all other sorts by arranging the temperature and other surrounding conditions so as to be most favourable to the growth of the peculiar organism which is able to change sugar and starch into lactic acid. These organisms multiply to the exclusion of other forms: then a quantity of milk or starch is fermented in the presence of ground chalk, which neutralises the acid as it is formed, and produces the neutral lactate of lime, the whole mixture becoming a solid mass of crystals. This mass of neutral lactate of lime, containing the organisms which give rise to this peculiar fermentation, is what is known technically in the manufactory as the "ferment."

Thus much with reference to the preparation of the "ferment:" the actual process of manufacture is as follows: Large wooden vats are employed, and into each is put one ton of meal, two tons of water, and half a ton of bolted whiting. Then a barrel of "ferment" resulting from a previous operation is added, and the whole well mixed together. In about eight hours the temperature of the mass has risen to 48° Centigrade. A block tin foil, through which cold water circulates, is then inserted in the vat, and allowed to remain for from 12 to 15 hours, the temperature being carefully maintained at 47° C. This is an important point in the process, because, if the temperature falls below 40° C. the fermentation ceases, while if it rises to 52° the ferment is killed. At the temperature of 47° C. fermentation goes on rapidly, torrents of carbonic acid gas are evolved, and the whole mass seems to be in most active ebullition. This evolution of carbonic acid is most rapid from the sixth to the fifteenth hour; at this point the cooler is usually removed, as thereafter the chemical action becomes less violent and maintains the temperature at the right point. After about four days, as a rule, and without further treatment, the whole mass becomes solid owing to the formation of crystals of the neutral lactate of lime, but the action goes on slowly for a day or two longer. I will not trouble you with details as to the purification of the crystals, as to the drying of the products, and as to other manufacturing details, which involve nothing which is essentially new in principle. By treating the neutral lactate of lime with just enough sulphuric acid, the lime is converted into sulphate of lime and the lactic acid set free; the sulphate of lime is removed by filtration, and the lactic acid evaporated in the vacuum pan until it reaches the required degree of concentration. If only one half of the requisite quantity of sulphuric acid is added, there is formed the bilactate or acid lactate of lime, which is, to be sure, not a perfectly definite compound; but this compound and the lactic acid of various grades are the principal commercial products.

The next question is, to what uses are these products put? The answer, in a general way is, that it is intended to offer them as substitutes for other more expensive substances already in use in the arts and in the household. The acid lactate of lime can replace the more expensive cream of tartar as a mordant in dyeing, and the acid itself is capable of useful application; but it is principally in connexion with articles of food that we have to consider these products. The most important use—at least in the United States—is in raising bread. In the States baking-powders are used to an enormous extent in making bread. In many parts of the country rolls—or *biscuits*, as we call them—prepared in this way are eaten morning and evening hot and fresh from the oven. It was at first proposed to mix the acid lactate of lime and the bicarbonate of soda in proper proportions, and sell the mixture as a baking-powder; but this has proved impracticable since, owing to the deliquescent character of the neutral lactate of lime, such a mixture gradually undergoes decomposition, and becomes useless for the intended purpose. The two powders are therefore supplied separately, with directions as to the proper proportions. A strong solution of lactic acid, containing 40 per cent. of the real acid, is also put upon the market to be used for the same purpose, three tea-spoonfuls of the acid and one tea-spoonful of soda being successively incorporated with the dough.

Another use of the acid is as a beverage: mixed with water, and sweetened, it has an acid flavour, which is very agreeable to most persons. This may seem a matter of small importance commercially, but the quantity of beverages of this character consumed with us, as in England, is very great. Of course it can be charged with carbonic acid, and bottled, just as other so-called lemonades are sold. I believe the acid (a 10 per cent. solution) is already on sale in London for this purpose, but, as I do not wish to be an advertising medium, I must leave it to be brought to your attention in other ways.

Still another use is as a table acid. The acid is less sharp than vinegar, and what its future in this direction may be I do not venture to predict.

The most important question of all remains: Is the acid wholesome, and are the uses suggested above legitimate uses from a sanitary point of view? I dare say there are others here who can speak with more authority on these points than I can. I am not a medical man, although I have been long interested in sanitary matters.

I believe there is no question as to the wholesomeness of sour milk, at least in reasonable quantities, and it is a staple article of food in many localities. With us—as I presume is the case in England also—it is thought that there is nothing more wholesome than bread and cakes raised with sour milk and soda. The great trouble is that, the sour milk not being of a uniform degree of sourness, there is great danger of spoiling the bread with an excess of soda, or of having sour bread, on account of not adding soda enough. This trouble is, of course, obviated by the use of an acid of known and invariable strength. The lactate of soda (or the lactate of lime and soda, which results if the acid lactate of lime be employed) would no doubt be quite as wholesome as the Rochelle salt which is left in bread raised with a cream of tartar powder. I am not aware of any accurate experiments on the physiological action of the lactates taken in this way, but the general effect of the compounds seems to be sedative and slightly soporific.

How far the use of the various acid beverages which are consumed—especially in the summer, to an enormous extent—how far such use is advantageous, and what dangers there may be in excess, I will not attempt to investigate. At any rate, sour milk or a pure lactic acid is probably as wholesome a substance as can be used for the purpose. The opinion has also been expressed by medical men that, as an anti-scorbutic, lactic acid should rank with citric acid, and that it should form a part of the supply of vessels fitting out for Arctic voyages.

There is one other point to which I should allude. I saw recently an article by Dr. Richardson, in which he states that lactic acid is excreted in the system in the case of certain diseases. Lactic acid, or rather a variety of lactic acid called sarcolactic acid, has been thought to be a normal constituent of the gastric juice and of healthy muscle; and, I presume, the acid referred to by Dr. Richardson is sarcolactic acid, and not the lactic acid of fermentation. Although these two substances have the same percentage composition their chemical action is quite different, and their physiological action would probably not be the same. At any rate, even if the lactic acid of fermentation were formed in the system under certain abnormal conditions, it does not follow that the acid would be unwholesome to a person in normal health, any more than it follows that sugar should be banished from among articles of food, because in diabetes, for instance, a sort of sugar is found in the system, and eliminated in the urine.

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THE CHEMISTRY OF BREAD-MAKING.

BY

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July 3rd, 1884.

A LECTURE ON THE CHEMISTRY OF BREAD-MAKING.

By Prof. Charles Graham, D.Sc., F.I.C.

The chair was taken by Prof. Odling, F.R.S., who, in introducing the lecturer, said he hoped it would not be considered presumptuous in him to suggest that the Executive Council of the Exhibition had done well both in their selection of the subject and the lecturer. When primitive man ceased to be exclusively a hunter he became next a shepherd and a herdsman, and the next stage in the advancement of civilisation he became a husbandman; how soon after becoming a husbandman he became a bread-maker and a baker, he did not think the earliest prehistoric records would exactly tell, but, at any rate, he thought they might fairly look back upon bread-making as probably the earliest, or at least one of the earliest, chemical arts; one which had existed for a great many thousand years. Perhaps, he could not say, that during all those thousand years it had made such a rapid rate of progress as some of the more modern chemical arts; nevertheless, the art of bread-making still retained a very large amount of interest, and bread might still be regarded as the staff of life. He would only add that Prof. Charles Graham was one of the leading authorities in the particular department of chemistry which related to the study of those changes called fermentative, one of the most important of which was the process which was called panification, or the chemical art of transforming flour into bread.

LECTURE.

Our distinguished Chairman, Prof. Odling, the President of the Institute of Chemistry, in introducing me to you has been so good as to refer to my position in regard to fermentation chemistry, and I presume that it was in reference to this that the Council of the International Health Exhibition requested that I should give a lecture on a subject of vast importance to us all. I consented to do what I could in this matter; other men of science are also engaged aiding the Council of this Exhibition, not only in the awarding of prizes among the various exhibitors, but in aiding in the selection of the materials to be sent here, and also in assisting at conferences and lectures on various matters pertaining to the great object of this Exhibition, namely, Health.

The cereals are undoubtedly the most valuable of all the fruits of the earth, and it is, therefore, needful that we should rightly study their mode of preparation for the use of man. The question may have occurred to some of you, how càn science aid art? Surely a good baker requires no assistance from science. Let us see what is the answer to it. Without going through a number of instances in which undoubtedly science has advantaged art, I will refer only to one or two. In the first place, there is no doubt that agriculture has benefited largely by the investigations of Liebig, and, following him, of others, into the composition of the mineral matter of plant life. It is perfectly true that in metallurgy, steel was obtained ages ago of the very highest excellence. Yet surely the study of chemistry has enabled us to manufacture iron and steel at such a price and in such quantities as would have been utterly impossible in the olden time. Again, take another illustration, that of dyeing; there are two methods of dyeing of great historic interest—that of Turkey red dyeing and that of indigo dyeing—because these are the only two really permanent colours, and secondly because science has investigated the nature of Turkey red dyeing, and has found out that the important principle in the madder root was alizarine. Science has not stopped at merely finding out the nature of the dye; science has succeeded in creating the dye out of gas-tar products. Lately, indigo has in a similar way been created, it is already a success, and will soon become a great commercial success. I give those merely as illustrations of the way in which science can benefit art, and though we need not look for any such startling, such epoch-making discoveries as that of the making and building up alizarine and indigo, still I feel sure that science little by little will greatly improve the art of bread-making.

I have the honour of addressing some London bakers, and there are London bakers who are exhibitors in this Exhibition, and it is perfectly true that we now get in London bread of the highest excellence, but still the Council of this Exhibition are not thinking only of the best West-end bakers, they are not limiting their views solely to London bakers,—they are considering the interests of the United Kingdom, and, indeed, of other countries, and one of the arrangements I understand in regard to these lectures is that they shall be published in a very cheap form, so that in this way one's audience may be larger than that in this room. I had proposed to make a few remarks in regard to the history of bread-making, but after the introductory remarks of our Chairman I think I need do no more than briefly enumerate the three distinct stages. First; flour was mixed with water, baked, and then eaten; the next great improvement was the discovery of leaven; both of these are very old methods for the treatment of flour and known to the ancients; and at the present day we have examples of both systems; we have bread without any ferment at all, as in parts of Spain, and we have also leaven bread in the North of Europe, but the next great and important improvement was the use of yeast. This has occurred in more modern times, how many hundred years ago I know not, but still comparatively modern as compared with the older methods.

Before studying the phenomena of bread-making, it will be necessary to study the composition of the cereals employed in bread-making. In the corner of the room there is a Table taken from papers published by Messrs. Lawes and Gilbert, giving us the composition of wheat, barley, oats, rye, maize, and rice.

AVERAGE COMPOSITION OF THE GRAIN OF CEREALS.

	Old Wheat.	Barley.	Oats.	Rye.	Maize.	Rice.
Water	11·1	12·0	14·2	14·3	11·5	10·8
Starch	62·3	52·7	56·1	54·9	54·8	78·8
Fat	1·2	2·6	4.6	2·0	4·7	0·1
Cellulose	8·3	11·5	1·0	6·4	14·9	0·2
Gum and Sugar	3·8	4·2	5·7	11·3	2·9	1·6
Albuminoids	10·9	13·2	16·0	8·8	8·9	7·2
Ash	1·6	2·8	2·2	1·8	1·6	0·9
Loss, &c.	0·8	1·0	0·2	0·5	0.7	0·4
Total	100·0	100·0	100·0	100·0	100·0	100·0

COMPOSITION OF WHEAT GRAIN ASH.

	Lawes and Gilbert.	Way and Ogston.
Phosphoric acid	49·68	45·01
Phosphate of iron	2·36	0·82
Potash	29·35	31·44
Soda	1·12	2·71
Magnesia	10·70	12·36
Lime	3·40	3·52
Sulphuric acid	..	0·34
Carbonic acid	...	0·02
Chlorine	0·13	0·13
Silica, &c.	2·47	3·67
Total	99·21	100·02

I wish to draw your attention to some important points connected with those analyses. We may divide the constituents of the cereals of wheat, for example, into the mineral matter and the matter which is not mineral, and to which we give the term organic matter. The mineral matter consists of phosphate of potash, and of magnesia, about one-half being phosphoric acid, one-third potash, and one-tenth magnesia. The organic constituents consist of what are termed carbo-hydrates, together with a small quantity of fat. I say carbo-hydrates, an expression used to indicate that in these kind of bodies the carbon, the hydrogen, and the oxygen are united together to form the substance, starch for example, and that the hydrogen and oxygen are in the same proportion as in water, though they are not combined together as in water, and therefore, the expression carbo-hydrates is given to such bodies. These carbo-hydrates are the substances that yield heat to the body, and by so doing yield force, power. In addition to these we have the substances termed albuminoids. These are also spoken of as flesh-formers. Now, it is perfectly true that this expression correctly describes the function they perform, namely, to repair the waste of the muscular tissue, but at the same time it is somewhat misleading in that these flesh-formers are really mainly used up in giving heat and force by their burning or oxidation in the body, only a comparatively small quantity being necessary for the waste of the muscular tissues, which is by no means so great as physiologists formerly assumed.

Starch occurs stored up in vegetable structures for much the same reason as fat occurs stored up in animal structures, namely, for future use, thus we find starch in bulbs, and in tubers. It is the starch-yielding property of the potato which renders it chiefly valuable. We find it also in roots, such as turnips, and the beet-root; we find it of course in seeds, and lastly we find it in the thick leaves termed by botanists cotyledons, the two thick leaves which in leguminous plants such as the bean and the pea form the larger part of the seeds. The whole of the matter inside the testa or skin of the bean really consists of the two thick young cotyledon-leaves, thus we have various sources of starch. Starch, however obtained, will be found, when examined under a microscope, with a proper measuring arrangement, to have different characteristic appearances, and also sizes. For example, the starch of wheat varies much from that of barley, and very much from rice. It is by the size, which can be accurately measured, and by the form or shape which we can note under the microscope, that we are enabled to identify various kinds of starches. Starch, as you know, does not dissolve in cold water, and indeed water is used in the extraction of the starch after grinding the grain, or rasping the potato from which we are deriving the starch. But when to a mixture of cold water and wheat-starch a laundress pours boiling water, she raises the temperature, and the result is that the starch-cell bursts. The outside of the cell is composed of woody fibre, and at this higher temperature it bursts, the internal contents of the starch-cell then come out. To those contents we give the term granulose, which makes a paste with the hot water. This is an important point in regard to the digestion of starch. At a temperature of about 300° F. starch is converted into dextrine or British gum. If, however, instead of employing that plan you add, to a thick starch paste a little ground malt, the ground malt will convert the starch paste into dextrine together with another product which I will refer to presently. But the dextrine formed in that way is not pure. A still better plan is to make a mixture of 1000 parts of starch with 300 of water, to which previously two parts of nitric acid have been added ; you mix the two together, and this is afterwards air-dried, and when it is revolved in a cylinder at the temperature of not higher than 220° to 230°, it is converted into dextrine, and it is in that way that the dextrine of commerce is now manufactured. You are all acquainted with the appearance of it, because you have all of you seen the 1*d.* or 2*d.* bottles of British gum, and it is on the back of every postage stamp, and it is used very largely in the arts, in calico-printing for example. Closely allied to starch and dextrine comes cane-sugar and maltose-sugar. Cane-sugar, you know, is derived from the cane-plant, from the beet, or from the maple, its properties you are sufficiently well acquainted with, namely, that it is sweet, and dissolves in water and crystallizes easily. Maltose sugar is what I was referring to just now when I said that on the addition of a little malt to starch paste there was another product formed besides dextrine, and that other product is maltose, having the same centessimal composition as cane-sugar. Maltose sugar was discovered by Debrunfaut, and was afterwards the subject of experiment and study by Musculus, but it was not until comparatively recently, owing to the researches of Mr. O'Sullivan, of Burton-upon-Trent, that we really understood the nature of the change that took place by the action of these albuminoid bodies, such as we find in malt upon starch paste. He showed us that a starch solution is acted upon by the diastase, as it is called, of the malt, and that it takes up water and forms maltose sugar and dextrine, the maltose sugar having the same formula as cane-sugar. This process continues, and more maltose is formed by the action of the diastase upon the more complex dextrines which are formed at first. Ultimately, however, a large portion of maltose is formed, and a very small quantity of dextrine, and under the most favourable conditions it is possible to convert the whole of the starch into maltose sugar. The maltose sugar thus made, dissolves in water, it is slightly sweet to the taste, and it does not crystallise in the way that cane-sugar does, and it is much more difficult to obtain in a crystalline form. Maltose sugar is readily acted on by the yeast ferment.

The next matter of interest in the study of these bodies are the albuminoids; the albuminoids contain carbon, hydrogen, and oxygen just in the same way, but not in the same proportion as the carbo-hydrates, but they have in addition nitrogen, and sometimes a little sulphur. Their general composition is given in this table :—

Average Composition of Albuminoids.

Carbon	53·3
Hydrogen	7·1
Nitrogen	15·7
Oxygen	22·1
Sulphur	1·8
	100

Hypothetical formula, $C^{72} H^{112} N^{18} SO^{22}$.

If we take the formula of starch as being C_{72}, H_{120}, O_{60}, you may not see any relationship between that and the albuminoids, but yet the probabilities are that the starch is only an altered form of the albuminoid, and that it has previously gone through such an albuminous stage. In the Table, by Lawes and Gilbert, you will find that the albuminoids are given there for different cereals. At the same time, as we shall see presently, cereals differ very much in the percentage of albuminoids they contain, and in the Table the placing of 10·9 of albuminoids to old wheat was perfectly correct for the sample of wheat analysed, but it leads one to assume that wheat is less rich in albuminoids than barley and oats, but it is distinctly on the average not less rich, but rather more so than barley. If we take ordinary flour, and then elutriate it with water so as to get rid of the starch, we shall ultimately obtain crude gluten. The crude gluten, of which we have some samples on the table, is a tough elastic mass, and it is on account of this great resisting tendency that we are enabled to keep in the carbonic acid that is subsequently formed in fermentation, and thus to make a well-piled loaf. Now crude gluten contains fibrine and gluten; about four-fifths of fibrine and one-fifth of gluten; the gluten is slightly soluble in water, but not the fibrine. Of course, if fibrine be moistened and left for a time it will gradually break down in the complexity of its structure, and will form simpler kinds of albuminoids, and this is the kind of deleterious action that takes place when we have a long-continued period of wet weather at harvest time. But while washing the flour in order to obtain this crude gluten, we have already dissolved out some soluble albuminoids.

Now these soluble albuminoids occur to a small extent in wheat, even the best elaborated; but they occur to a much larger extent in other kinds of cereals, as barley for example. Of these, albumin and legumin, so called from the legumenosœ in which it is abundantly found, differ mainly in this respect, that the albumin can be coagulated by boiling, whereas the legumin cannot. In addition to the albumin and legumin, we have also another albuminoid substance called cerealine. Now it is the cerealine which is found so largely in the bran of wheat, and not to the same extent in barley. If we take what is termed, botanically, the caryopsis, or the seed, of barley, and moisten it and keep it at a proper temperature in a warm room it will gradually grow, and, as it grows, rootlets will come out from the bottom, while the plumule pushes up inside the testa or skin; as it does so, this plumule, which is growing up inside the testa, gradually by an osmotic action from cell to cell sets up a diastasic change throughout the whole of the berry, so at last, as it grows up and ultimately gives off a stem and leaf, it has greatly affected the starch granules inside the seed. Now, in the case of wheat, the little embryo at the bottom pushes out its root, but at the same time the plumule comes out also, thus the plumule has no diastasic action, except by osmotic action through the cells at the base. Nature, however, partly gets over this difficulty by the diastasic action set up by the albuminoid cells in the cerealine acting throughout the whole mass, so that sugars are formed for the nourishment of the young growing plant. This is the important function of the cerealine in the bran of wheat. Now, barley has got but little gluten, the albuminoids are not of that character, they are not dense and coherent, and rye-flour, maize and rice are all equally deficient, and the consequence is that for the preparation of fermented bread there is no cereal that can compare with wheat.

I will ask you now to look at some results obtained by the chemist Péligot. In this Table you will find the composition of different typical wheats—Flemish, Odessa, Herisson, Provence, Midi, Polish, Hungarian, Egyptian, Spanish, and Russian. In this Table we have the albuminoids divided into those which are insoluble and those which are soluble. This method of stating the results is of very great importance to the baker. If you look at this Table you will find, by dividing the insoluble albuminoids by the soluble, that we have in the Flemish a ratio of 3½ of the insoluble to 1 of soluble; in the Odessa, 8 of insoluble to one of soluble; in the Midi, 9 to 1; in the Egyptian, 13 to 1; and in the Spanish, 5 to 1.

ANALYSES OF WHEAT (PÉLIGOT).

	Flemish.	Provence.	Odessa.	Hérisson.	Poulard Roux.	Poulard Bleu.	Poulard Bleu. Dry year.	Midi.	Polish.	Hungarian.	Egyptian.	Spanish.	Taganrogg.
Water	14·6	14·6	15·2	13·2	13·9	14·4	13·2	13·6	13·2	14·5	13·5	15·2	14·8
Fat	1·0	1·3	1·5	1·2	1·0	1·0	1·2	1·1	1·5	1·1	1·1	1·8	1·9
Insoluble Albuminoids	8·3	8·1	12·7	10·0	8·7	13·8	16·7	14 4	19·8	11·8	19·1	8·9	12·2
Soluble Albuminoids .	2·4	1·8	1·6	1·7	1·9	1·8	1·4	1·6	1 7	1·6	1·5	1·8	1·4
Dextrine	9·2	8·1	6·3	6·8	7·8	7·2	5·9	6·4	6·8	5·4	6·0	7·3	7·9
Starch	62·7	66·1	61·3	67·1	66·7	59·9	59·7	59·8	55·1	65·6	59·8	63·6	57·9
Cellulose	1·8	..	..	..	..	1·5	..	1·4	..	..	..	..	2·3
Saline Matter . . .	..	..	1·4	..	..	1·9	1·9	1·7	1 9	..	..	1·4	1·6

I only give those as being illustrative of the very great variety that occurs in different cereals. A very interesting point to notice in the Table of determinations made long ago by Péligot is this, you will find that if you divide the dextrine, as he termed it, by the soluble albuminoids, you will, with the exception of one or two, that it is nearly four times as much as the soluble albuminoids; in many cases it is exactly. In the Midi it is 1·6 soluble albuminoids to 6·4 dextrine, which is exactly 1 to 4. I can see in the next one, the Polish, it is 1·7 of soluble albuminoids to 6·8 dextrine, showing that there must be some very distinct relation between the amount of dextrine formed and the albuminoid body that has gone to form it. That is an interesting point for chemists.

It is of the highest importance for the milling interest, and also for the baking interest, that a very large and numerous series of analyses, made even with further determinations than were possible at the time of Péligot, should be made in order to guide the miller in his selection of wheats for the different kinds of flour. I have now to call your attention to a diagram headed "The Influence of Seasons on Wheats," and have marked certain years +, and have marked some other years –, and there are one or two years marked with a slanting mark. Now, if we take those years against which I have attached +, 1846, 1849, and 1851, we learn that those years were dry years of fine harvest weather, and the result was that the total produce for those years was high. The amount of dressed corn in the total produce was also very high, and, in addition to that, the weight of corn per bushel, which is the farmer's

INFLUENCE OF SEASONS ON THE CHARACTER OF WHEAT CROPS.
(LAWES AND GILBERT.)

HARVESTS.	PARTICULARS OF THE PRODUCE.				COMPOSITION OF GRAIN.			COMPOSITION OF STRAW.		
	Total Corn and Straw per Acre in lbs.	Per cent. Corn in Total Produce.	Per cent. Dressed Corn in Total Corn.	Weight per bushel of Dressed Corn in lbs.	Per cent. Dry (212° F.).	Per cent. Ash in Dry.	Per cent. Nitrogen in Dry.	Per cent. Dry (212°).	Per cent. Ash in Dry.	Per cent. Nitrogen in Dry.
— 1845 . .	5,545	33·1	90·1	56·7	80·8	1·91	2·25	..	7·96	0·92
+ 1846 . .	4,114	43·1	93·2	63·1	84·3	1·96	2·15	..	6·02	0·67
1847 . .	5,221	36·4	93·6	62·0	..	..	2·30	..	5·56	0·73
— 1848 . .	4,517	36·7	89·0	58·5	80·3	2·02	2·39	..	7·24	0·78
+ 1849 . .	5,320	40·9	95·5	63·5	83·1	1·84	1·94	82·6	6·17	0·82
/ 1850 . .	5,496	33·6	94·3	60·9	84·4	1·99	2·15	84·4	5·88	0·87
+ 1851 . .	5,279	38·2	92·1	62·6	84·2	1·89	1·98	84·7	5·88	0·78
— 1852 . .	4,299	31·6	92·1	56·7	83·2	2·00	2·38	82·6	6·53	0·79
— 1853 . .	3,932	25·1	85·9	50·2	80·8	2·24	2·35	81·0	6·27	0·20
/ 1854 . .	6,803	35·8	95·6	61·4	84·9	1·93	2·14	83·7	5·08	0·69
Means .	5,053	35·4	92.1	59·6	82·9	1·98	2·20	83·2	6·17	0·82

way of determining the specific gravity of corn, was also very high. In 1846 it was 63, and that is a high weight for English wheat; on the other hand, if we take 1845, 1848, and 1852, against which I have placed –, we had wet summers, cold harvest weather, and the result unsatisfactory; such years as, indeed, we have experienced much more recently, and in these cold wet summers and autumns we obtained wheats with a low total amount of produce. The total dressed corn was low in 1848, being only 89, whereas in 1846 it was 93, and in addition to that the specific gravity of the corn was also low; 56 in 1845, and 58 in 1848, instead of being, as I have said before, 63 in a good year. Then we have a high nitrogen; the amount of albuminoids was high, but the amount of resisting gluten was very low—in other words, those flours were ill-adapted for baking purposes. On this other Table, I have some experiments I made for the purpose of this lecture, in order to point out to you by experimental numbers the character of the changes which take place when flour and water are kept together at about a temperature of 85° F., which is the temperature that the baker employs. Vienna whites, allowed to stand only 10 minutes, give us ·76 of

INFUSION PRODUCTS OF FLOUR.

	Cold. 15 Mins.	2 Hrs.	4 Hrs.	8 Hrs.		Cold.	2 Hrs.	4 Hrs.	8 Hrs.
Vienna Whites.									
Maltose	trace.	2·41	3·65	4·09	Second Households. No. 1.	1·36	2·83	4·09	5·39
Dextrine	trace.	2·17	2·79	4 35		0·89	2·34	2·40	3·80
Soluble albuminoids .	0·76	0 58	0·76	1·29		0·76	0·65	1·29	2·12
	0·76	5·16	7·20	9·73		3·01	5·82	7·78	11·31
Best Whites.									
Maltose	none.	1·57	2·04	3·41	Second Households. No. 2.	1·57	6·01	6·01	7·59
Dextrine	1·21	1·48	2·74	2 85		1·04	0 84	1·21	0 67
Soluble albuminoids .	0·71	0·58	0·81	1·54		1·05	1·45	1·31	1·89
	1 92	3·63	5·59	7·80		3·66	8·30	8·53	10 15
Best Households.									
Maltose . .	1·00	1·36	4·09	3·93	Brown meal.	trace.	3·41	3·93	4·99
Dextrine .	1·13	2 46	2·09	3 79		2 70	0·95	2·09	2·89
Soluble albuminoids .	0·93	0·79	1·23	1·42		0·62	0·70	1·39	1·33
	3·06	4 61	7·41	9·14		3·32	5·06	7·41	9·21

Inferior Flour.	4 Hrs.	8 Hrs.	With Lime. 4 Hrs.	With Lime. 8 Hrs.	High Dried. 4 Hrs.	High Dried. 8 Hrs.
Maltose	6·82	11·14	6·82	8·20	4·44	4·44
Dextrine	0·43	1·28	0·11	2·15	1·78	2 91
Soluble albuminoids . .	3·19	3·74	3·34	3·34	2·48	3·29
	10·44	16·11	10·27	13·69	8·70	10·64

soluble products. In 2 hours, however, it is as high as 5·16, in 4 hours 7·2, and in 8 hours 9·73. In second households, we have in the cold 3·01; 2 hours, 5·82; 4 hours, 7·78; in 8 hours, 11·31. Now, in No. 2 we have also in 8 hours 10·15—the brown meal being very much of the same general character as that of No. 2. A small Table shows the results of a distinctly soft flour, in which in 4 hours the amount of soluble matter was 10·49, in 8 hours 16·11. When, however, that flour was treated by a method investigated by our distinguished Chairman in 1858, with lime (only in this particular instance I simply used a little chalk instead of quicklime), we had a considerable reduction at the end of eight hours; and that is the important point, because the process of the London baking requires a great many hours, and therefore it is desirable to see what influence hard water, such as one would get in Kent, or made so artificially, would be. You will see that we are enabled to lower somewhat the amount of soluble albuminoids. That same flour, when heated to a temperature of 100° for several hours, as in the kiln-drying process, gave still better results, and at the end of eight hours the amount of soluble products was reduced from 16 down to 10·6, showing therefore that the heat-stiffening action of the kiln is of the very greatest importance indeed in improving the character of our inferior wheats, due, perhaps, to inferior harvest conditions.

I proceed now to the subject of milling. I am not a miller, and I have not sufficient time, even if I had sufficient knowledge, to entertain you with a discussion as to the respective merits of high and low reduction, of rollers *versus* stones. The City and Guilds Institute of London a few years ago established examinations in the chemistry of bread-making, and, due chiefly to the active aid of Mr. Dunham, the proprietor of the *Miller* newspaper, and also aided by active millers taking a keen interest in their trade, they have recently added milling to their curriculum of examination. You are probably most of you aware that the City and Guilds Institute carry on in technology much the same kind of examinations, although I hope better in character, as the Science and Art Department do throughout England, Scotland, and Ireland in their May Science Examinations. Milling has been given to those interested in milling, and in looking over the character of the questions set I am bound to say that in a very short time it must stimulate the young millers to study, not merely the chemistry of their art, but to study the engineering part of their profession in a way that has not been hitherto done in our country, and therefore I think that the City and Guilds Institute will do considerable good in this direction.

As a chemist, however, and as I am lecturing upon the best means of preparing wheat bread fit to compare with the beautiful bread of Moscow or Paris, I think the following conditions are essential to be aimed at in good milling. In the first place, the corn must be degerminated, because the germ is an active hydrating and diastasic body; secondly, the bran must be thoroughly eliminated, because the cerealine of the bran has this injurious action on the fermentation, that it produces too great a quantity of maltose sugar and dextrine, and introduces also too large a quantity of soluble albuminoids into the bread, which soluble albuminoid, not the starch, as some people imagine, give high colour in the oven. Degermination and elimination of the bran are, I hold, tests of the highest milling, whether it be by rollers or by stones. For brown bread and for whole-meal bread there is a difference, and I will later on point out how we may to some extent eliminate or obviate the difficulties when we employ brown flour or whole-meal flour. A very important point is the admixture of wheats; formerly millers were obliged to use the wheats as they could find them in their own country, but now we have excellent wheats from the United States, from Canada, from the Black Sea, from Australia, and lastly, and not of the least interest, from India and Persia. I read a statement in a newspaper yesterday that the

Indian Government had been making an investigation into the question of the expense of growing wheat in India, and they find the natives can grow wheat for 12*s.* a quarter—16*s.* will leave a profit. Some objection has been made to the employment of too large a quantity of Indian wheats when mixed with our own, owing, it is said, although I have not noticed it myself, to the aromatic flavour of bread that has had too large a proportion of Indian wheat ground with our English or other wheats. This is, however, a matter that the miller can readily obviate by a little attention to the admixture, and by not using perhaps quite so much of the Indian wheats. At the present moment we are able to get excellent wheats as low as 32*s.* per quarter. Now I remember at a dinner, I think it was in 1872, the motto of the Royal Agricultural Society of England was given as a toast after dinner, that motto being "Practice with Science;" and I was associated, being a scientific man, with a practical farmer in replying to that toast. In my reply I referred to some of the advantages of science; but then, speaking to British farmers, I pointed out some of the disadvantages of science; I pointed out how by using both high and low pressure steam on board ship, as Elder was beginning to do, with the development of the railway carrying powers of America, the United States farmer would in a very few years be able to sell wheat at a profit at 40*s.* per quarter at Liverpool, not only were they very incredulous, but they laughed at me; but to-day you can get it at 32*s.* per quarter, and this is not entirely due to the great activity of the Americans in growing wheat; the fact is, that the great wheat speculators in America were not aware of the enormous amount of wheat that India can send to us. This great speculation in wheat, what they call the "wheat ring," has broken down completely, and we are now able, thanks chiefly to India, to have wheat at this very low price. It is an additional satisfaction to an Englishman that South Australia, New Zealand, and also India, have a large wheat-growing capacity, because in India free trade is the rule, whereas the Americans are protectionists, and by our purchasing large quantities of wheat from India, we may expect, of course, that they will take large quantities of our manufactured products, hardware and cotton, from us in exchange, so that in that way from our colonies and from India we shall not only have cheap wheat, cheap flour for some time to come, but also have the prospect of a better condition of our manufacturing industries.

The miller's method of testing wheats consists in judging by their appearance, by the weight per bushel, by the country in which it is grown, and lastly by grinding, by baking some. A distinguished baker in Paris, M. Bolland, adopted a method by which he separated the gluten from the flour, and this gluten was put into a tube, and the tube put into the oven, and according to the amount of expansion of the gluten, so did he decide upon the quantity of the gluten there, and its resisting action to steam—in other words, he judged in that way of the goodness of the flour for the fermenting process of making bread.

The plan which I suggested some time ago was this, that 1 oz. of flour should be mixed with 4 ozs. of water, and allowed to stand at the temperature of about 80° or 85° for two hours; that it should then be filtered, the first portion of the filtrate will be a little thick, but the latter portion will not be so thick. You put this into a test tube, which you have previously marked at 1 oz. and 2 ozs.; it is filled up to 1 oz., and then is mixed with 1 oz. of strong methylated alcohol, which we can get for about 5*s.* a gallon; the result is this, that you obtain a precipitation of most of the soluble matters, of maltose, of dextrine, and the soluble albuminoids; and according to the amount of precipitation, so you would decide as to the amount of soluble matter that would be produced during the sponge stage of bread-making.

I proceed now to consider the question of bread-making. The ways of making bread are very numerous in different parts of the country. I will therefore limit myself solely to the London system of bread-making, which is one of the best. The London system consists of three parts—the preparation of the ferment, the preparation of the sponge, and the preparation of the dough. A sack of flour is 280 lbs. in weight, and it should yield from 94 to 96 quartern loaves. In the preparation of the ferment, 6 lbs. to 8 lbs., sometimes as much as 12 lbs., of the very best potatoes are employed; inferior potatoes will not do. These are thoroughly cleaned, washed, cut up and boiled, and then when made into a thin paste they are poured into a tub, and cold water added until the temperature is lowered to 85°. When this is done, about 2 lbs. of flour are added, and then one quart of good brewers' yeast stirred in; this is the preparation of the "ferment;" fermentation begins, the yeast acts upon the albuminoids of the wheat, and the albuminoids of the wheat so acted upon act then upon the starch of the boiled potato, and the result is we have maltose sugar, and dextrine, and peptone bodies formed. After five hours, the time depending on the temperature, the head falls and then the ferment is allowed to rest for about two hours. The baker then proceeds to the next stage, which is the preparation of the sponge or "stirring the sponge." In making the sponge one-fourth, or according to some bakers one-third, of the flour is taken, placed in the trough, the ferment added through a sieve which retains the potato-skins, the water in the ferment and sponge being about thirty quarts; bear in mind I am always speaking of the sack of 280 lbs. of flour. The quantity of water, however, varies slightly with the kind of flour and slightly with the baker's own particular practice. The other ingredient is salt. Now many London bakers do not use salt in the sponge stage, nor is it needful in the very highest classes of flour; others, however, prefer to use some of the salt, and the quantity of salt therefore used in this stage varies. The amount altogether used for a sack of flour is 3 lbs., or 48 ozs., that is $\frac{1}{2}$ oz. for each quartern loaf. Now, salt acts as a check upon fermentation. The more salt you add to the sponge stage the more you check the degradation or breaking up of the albuminoids. The sponge being made ferments, and in about five hours it breaks, carbonic acid being given off, and in an hour it rises again and again breaks. This last will depend on the temperature. After the second break, the remainder of the flour, be it three-fourths or two-thirds, according to the practice of the baker, and the remaining portion of the water, is added; the total quantity of water for the whole sack is 60 quarts. These are thoroughly mixed together, and in the dough stage many bakers, as I said, add the whole of the salt. Those, of course, who have used part of the salt in the sponge stage simply add the remainder. Of late years machinery has been invented to do away with the manual labour and other objections to the mixing of the dough; it is very hard work, and I should be glad for those of you who have time to look not only at the very useful mixing machine of Mr. Pfleiderer, but also to look at the mixing machine of Melvin, of Glasgow, in Mr. Marshall's model bakery, which consists of a number of revolving cutters which mix up the dough. The dough well mixed is then left for an hour, it rises, it is then scaled, that is to say, weighed and put in the oven, where it remains for one hour and a half, the atmosphere of the oven being about 400° to 450°. The temperature of the bread, I need hardly say, is not 400°, but much less, appreciably not more than 212°, but it may be a little over, owing to the resisting action of the crust, but at that temperature you know water boils, and therefore the temperature could not be higher. Before I pass on to a description of the scientific phenomena underlying these processes, I will briefly refer to the manufacture of fancy bread. Bakers, of course, differ in their manufacture of fancy bread in the same way as they do with ordinary household bread, but the following will give you an idea of the general method. In the first place a "ferment" is prepared as before, that is to say boiled potato with a small quantity of flour, and with brewer's yeast. Having prepared the ferment; in the sponge state, the baker uses a large quantity of German yeast, and in this way he gets a very rapid fermentation and a large, light, porous bread. In regard to the chemistry of these operations, the fruit, that is to say, the boiled potato, yields ferment food, and thereby, by the action of the yeast on the soluble albuminoids of the flour, gives a rapid formation of maltose and dextrine. In 8 lbs. of potatoes there are only 2 lbs. of starch, so manifestly the baker does not use this small quantity for the sake of cheapness. It is because it is one of the largest of all starches, and therefore it is one of the best means of preparing albuminoid and sugar food for the active stimulus of yeast growth. The ferment stage increases the production of these albuminoids and sugars, and the yeast is in this way greatly stimulated; but another object that I ought to mention that the London baker has in making this preparation of the ferment is that he largely increases the amount of yeast. This method of feeding yeast during this number of hours, is a method of making a considerable amount of yeast out of the one quart that he takes. In the sponge state we have a very active fermentation going on; the sugar there is broken up into carbonic acid and alcohol, and there is a rapid action; and it is in this particular stage which lasts so many hours that inferior flours turn out so badly, because they produce more and more soluble albuminoids, and these give a high colour to the final product. In the dough state, which is practically the inert stage, because in the dough stage we have added all the flour, and only thirty more quarts of water; we have also a less period of time allowed, only one hour, and the result is that very little further change goes on If the flour has withstood the sponge stage without injurious result, it will perfectly well stand the dough stage. The objects aimed at by the baker being to obtain good aëration, numerous small cavities of gas, in other words to give a well-piled loaf, also to avoid colour, because colour always gives rise to a suspicion of inferiority of the flour; and lastly, the baker's aim is to obtain a nice aroma, a fine nutty taste, such as indeed cannot be got by any other method than that which I have been describing.

Fermentation is a subject that has been a source of considerable interest and speculation. I need not, however, do more than simply call your attention to our present knowledge on the subject, for which we are mainly indebted to Pasteur, in that it was he who first of all pointed out most clearly that it was due to minute organisms that fermentation was brought about. M. Pasteur proved that by withdrawing the internal contents of the grape that those contents would not spontaneously ferment, but that if you took a little cotton wool, and rubbed the outside of the skin and added that to that which was withdrawn, the fermentation was set up. We are all now of the same mind that fermentation is brought about by the action of living organisms, saccharomyces. The fermentation of the must of grape, which is the term for the expressed juice of the grape, which is brought about spontaneously, is not the only instance of spontaneous fermentation. Leaven bread, which I have spoken of, originally arises in this way, and is to some extent the result of spontaneous fermentation. The production of the old sour beers of Dorsetshire, the production of Lambick, or Faro, is of the same nature. Only the other day I had occasion in this Exhibition to taste a sample of Lambick beer, which is made by taking the wort of malt and leaving it to receive whatever dust falls into the large vat, and in the course of one year or two years the product, which they call Lambick or Faro, is obtained, which is excessively sour, because all kinds of ferments have brought about the change, not merely the alcoholic ferment. The yeast organism is one of considerable interest, and I have a diagram of the indications of the English country yeast, and Burton yeast, and there is also a drawing to represent the acetic acid organism, the lactic organism, and the organism which produces butyric acid, and also the organism which produces the ropy fermentation, the mannite and gum, instead of alcohol and carbonic acid. The yeast organism under a good microscope will be found to have a cell wall. You will find inside a space, such as I have indicated, which is termed the vacuole, it is not really a vacuous space, but is filled up with a very thin protoplasm, or, as Professor Huxley calls it, the physical basis of life. The other portion is also filled up with protoplasm. Yeast contains a little granulated protoplasm. When it has been kept a long time it gets exhausted, and part of the albuminoid compounds or protoplasmic matter gets converted into other bodies, and they ooze out, and the result is that in looking through a microscope at the organism, instead of having to look at a well-filled cell, we have a thinner cell to look through, and the result is that the granulated protoplasm is seen much more distinctly. I have, therefore, given a rough representation of old yeast, or yeast that is exhausted. The conditions necessary for active yeast growth are that we should supply broken-down albuminoids and peptones for its nourishment, a certain quantity of phosphate of potash, lime, magnesia, together with a little air.

The microscope not only is of value in examining different kinds of flour for the purpose of seeing what mixture of other cereals have been added besides wheat, but it is also of the highest importance to the baker in judging of his yeast, because he will be able to see whether he has the organism which will produce acetic acid which would make vinegar or lactic acid, which would produce sourness, or even a worse organism still.

The particular process I have been describing, for making bread then, depends on making carbonic acid gas from the decomposition of the sugar which has formed in the previous stages yielding carbonic acid gas and alcohol. I have said very little about the alcohol; it is with the carbonic acid that we are chiefly concerned. There are other methods, however, of aërating bread without the carbonic acid of fermentation; bicarbonate of soda, and hydrochloric acid, when added in proper quantities, so that one exactly neutralises the other, or at least so that the bicarbonate is slightly in excess, is another method of making carbonic acid; or there is Dr. Dauglish's plan for making aërated bread, which depends upon aërating the bread with carbonic acid made in chemical ways, not by making use of the yeast organism. The hydrochloric acid and bicarbonate of soda method has very grave objections, because it requires very great care in mixing them, so that you should not have too much bicarbonate on the one hand, or too much hydrochloric acid, or spirits of salts as it is called, on the other. Dr. Dauglish's method has its merits, because you do not introduce anything into the bread like hydrochloric acid or bicarbonate of soda; it is merely carbonic acid that is introduced, and it has for some years been used in London, and one or two other towns. For a long time apparently it had no very great measure of success. It is very interesting, because this method is an entirely mechanical one, and it gets rid of many of the objections which have been brought to the fermentation plan and to the hand method of kneading. I understand that during the last two or three years a greater sale has been found for aërated bread, which shows that the objections which I have for it have not been entertained by those who like it. I find that aërated bread is very nice the first few times of eating it, but after a time I long again for the nutty flavour of the well-fermented bread.

High-class flours and a skilful baker will make good bread. The real difficulty is to make good bread with flours that are not derived from highly elaborated wheats, and this is a point that I wish to say one or two words about before concluding. The Council, of course, desire the greatest extension of knowledge throughout the country, and inasmuch as we only grow one-third of the wheat we eat, and we are always obliged to import two-thirds, it seems to me that even in seasons that are not very favourable we have a remedy in our hands. In other words, as I have pointed out to you, where it is that so much injury takes place is in the sponge stage. It seems that we should divide our flours. Every miller should send out two distinct flours.

A few years ago I recommended that, and there are many millers who do that now, and many bakers who use two distinct flours; but I wish the recommendation I made at the Society of Arts should by means of the cheap publications of this Exhibition be more generally known. In order to show you that this is a very feasible plan, I have asked Messrs. Hill of Bishopsgate Street, to make me an experiment to illustrate it. I preferred not to have anything to do with it myself, in order that it should not be a lecture experiment in which one is liable to exaggerate. I asked Messrs. Hill through Mr. Dunham to get some good American flour and some soft Norfolk flour—not bad flour, only rather weak. Then I asked them to have them in the proportion of one-quarter American to three-quarters Norfolk. One set of loaves has been made in which the American flour has been kept separate, and only used for the sponge state, whilst in the other experiment the American and Norfolk flours were mixed, and used both for the sponge and for the dough. Loaves were made at precisely the same time, the same flours, the same quantity, the same salt, and baked at the same temperature, and *here* is the result. Those who are interested in the matter will see that in the case where they were mixed the loaf has not risen well, and in addition to that it is not so good in colour.

With reference to the use of brown meal, or whole meal, I would suggest either that you should make your sponge of very fine sponge flour, as a baker would term it, good hard whites, and then in the dough stage mix up the whole meal into it, or if there is an objection to this, that it is diluting your whole meal; then I would suggest another matter of getting over the difficulty. Make first of all a ferment, and in the ferment take care you use potato and flour as I have indicated; then add in the second stage a small quantity of glucose, using however in the sponge nearly all the salt and using a large quantity of yeast, pushing on therefore the sponge stage rapidly; then mixing up the remainder of the whole meal, and rapidly making your bread and baking it.

I did intend to call your attention to some drawings of the Vienna oven, to show how foreign rolls are glazed, but I will not detain you any longer. I will only ask you when you have the opportunity at the Exhibition to go round to the east corridor to Mr. Hill's exhibit, and there are one or two others, who are also making these foreign breads, and you will there see the process of glazing these rolls. It is done by steam, which is what we term super-heated. It is forced into the oven which is at a temperature of at least 500 degrees, and the steam coming against the hot walls of the oven becomes super-heated, it then passes over the surface of the roll, and glazes it or covers it with dextrine. I will only detain you with two or three other remarks. In the baking the cells of the starch are burst, which renders the bread easily digestible, the carbonic acid gas bubbles are enlarged, and that together with the expansion due to the steam enables the bread to be well piled. The crust keeps the moisture in, and from the elaborate experiments made by Lawes and Gilbert, Dr. McLagen, and our distinguished chairman many years ago, we now know the exact percentage of moisture that may be found in ordinary quartern loaves. To put it in another way, 100 lbs. of flour will give about 135 or 136 lbs. of bread ; in other words, a sack of flour will give 96 loaves. I dare say one or two practical bakers would say that fine flour would give even more.

I have called attention to the chemical phenomena underlying a very important industry ; I have asked your attention to this experiment, made for me by Messrs. Hills, and I will also ask you to notice the exhibit of Mr. Bonthron, No. 179, in the main corridor, to see the character of his crude gluten. I have some on the table, some dry, and some mixed with water, and I would ask you to notice the excessive tenacity of this gluten. If I have contributed anything to show how wheats that have not been well elaborated may yet be used with our foreign importations; if I have in any way, not merely to this audience but to the still larger audience, I hope to address by means of the Exhibition publications; if I have called your attention and that of others to interesting exhibits which you will find all through the building connected with bread and corn; and if I have shown you the importance of science to the advancement of this technical art, and caused you to take an interest in the scientific phenomena on which it is based, I shall not have failed in the object with which I came here to-day.

The CHAIRMAN, in moving a vote of thanks to Professor Graham for his exceedingly interesting, scientific and practical lecture, remarked that if none but the best qualities of wholesome food were used, the prices would evidently rise to such an extent as to seriously interfere with the supply; but science was able to teach how to employ inferior qualities of that which was nevertheless essentially wholesome so as to succeed in producing the result which, if not quite the best, was at any rate of a highly satisfactory character, and all must feel that Professor Graham's efforts towards the elucidation of that problem in the case of the conversion of flour into bread were worthy of the most hearty vote of thanks which could be accorded to him.

Mr. BONTHRON, as a practical baker of forty years' experience, begged to second the vote of thanks. He was very pleased to find science following so closely on the heels of observation and experience. He saw several practical bakers present, and he would call their attention to the very important consideration arising out of what they had heard, *viz.* the importance of the time to be given in London sponge to first-class flour, in order that the proper change might take place. This was a matter he had a great deal of difficulty in impressing on his workmen, but there was no doubt that the fine flour required longer time to undergo the necessary changes, and it must not be supposed for a moment that it could be done hurriedly. You could not ripen a grape properly except by the natural sun and by the natural time, and the same thing applied to bread-making. He had been much struck with the diagram of the ferments. It was well known that heat accelerated and cold retarded fermentation. In this particular season of the year yeast must be in a condition in which it was necessary that every care should be taken to nourish it. There was a serious danger of putting yeast which was weakened by warm weather into too cold a ferment. It should be tenderly nourished, always put in with a good body of food for it to work upon, never into the water, but always after the flour and other matters were put in.

(The vote of thanks was carried unanimously, and the proceedings terminated.)

International Health Exhibition,
LONDON, 1884.

THE

MEAT SUPPLIES

OF

THIS COUNTRY.

CONFERENCE ON WEDNESDAY, JUNE 18, 1884.

THE SOURCES OF OUR MEAT SUPPLY.

THE CAUSES WHICH HAVE CHECKED THE DEVELOPMENT OF OUR HOME PRODUCTION OF MEAT.

HOME-GROWN MEAT SUPPLY AND THE INCREASED PRODUCTION OF HOME-GROWN MEAT.

THE MEANS OF SECURING THE SUPPLY OF MEAT TO LARGELY POPULATED CENTRES.

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International Health Exhibition,

LONDON, 1884.

THE MEAT SUPPLIES OF THIS COUNTRY.

CONFERENCE ON WEDNESDAY, JUNE 18, 1884.

1. "*The Sources of our Meat Supply.*" By Major P. G. CRAIGIE.
2. "*The Causes which have checked the Development of our Home Production of Meat.*" By THOMAS DUCKHAM, M.P.
3. "*Home-grown Meat Supply and the Increased Production of Home-grown Meat.*" By JOHN CLAY.
4. "*The Means of securing the Supply of Meat to Largely Populated Centres.*" By S. B. L. DRUCE.

THE EARL OF SUFFOLK AND BERKSHIRE (Vice-Chairman of the Central Chamber of Agriculture for 1884), who presided, in opening the proceedings and stating what would be the order of business, said those who had urged on the Government the necessity of adopting the House of Lords' Amendments to the Cattle Diseases Bill, had almost pledged themselves to the statement that the restrictions proposed on the importation of foreign cattle would not materially enhance the price of meat. He himself took the very strongest view on that subject, for he felt perfectly certain that increased security would be followed by such increased production, that in reality the price to the consumer would be reduced; and he should be both surprised and disappointed if this view were not borne out by the proceedings of that Conference.

THE SOURCES OF OUR MEAT SUPPLY.

By MAJOR P. G. CRAIGIE,

Secretary of the Central Chamber of Agriculture.

RECENT controversies over the spread and consequences of imported diseases among the live stock of this country have not unnaturally directed the attention of enquirers into the present extent and the possible expansion of the meat supply of this country, while there is probably no question during the recent years of agricultural depression which has been more frequently agitated than the propriety and profitableness of meat production being attempted in this country on a larger scale than has been customary in the past epoch, when prices of corn were remunerative to the farmer. Before inviting discussion, therefore, on these points, it may be useful to make some endeavour to set out what is the probable amount of butchers' meat furnished in one shape or another to the inhabitants of the United Kingdom.

There may be raised in one or two quarters, but hardly, I anticipate, with any emphasis in this room, what I may call in a sense "the previous question," whether it is well for our people to demand a meat diet at all, or, at least, to rely so largely as we do on animal food. Without inviting a vegetarian discussion, I may be allowed to quote the old plea in favour of meat-eating, that it is but one form of economy of labour, and that the use of flesh as food may be supported on the ground that, in eating meat, we are simply using the stomachs of other animals to do that which we could not so well do with our own. In butchers' meat we are certainly able to receive in a more concentrated and more easily appropriated form certain elements of necessary food, which, in any other shape, we could not possibly assimilate with anything like the same rapidity and ease. Granted, therefore, that we must have animal food, my object to-day is to ask from what sources do we usually gather our supplies.

Beef or veal, mutton or lamb, pork, bacon or ham are not of course the only animal food which might come under review in a survey of our meat supplies. If the horse has not yet descended from the place which he holds in an Englishman's sense of propriety, and claimed an entry among food-yielding animals in this country, there is still a large amount of animal food involved in the poultry, the game, the rabbits, the wild fowl of all sorts, and, I should probably add, the eggs which are annually consumed in the United Kingdom. Important as they are, I do not propose, for the purpose of this merely introductory paper, to embrace any calculations of the peculiarly uncertain statistics of what I may call the minor and miscellaneous articles of the larder; nor do I attempt to include the cognate, but distinct, branch of animal food involved in the supply of milk, butter, and cheese. No record of our home production, in Great Britain at all events, is kept that I could appeal to as furnishing any figures worthy of your consideration. Limiting the question, then, to the produce of cattle, sheep, and pigs, the statist who would estimate the present consumption of the country has at least two guides to rely upon—the yearly census of these animals, so far as they are enumerated on British and Irish farms, and the records of the imported animal produce, alive or dead, which comes from other lands to feed the growing wants of our population. This population, we must all of us admit, has for long been in excess of the number who could be exclusively supported on the yearly out-turn of our home produce. There were in the United Kingdom, in the middle of last year, some 35,631,000 persons of all ages, and there were available for food, or in process of development, in round numbers, 10,000,000 head of cattle, 28,000,000 head of sheep, and 4,000,000 pigs. By no process of calculation of which I am aware, and under none of the estimates of the annual yield of meat from the stock above enumerated which I have met with, could we feed, with the customary allowance of animal food, the population of the islands, unless we very materially increase these totals of our stock. No inconceivable portion of the people's rations must in some form or another be raised abroad, and it must not be forgotten that the acres of other lands than our own are now laid under yearly contribution to fatten our British live stock, and this not alone in the foreign feeding stuffs and cake employed, but in the additional produce of our farms due to the application of manures of foreign and often distant origin.

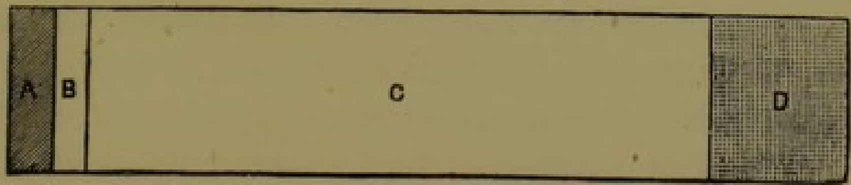
The meat-producing animals of the United Kingdom have by no means increased in the same ratio as the meat-consuming animal, viz., the human race. It is true we possess only an authentic live stock census for the past sixteen or seventeen years, yet the growing gap between home supplies and home wants is very clearly apparent when anyone compares the figures of the past with our present statistics. We had in the year 1868 9,000,000 cattle, 35,600,000 sheep, and 3,000,000 pigs—in all nearly 48,000,000 living animals, and there were but 30,300,000 inhabitants of the United Kingdom in that year. To come to a still later period, let us contrast the 48,500,000 animals of 1874, with the 32,400,000 of our population in that year, and then turn to the figures which confronted us last season when our 35,600,000 people possessed a total live stock which did not then reach 42,500,000 head, even after a recovery from the losses apparent a year or two before. This is an absolute as well as a relative decrease, and while the mouths have multiplied, the meat forthcoming at home is less. Indeed, if certain old writers are to be believed, the decrease of available meat supply is even more apparent if we were to carry our survey further back, and place any reliance on the estimates of what I may call, not certainly pre-historic, but, perhaps, pre-statistical times. A hundred years ago Arthur Young would have it England by herself stood possessed of 3,500,000 cattle, and we know that the population of this section of our island at that period is not believed to have exceeded 7,000,000, that is to say, we possessed one head of horned stock for every two persons living on our soil. To-day, England, with her 27,000,000 souls, only rears, it would seem, some 4,200,000 cattle, so that were we isolated from the surplus beef produced in Ireland and in Scotland, as well as abroad, we should stand in the position, as compared with our forefathers a century ago, of having, with what is generally recognized as a larger appetite for meat, nearly seven persons instead of two claiming his share of each head of cattle.

Nor is the case better as regards our flocks. Several foreign estimates have been made purporting to show that Great Britain was early in this century the mistress of forty or fifty million sheep. I have seen, however, no evidence, that this was ever proved to have been the case. A far more reliable calculator, like McCulloch, used figures which will suffice for my case. He put the entire English flock at 26,000,000, the Scotch at 3,500,000, and the Irish at 2,000,000, as recently, as 1847. England had then a population well under 17,000,000, that is to say, less than two persons for every three now living. But, according to the authority just quoted, she then maintained half as many more sheep as she now has when she is blessed with 27,000,000 inhabitants. It will be obvious, therefore, that the increase in the Scotch and Irish flocks which, if McCulloch is right, has occurred in the course of a single generation [from five and a half to ten millions] is no sufficient set-off for the reduction of the sheep stock of our English and Welsh pastures from 26,000,000 in 1847 to 21,000,000 in 1868, and now to 18,000,000 in 1883. With such data before us, it cannot be wondered at that some uneasiness has been occasioned at the increased reliance of the nation on foreign meat supplies, that consumers are paying more for their meat, and that the scramble to share in these bigger prices has led occasionally to a degree of carelessness in the sources of our foreign supplies which has resulted in the importation of disastrous diseases among what is left of our stock, sometimes, as statistics have proved, with the ultimate infliction of far greater real loss to the food supply of the nation than the actual absence of such dangerous imports would have caused. It cannot be, therefore, amiss that we should meet together here in a building devoted to the illustration of the best means of maintaining the public health and securing the best form of food for the people, to discuss how we may develop the animal wealth of our own country, and, if we must supplement our home efforts, how we can feed our huge workshop population with meat, either imported alive from healthy as distinguished from more or less diseased districts, or else imported in what many of us regard as the safer form of dead meat which the resources of modern science now place within reach of the importer.

In offering you an estimate of what our supplies are, whereon to found this day's discussion, for I do not attempt to do more in the course of this paper, I take as my basis for the meat product of each year from our home stock, which is so immensely the largest factor in the calculation, the estimate that something like one fourth of the cattle enumerated in June, two-fifths of the sheep, and at least one-sixth more than the enumerated pigs are annually slaughtered for the people's food. Although I am aware this is a point on which opinions differ, I believe such a basis may be roughly relied on as indicating, for comparative purposes, the available supply.

Of course it would be rash to assert that in a calculation attended by many elements of uncertainty the method employed reflects with exact accuracy our present meat outturn in the United Kingdom ; but I could quote, were it needed, a fairly long record of authorities who have deemed the scale, if rough and ready, yet a fair and practicable one. We may accept it, at least for such general purposes as our discussion to-day, pending the time when, either by means of the enquiry the Royal Agricultural Society have been urged to make, or by other researches, more definite data are forthcoming. I fear, however, we shall be much in the dark as to the actual weights of animals slaughtered until such time as farmers abandon their apparently inexplicable practice of failing to use the only true measure of value, viz., weight, in the daily business transactions by which they sell the meat that is manufactured upon British farms.

Working out, on the plan above indicated, and on the basis of the 1883 animal census, the weight of home-grown meat would come out as 1,307,000 tons. The official records of our imports shew that in the same year 301,000 tons were imported as dead meat from foreign or colonial ports, and the estimate most nearly in accord with the recently issued official weights of live foreign animals, leads to the conclusion that 173,000 tons will represent quite the outside figure of the foreign live supply. The total consumption of 1883 thus reaches 1,781,000 tons of meat; and in the accompanying diagram I have in a form, appealing more directly to the eye, shown the relative magnitude of our home and foreign meat supplies. These consist in far the largest proportion, three pounds out of four, of our own produce. Only the rest is derived from foreign sources, alive or dead, as the case may be. In this diagram I have also indicated the proportion of our supplies coming from countries tainted more or less with foot-and-mouth disease.



A. Proportion of meat received alive from countries which have sent us foot-and-mouth disease.
B. " " received alive from countries which are undoubtedly free from foot-and-mouth disease.
C. " " produced at home.
D. " " imported as dead meat.

I leave it to those who are to treat of the special points of this Conference to explain the causes underlying the changes that have been from time to time apparent in our home meat supplies, and especially the decline which followed 1874. I leave it to them also to argue how larger supplies are to be raised at home, and how the problem of finding the capital required for heavier stock-farming is to be met; and I leave it also to other and to foreign or colonial speakers, to tell us what are the prospects of larger foreign supplies, remembering that we must never dissociate from this problem how the risk of importing disease is to be eliminated, and how we can improve our machinery of live or dead meat distribution at home.

There are, however, two or three notes on the composition of our supplies I desire to offer. First, as regards the relative proportions of the cattle, sheep, and pigs consumed as meat. In so far as our home-stock is concerned, it would appear that the 1,300,000 tons I assume for the purpose of this paper to have been placed on the market last year, rather more than half, or some 670,000 tons, consist of beef or veal. This is a larger figure than in any one year since 1873–5. Not much over 4 per cent. of this has been computed to consist of veal. Half as much as the beef, or somewhat over 350,000 tons, may be credited to our flocks in the shape of mutton or lamb; and, according to the estimates made in some quarters, more than 12 per cent. of this is consumed as lamb. Unlike the beef supply, that of mutton is, with the exception of the two immediately preceding years, 1881 and 1882, considerably less than could be estimated in any year from 1867. The pork, bacon, and hams, which are the produce of British or Irish pigs, are computed as supplying us with something under 280,000 tons. Owing to the form of our Customs records we cannot tell with perfect accuracy how much of dead meat is beef, and how much mutton, for any long series of years. Since the great trade in frozen mutton sprung up, some three years ago, a separate entry of the mutton thus prepared has been given, but there is no distinction drawn in the imports of tinned and preserved meats between the produce of the cow or the sheep, while I understand that the meat of another animal, the rabbit, is now not by any means an infrequent item of this class of provisions. Grouping, therefore, in one item foreign dead supplies of beef and mutton, we find a total of over 98,000 tons in 1883, a figure greatly in excess of any previous year, while more than twice this amount, or 203,000 tons, represents the bacon, hams, and pork imported in the same year. Owing, no doubt, to the much greater ease of transporting and handling salted provisions, it will be seen that in the dead meat imports the English pig meets a far stiffer competition than falls to the lot of the ox or the sheep. In the live animal trade the positions are exactly reversed, the entire weight of foreign live pigs landed on our shores does not apparently reach 2000 tons, quite 99 per cent. of live imports being beef and mutton.

Lastly, I would invite attention to the remarkable changes in the sources of our foreign live supplies. Thus, in 1883, taking the case of cattle alone, 208,000 head out of a total of 473,000—that is to say, 44 per cent.—come across the Atlantic, i.e., from the United States or Canada. Ten years before, this trade did not even appear in the Official Returns, and in 1877 it did not reach 20 per cent. of the whole. Another remarkable increase is in the Scandinavian trade, where Denmark, Norway, and Sweden, which sent us only 8000 cattle in 1869 out of 220,000, now supply 147,000 out of 473,000 last year. It is at least satisfactory to those who contend that our duty is to welcome supplies from those countries which have made a successful effort to keep themselves free from disease, to contrast these figures with the stationary or receding amount of the live animal trade from countries like Spain and Portugal, whence the import in 1870 was even greater than it is at present; or the trade with Belgium, Holland, France, and Germany, whence we get no growing supply, and whence we need under no circumstances look for an increase. All of them collectively do not send us nearly as many cattle as their little neighbour Denmark; and though the German sheep exports, if not actually increasing, form yet a very considerable trade, it is one which we know to be carried on from a steadily diminishing source. The reduction of the flocks of Germany and several Continental nations have been of late years even greater than our own. Even, therefore, if our farmers cannot in this Conference show us that our own soil can rear a full and sufficient supply of meat for our own people at present—and even if any check should occur to what I believe to be the growing dead-meat trade—on the whole it cannot but be gratifying to note that it is precisely from those countries whence the safest imports may be brought that any increased supplies to fill up the vacuum are likely to be obtained. This should give our statesmen courage to resist the offer of these exceptionally dangerous imports from countries which are tainted with disease, which in time past have been too often a cause of a diminishing meat supply to the people of the United Kingdom.

THE CAUSES WHICH HAVE CHECKED THE DEVELOPMENT OF OUR HOME PRODUCTION OF MEAT.

By THOMAS DUCKHAM, M.P.

IT is, I consider, beyond any question, that of all other causes, the seasons have the most direct influence in increasing or decreasing our home productions of animal food, and, as those are regulated by the Divine will, over which the cultivators of the soil can have no control, their duty to their country ceases when they have used their best exertions towards making it render its full increase. Under the heading of this paper it becomes my duty to consider whether that desiderata has been attained, and if not, what have been the counteracting influences. Agricultural statistics were first collected for Great Britain in 1866, but, as they were for that year very incomplete, I commence my researches in those for 1867. They show that in Great Britain and Ireland, including the Isle of Man and Channel Islands, there were 45,387,066 acres of land under corn and other crops, bare fallow and grass;

of that acreage there were in Great Britain 11,967,988 acres of permanent pasture, 9,284,780 acres of corn crop, 3,498,163 acres of green crops, 3,989,974 acres of grass, clovers, &c., in rotation, and 922,558 acres bare fallow. In Ireland there were 10,057,072 acres of permanent pasture, 2,115,137 acres of corn crops, 1,432,252 of green crops, and 1,658,451 acres of grass, clovers, &c., in rotation, and 26,191 acres of bare fallow. But the acreage of permanent pasture for Ireland included a large area of mountain or other lands which were retained in the returns up to the year 1877, when 364,022 acres were transferred to mountain, bog or waste lands. Therefore the permanent pasture in Ireland for 1867 should appear as 9,693,050 acres, and the total in the United Kingdom as 21,661,038 acres. In 1883 there were 47,655,230 acres under corn and other crops, bare fallow and grass, being an increase of 2,632,186 acres. The acreage of permanent pasture in Great Britain had increased to 15,065,373 acres, and in Ireland to 10,191,118 acres, making a total of 25,256,491 acres, showing an increase of 3,595,453 acres. Of that great increase there are 3,097,385 acres in Great Britain, and 498,068 acres in Ireland. A further reference to the returns show that in Great Britain there were 754,714 acres less wheat, and 20,081 acres less roots grown in 1883 than in 1867; whilst there were 32,287 acres more barley, and 224,894 acres more oats, and 405,948 acres more clover, sainfoin, and grasses in rotation grown in 1883 than in 1867. In Ireland there were 167,106 acres less wheat, 11,378 acres more barley, 278,541 acres less oats, 201,999 less roots, and 272,650 acres more clover and grasses in rotation.

The foregoing statistics show that, notwithstanding there was, during the past 16 years, a very great increase of cultivated land, the area of wheat was very greatly decreased, the question naturally arises, What is produced as compensation for this great decrease as food for man? For the answer we naturally look to the live stock returns. In doing so, I feel it right to take the returns for 1868, because those for 1867 were seriously affected by the losses sustained from that direful calamity the cattle-plague and other diseases amongst our flocks and herds. I also consider it the more correct course, as the returns for live stock are made in June, whilst the returns for growing crops represent those of the current year. This fact points to the desirability of obtaining returns of live stock twice in the year—a question I raised in the House of Commons a short time since, and I hope to do so again and again, until they are obtained.

LIVE STOCK RETURNS.

GREAT BRITAIN.

	Cattle.	Sheep.	Pigs.
1868	5,423,981	30,711,396	2,308,539
1883	5,962,779	25,068,271	2,617,757

IRELAND.

	Cattle.	Sheep.	Pigs.
1868	3,620,352	4,822,444	862,443
1883	4,096,021	3,219,098	1,351,990

	GREAT BRITAIN.		IRELAND.	
1883—	Increase of cattle,	538,798	Increase of cattle,	475,669
„	Decrease of sheep,	5,643,125	Decrease of sheep,	1,603,346
„	Increase of pigs,	309,218	Increase of pigs,	489,547

Before commenting upon those figures, I think it right to state that the sheep in Great Britain in 1868 were in excess of any other known year, a fact which arose from an unusual number of sheep being bred in that and the preceding year, as those whose pastures had been denuded of cattle by the plague feared further outbreaks of that direful disease if they stocked them with cattle. The effects of the calamitous seasons of 1879–1880 and 1881, when an enormous number of sheep died with the disease known as fluke or liver rot is not to be lost sight of in comparing the statistics for the sister Isles—yet, notwithstanding all the allowances that must be made for that calamitous visitation, there is something very startling in the fact that, with an increase of 3,097,385 acres of permanent pasture, and an increase of 405,948 acres of clover, &c., in Great Britain, that there should only be an increase of 538,798 cattle, whilst there is a decrease of 5,643,125 sheep. Those facts become the more striking when we find that, with an increase of 498,068 acres of permanent pasture, and an increase of 272,650 acres of clover, &c., in Ireland, there is an increase of 475,669 cattle, and a decrease of only 1,603,046 sheep. I cannot for a moment admit that the farmers of Great Britain are less intelligent or less persevering in their business than those of Ireland, and therefore I cannot help feeling that there must be something more than even the seasons, disastrous though they have been, to produce such a serious contrast in the supply of animal food furnished by the two islands. In my opinion, the reason is not far to seek—no business can flourish without security for the capital invested. That security the tenant-farmers of Great Britain long and loudly called for, but a deaf ear was turned to their call. They had to submit to an unjustifiable increase of rents, fostered under an arbitrary and cruel law of distress, an increase that was very frequently made upon the improvements they had effected on their holdings, or, if they did not so submit, they had to turn out and leave their capital in the soil for the benefit of others. They had to stand passively by and see their crops destroyed by game, whilst the lands they occupied and paid rent and taxes for were laid waste. They had to bear the brunt of increased taxation, and increased wages with less labour performed, notwithstanding the increased amount paid, and, added to all this, their capital was repeatedly filched from them by imported diseases amongst their flocks and herds, against which they were powerless to guard. It may be asked, had not the farmers of Ireland similar grievances to contend against. In reply, I say no; they had far greater security in their holdings, their crops were not destroyed by game, they had not such excessive burdens of taxation imposed upon them, they had not to contend with the labour question, and their flocks and herds have been better guarded from disease. The farmers of Great Britain are a law abiding and loyal class, and they bore for several years the burdens imposed with patience and endurance, but the result of the combined causes I have enumerated induced numerous good substantial men to retire from business with a limited income, rather than attempt to carry burdens which their experience showed them were too heavy to be borne, unless under very exceptional circumstances. Many others left the land of their birth with their remaining capital, and emigrated to distant lands, hoping to find better security for its investment. The sad experience of the past seven years has proved to many of those who resolutely endeavoured to combat with their position how fruitless were their endeavours. The unprecedented number of failures, the large area of the kingdom which has been thrown upon the landlord's hands in a wretched state of cultivation, much of which has gone altogether out of cultivation from want of tenants to occupy, on the one hand, and the want of knowledge, inclination, or capital of the owner, on the other hand, have all tended to produce the results which all must now deplore, when considering the humiliating position the statistics show the nation to be placed in.

Recent legislation has done much to correct the evils which have so materially contributed to produce these painful results. The efforts of tenants to grow crops upon their holdings are no longer to be frustrated by the destruction of ground-game. Advantage can no longer be taken of the improvements they effect upon their holdings without compensation. The arbitrary powers of the ancient law of distress no longer exist. Some relief of their burdens of local taxation has been given, and more relief has been promised. A re-adjustment of rents has very generally taken place, and last, not least, their flocks and herds are now guarded by legislative enactments from the importation of those diseases which have been fraught with such disastrous results to the owners, and have tended to so materially increase the price of animal food to the consumers in this densely-populated country. I will quote a few statistics to show how seriously the prevalence of disease has affected the price of meat. The average price of beef in the metropolitan market for the years 1864–5 and 6, when diseases were rife and unchecked, was 4*s.* 6¼*d.*, and of mutton 5*s.* 3*d.* per 8 lbs. The average value of importations of live animals for those years was £5,554,565, and of dead meat, £3,328,108. The cattle plague was stamped out in 1866, and with it other diseases that had proved so disastrous in the flocks and herds of the country. The average price of beef in the metropolitan market for 1867 was 4*s.* 2½*d.*, and of mutton 4*s.* 5½*d.* per 8 lbs. The value of the importations of live animals was £4,148,409, and of dead meat £2,701,202. In 1868, another healthy year, the average price of beef was 4*s.* 1⅛*d.*, and of mutton 4*s.* 3¼*d.*, per 8 lbs. The value of the importations of live animals was £2,698,511, and of dead meat £2,891,012. It will be seen that during the three years when diseases were prevalent the average price of beef was 5*d.*, and of mutton 10¼*d.*, per 8 lbs., more than during the two following years, when the flocks and herds of the country were comparatively healthy, and that notwithstanding the average value of the meat imported was £2,663,106 less than for the three preceding years. There are other similar cases to those I have quoted, which a careful investigation of the annexed tables will disclose, but I will pass them over and confine my further remarks upon this head to quotations from the returns for 1883. There were that year, in the United Kingdom, 265,526 more cattle, 899,340 more sheep, and 29,932 more pigs than in 1882. That great increase of live animals was calculated to yield an increase of meat for the year of 27,385 tons, supposing its production had not been so seriously interfered with by foot-and-mouth disease. Now, taking the increase of population at 400,000, and allowing 100 lbs. of meat as the consumption for the year of each person, they would require 17,857 tons to meet their demand, being 9,528 tons less than the extra production; now, calculating the 27,385 tons at £80 per ton, the value was £2,190,960 —and that of the extra 9,528 tons of extra production, beyond the requirements of the increased population, £762,240, of which the general consumer should have taken the benefit, according to the first principles of political economy, viz., that supply and demand must rule the price of the article produced. But, in our meat supply, we find the very opposite result, as there was last year an increase in the importation of live animals of the value of £2,707,018, and of dead meat of the value of £3,653,422, making a total increase of £6,360,440 beyond the imports of 1882, and the average price of beef was 2½*d.*, and of mutton 7¾*d.* per 8 lbs. more than in 1882.

This clearly illustrates the fact that the losses sustained by the nation in 1883 from foot-and-mouth disease not only exceeded the value of the extra production, but that the value of the enormously increased importations failed to meet the deficiency created by the disease. There are not any statistics for Great Britain from which reliable calculations can be made of the losses. But there are official returns published, giving the exact number of animals annually received from Ireland, and as I have shown that there was a considerable increase of cattle and sheep in Ireland in 1883 as compared with 1882, and as the price of both fat and store stock ruled very high in Great Britain throughout the past year, there was every reason to expect increased receipts from Ireland had the supply not been interfered with by disease. The following table will show that the reverse was the case :

RECEIVED FROM IRELAND.

	1882.	1883.	Decrease.
Fat Cattle	291,777	229,603	62,174
Store „	427,798	278,518	149,280
Other „	3,006	1,819	1,187
Calves	59,693	46,927	12,766
Total . . .	782,274	556,867	225,407

I estimate the value of those 225,407 cattle thus deficient, and also of the 97,675 sheep which were likewise deficient in our supplies from Ireland last year, to be about four millions sterling—I have no doubt that much of the fat stock found its way to our dead meat markets, but its value was greatly depreciated to the producers.

The deficiency of receipts from Ireland arose from two causes; first, by the disease amongst the flocks and herds at home, and the prohibition which the authorities in Great Britain felt constrained to impose in consequence of the frequent outbreaks of disease amongst Irish stock upon its arrival on this side of the Channel. The loss occasioned by the prohibition was two-fold; first it fell heavily upon the Irish stock owners, who could not dispose of their animals, and secondly upon the graziers of Great Britain, who had an abundance of food which they were anxious to convert into meat, but could not obtain animals to consume it.

Notwithstanding the sad experience of the past forty-five years, during which long period the flocks and herds of the nation have been so seriously subjected to imported diseases, there are those who still stoutly adhere to the opinion that the diseases arise spontaneously in this country, that they are become acclimatised and indigenous to the soil. Unquestionably the climate is such that neither the extremes of heat nor cold are sufficient to affect them. But we have the fact that the regulations enforced for stamping out cattle plague during the years 1866, 1872, and 1877, had each time a decided effect towards ridding the country of pleuro-pneumonia and foot-and-mouth disease.

Since those visitations we have the experience of the working of the Contagious Diseases (Animals) Act of 1878, to which I have before referred, and experience has shown that those local authorities, who have acted firmly in enforcing the power placed in their hands by the Privy Council, have retained the health of the flocks and herds in their several counties. That when an outbreak has taken place it has rarely, if ever, occurred without its source being clearly traceable, and the adoption of strictly guarded cordons have rarely failed to prevent the spread. These things being so, it becomes apparent that prompt and stringent uniform regulations are essentially requisite to be enforced to free the country from the scourges which have so disastrously visited this nation for so many years past.

DISCUSSION.

Mr. W. J. Harris, M.P., said,—Of the two interesting papers which we have heard read, I confine myself in criticism to the last, viz., that by Mr. Duckham. With the paper by Major Craigie I entirely agree. Mr. Duckham has given us a long account of the decrease in corn growing in England, and the consequent increase in pasture during the last decade, and he argues therefrom that instead of our home supplies of meat decreasing they ought to have increased. I join issue at once with Mr. Duckham on this argument. I maintain that more meat is produced where corn is grown as well as grass, than where grass alone is produced. Mr. Duckham gives us the instance of Ireland, where the decrease in the number of cattle and sheep has not been nearly so great as in England, and he attributes this to the fact that the Irish farmers were lower rented and had smaller taxes and more grass land than in England. Surely Mr. Duckham must be aware that if this were indeed true, viz., that the conditions of farming in Ireland, as to rents, &c., were, during the period under review, so much more favourable than in England, he can hardly explain why the late Irish Land Act was so necessary. (Cheers.) I think, however, we may take it as an axiom that mixed farming produces more meat than any other, and that the increase shown in the number of stock in Ireland may be set down to store stock rather than to fat stock ; in fact, the Irish farmer has adapted himself to the rearing rather than to the fattening of stock. The next

Summary of Live Stock in the United Kingdom and the Average Price of Beef and Mutton in the Metropolitan Market for the Years 1867 to 1883 inclusive.

Year.	Great Britain.			Ireland.			Total in Great Britain and Ireland, including Isle of Man and Channel Islands.			Average Beef, per 8 lbs. Metropolitan Market.	Average Mutton, per 8 lbs.	Year.
	Cattle.	Sheep.	Pigs.	Cattle.	Sheep.	Pigs.	Cattle.	Sheep.	Pigs.			
1867	4,993,034	28,919,101	2,966,979	3,702,378	4,826,015	1,233,893	8,731,473	33,817,951	4,221,100	4·2¾	4·5½	1867
1868	5,423,981	30,711,396	2,308,539	3,620,352	4,822,444	862,443	9,083,416	35,607,812	3,189,167	4·1	4·3¼	1868
1869	5,313,473	29,538,141	1,930,452	3,727,794	4,648,158	1,079,793	9,078,282	34,250,272	3,028,394	4·5¾	4·10	1869
1870	5,403,317	28,397,589	2,171,138	3,796,380	4,333,984	1,459,332	9,235,052	32,786,783	3,650,730	4·6¾	4·7¼	1870
1871	5,337,759	27,119,569	2,499,602	3,973,102	4,228,721	1,616,754	9,346,216	31,403,500	4,136,616	4·5½	5·3¾	1871
1872	5,624,994	27,921,507	2,771,749	4,057,153	4,262,117	1,385,386	9,718,505	32,246,642	4,178,000	4·9	5·8	1872
1873	5,964,549	29,427,635	2,500,259	4,151,561	4,486,453	1,044,218	10,153,670	33,982,404	3,563,532	5·5	6·1½	1873
1874	6,125,491	30,313,941	2,422,832	4,118,113	4,437,613	1,096,494	10,281,036	34,837,597	3,537,354	5·3¾	5·4½	1874
1875	6,012,824	29,167,438	2,229,918	4,111,990	4,248,158	1,249,235	10,162,787	33,491,948	3,495,167	5·2	5·11½	1875
1876	5,846,302	28,172,951	2,293,620	4,113,693	4,007,518	1,424,143	9,997,189	32,252,579	3,734,429	5·4½	6·1½	1876
1877	5,697,933	28,161,164	2,498,728	3,996,027	3,989,178	1,467,999	9,731,537	32,220,067	3,984,447	5·4¼	6·4½	1877
1878	5,738,128	28,406,206	2,483,248	3,984,751	4,094,230	1,269,340	9,761,288	32,571,018	3,767,960	5·4¼	6·2¼	1878
1879	5,856,356	28,157,080	2,091,559	4,067,094	4,017,889	1,071,990	9,961,536	32,237,958	3,178,106	4·10¾	5·9½	1879
1880	5,912,046	26,619,050	2,000,842	3,921,026	3,561,361	849,046	9,871,153	30,239,620	2,863,488	5·2¾	6·0¼	1880
1881	5,911,642	24,581,053	2,048,090	3,954,479	3,258,583	1,088,041	9,905,013	27,896,273	3,149,173	4·10½	5·11	1881
1882	5,807,491	24,319,768	2,510,402	3,986,847	3,071,493	1,429,930	9,832,417	27,448,220	3,956,495	5·1¾	6·4¾	1882
1883	5,962,779	25,068,271	2,617,757	4,096,021	3,219,098	1,351,990	10,097,943	28,347,560	3,986,427	5·4¼	7·0½	1883

Summary of the Acreage of Land under Cultivation in the United Kingdom.

Year.	Great Britain.					Ireland.					Total acreage, including Isle of Man and Channel Islands.	Year.
	Permanent Pasture.	Corn Crops.	Green Crops.	Bare Fallow.	Grass, Clover, &c.	Permanent Pasture.	Corn Crops.	Green Crops.	Bare Fallow.	Grass, Clover, &c.		
1867	11,967,288	9,284,780	3,498,163	922,558	3,989,974	10,057,072	2,115,700	1,432,352	26,191	1,658,451	45,387,066	1867
1868	12,136,036	9,433,532	3,385,866	958,221	3,960,008	10,003,918	2,192,785	1,456,307	24,017	1,691,797	45,652,545	1868
1869	12,735,897	9,758,037	3,575,067	738,836	3,448,726	10,046,877	2,207,970	1,468,895	20,981	1,669,800	46,100,153	1869
1870	12,072,856	9,548,041	3,586,730	610,517	4,504,884	9,990,968	2,173,109	1,498,719	19,054	1,775,835	46,177,370	1870
1871	12,435,442	9,675,261	3,738,180	542,840	4,369,448	10,068,843	2,124,079	1,511,532	22,323	1,827,733	46,667,178	1871
1872	12,575,606	9,573,551	3,616,383	647,898	4,513,451	10,241,513	2,090,673	1,473,916	18,512	1,799,930	46,868,290	1872
1873	12,915,929	9,458,928	3,576,486	706,498	4,366,818	10,420,695	1,930,824	1,372,420	13,474	1,837,483	46,926,917	1873
1874	13,178,012	9,431,490	3,581,270	660,206	4,340,742	10,472,161	1,901,508	1,353,362	12,187	1,906,083	47,143,320	1874
1875	13,312,621	9,451,650	3,664,107	557,979	4,354,071	10,431,776	1,916,398	1,370,086	11,287	1,943,923	47,313,789	1875
1876	13,515,944	9,194,669	3,571,874	651,212	4,540,273	10,507,249	1,848,487	1,363,224	11,652	1,861,464	47,393,450	1876
1877	13,728,355	9,210,129	3,584,846	616,147	4,494,216	10,145,227	1,861,847	1,354,853	16,678	1,925,168	47,263,185	1877
1878	13,911,296	9,167,646	3,491,010	632,423	4,573,107	10,124,745	1,831,421	1,317,760	16,971	1,942,716	47,326,615	1878
1879	14,166,724	8,985,234	3,554,318	721,409	4,473,373	10,198,139	1,761,800	1,294,636	16,295	1,937,348	47,436,820	1879
1880	14,426,959	8,875,702	3,476,653	812,566	4,434,339	10,261,266	1,766,424	1,247,359	15,366	1,909,907	47,586,700	1880
1881	14,643,397	8,847,976	3,510,568	795,809	4,342,285	10,091,688	1,776,877	1,268,997	21,186	1,998,402	47,646,112	1881
1882	14,821,675	8,833,380	3,475,660	784,425	4,327,392	10,110,079	1,756,819	1,248,954	21,263	1,961,773	47,655,230	1882
1883	15,065,373	8,618,675	3,454,579	778,203	4,395,922	10,191,118	1,678,125	1,230,253	24,698	1,931,101	47,667,274	1883

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point I have to mention is the recent prevalence of foot-and-mouth disease. There is no doubt that this has acted in the most prejudicial manner, both on the success of farmers and in the home meat supply. I am fully convinced that the late legislation has not been in the least degree too stringent. It has simply put the onus on foreign countries of preserving a clean bill of health for themselves instead of giving to us all the trouble and expense of proving the existence of disease. It will make all those countries which depend upon our demand the more anxious to take such means as will stamp out the disease, and I look to the legislation of this session having the ultimate effect of stamping out foot-and-mouth disease all the world over. (Hear, hear.) That the complaint is not spontaneous in this country can be asserted with tolerable certainty. I can give some evidence on this point. I farm a tract of land on the Devonshire hills, where the business of the whole district is to rear cattle and sell them to more favoured districts. The consequence is that cattle are always going away and never coming to us, and as a consequence we have never had the epidemic of foot-and-mouth disease. (Hear, hear.) I believe that in the near future there will be an increase in our home supply, following upon the legislation so wisely passed by this Parliament. There is another cause which in my opinion will contribute in a marked degree to the increase in our meat supply. I refer to the system of ensilage, which has been already proved a success. I may mention that my own experiments have proved to me conclusively that at least 30 per cent. more cattle can be wintered on an ensilage farm than on the old system. (Hear, hear.) And now for a few words as to our supplies from abroad. We have seen the ability of the United States and Canada, and we may now add several other countries, as likely to equal, if not to exceed them. Australia and New Zealand can send us an almost unlimited supply of frozen mutton, and the River Plate and Brazil can likewise produce both beef and mutton at a very low price and in almost unlimited quantities. Until recently the difficulty has been to make these supplies available, but the discovery of the refrigerating process has made all the difference, and mutton now reaches us from the antipodes in just as good order as when it was shipped. In fact, there are persons willing to insure the whole risk of damage at 10*d.* per sheep. To show how this trade has grown since its commencement, I will give a few statistics from the London Dock Company's receipts. As one of the directors, I wish to say that the Company is willing to give these statistics simply as a contribution towards the discussion on this occasion, and not with a view of attaching to them any opinion. You must therefore understand that the statistics are the facts on which I rely, and any opinions that I found on them are my own. The trade commenced in 1881, and the landings to our refrigerated chambers in that year amounted to 11,355 sheep. In 1882 the landings in our refrigerating chambers amounted to 40,976 carcases. In 1883 we had to enlarge our storage room and all our appliances, and the quantity stored amounted to 108,703 carcases, while in this year up to to-day (18th June) less than half-a-year, the number has increased to 142,622. Thus the quantity arriving to our stores is more than doubling itself every year. The cost of bringing the mutton for freight and refrigerating while on passage is at present about 2*d.* per lb. With the great depression in shipping and the probability of discoveries of cheaper means of refrigerating, the cost will doubtless be reduced. When once landed in the dock chambers, the meat can be held without fear of injury for any reasonable time. There is no need to force it on an unwilling or depressed market. The cost per week for rent and keeping only amounts to 3·32 of a penny per lb., where the quantity is over 1000 carcases. On the other hand, to meet the daily wants of the market the following rates are under discussion and will probably be agreed to. Carcases delivered direct from ship to vans or railway trucks whilst the meat is being discharged, 3*d.* each. When several marks are imported in the same ship, 4*d.* each. Landing, housing, and delivery, including overtime and lamps at delivery and stowage for 48 hours, from breaking bulk, 8*d.* per carcase. Sorting in addition at chambers when several marks are imported on same manifest, 1*d.* each. Rent after 48 hours, 1½*d.* per cwt. per day, on market weight. Weighing at delivery, if required, ½*d.* each. Nothing would facilitate the manipulation and consequent reduction of dock charges so much as that each consignee should provide his shipper on the other side with a more distinct wrapper, so that they shall be easily identified for sorting on discharge. I may mention that the refrigerating chambers at our docks are immediately contiguous to the railway lines, and the meat can be loaded on trucks in the evening and delivered in the most distant town in England the next morning without fear of deterioration. In fact, the meat requires keeping for some little time after emerging from the frozen atmosphere, as if cooked at once it eats hard; whereas when kept for some days (more or less according to the season of the year) it has time to thaw thoroughly and becomes perfectly tender. The wholesale price of this mutton is to-day from 4¾*d.* to 5¾*d.* per lb. from the dock stores, and although this may not be welcome news to the English farmer, yet it is of inestimable importance to the working classes. When the quantities increase, as they no doubt will do, I apprehend that we shall see meat sold from costermongers' barrows in many of the crowded quarters in London where the working classes mostly congregate. There is only one other fact which I wish to bring forward as to the permanence of the supply. I can really see no reason for any fear on this head. The stock of sheep in Australia and New Zealand is nearly 80,000,000. It could easily be doubled or trebled. Since the refrigerating process has been discovered the value of sheep has nearly doubled there, thus stimulating the production. The vast capacities of the South American Continent have only been slightly trenched upon thus far. India has done nothing thus far in meat raising, the reason being that while cattle food is in luxuriant growth during the rainy season, it is quite wanting during the rainless period of the year. The discovery of the ensilage system, which is already being applied in India, may render the raising of meat in that vast continent an important trade. Russia is already exporting largely and promises to do far more for the future. The prophecies lately indulged in by Mr. Giffen, of the Board of Trade, as to the population of the United States rapidly overtaking its productive powers, were founded on statistics which were collected without a due regard to natural causes and effects. Mr. Giffen completely forgot that the exhaustion of land is a temporary and not a permanent matter. The exhausted corn land of America and Canada when left idle for twenty or thirty years would recoup itself by the natural atmospheric and chemical action, and the cultivation would recommence and repeat itself instead of being at an end as Mr. Giffen supposed. I well remember when Mr. Giffen read this paper at the Statistical Society, asking him how far he had travelled in the States before he wrote it, and he told me he had not been further than Washington. The statistics of such gentlemen are valuable studies of arithmetic, but when they are compiled without any regard to the natural causes which may entirely alter the conclusions arrived at, they are very deceptive for practical purposes. The results that I arrive at are as follow: 1st. I believe for many years to come that meat will be rather cheaper here than it has been during the past decade. 2nd. I think that all meat-producing countries will have a prosperous occupation, and I would strongly advise them to reciprocate by receiving our manufactures in exchange at a very moderate tariff, in order to prevent our finding it necessary to retaliate. 3rd. I believe that our own colonies are likely to be the largest gainers, and as they are not only our own blood, but also give to us greater reciprocal advantages in commerce than other countries, I am very glad it is likely to be so. 4th. I think that the British farmer will still be able to compete, if his burdens are equalised with those paid by farmers in other countries, and he has perfect protection from the importation of contagious disease. I only have to add that with that portion of Mr. Duckham's paper which refers to the treatment of agricultural tenants by their landlords I take exception. I believe that on the whole the English landlords have been more considerate towards their tenants during the recent times of depression than any one could have believed possible. I have no wish to deprecate the recent legislation, but I know that between most landowners and their tenants very fair compensation for improvements existed before the Act was passed, and I think that the good feeling which really exists between landlords and tenants is to be encouraged, and not to be called in question. Of course, when prices are as high as they were ten or fifteen years ago, rents have a tendency to rise, just as when prices fall, as they have done recently, they decline. This is simply a natural sequence in both instances, but the interests of the tenants are so bound up with those of the landlord that I believe any further interference between them would be mischievous in the extreme.

Lord EGERTON OF TATTON considered that the thanks of the meeting were due to the authors of the papers for the interesting facts which they had laid before them. This was a question which concerned the whole community—the consumers and the occupiers of the soil equally. He should direct his remarks principally to the way in which an increased food supply could be got in this country. In doing so he would touch upon some of the remarks in the paper, and he would just say a word on the foreign meat supply. Any one who had visited the Health Exhibition would see the Australian meat hanging up in cases, and any one who would buy a leg of mutton and try it would find it was as good as he could desire. There was, however, an advantage in home grown meat over the Australian meat, namely, that we had not yet got over the difficulty that storing meat in an atmosphere of low temperature produced hardness in the meat which it was difficult under the ordinary mode of cooking to get over. He had no doubt that with better process of cooking this difficulty might be removed, but the fact as yet remained, and it might be some consolation to the farmers to think that they might go on growing their meat without fear of competition from abroad, because there would always be a sufficient number of people in this country who would give a higher price for fresh meat than for foreign meat in a preserved state. Passing on to the question of increasing our stock, statistics had shown that in consequence of the bad seasons partly, and also of the importation of disease from abroad, our home agriculturists had been discouraged in the rearing of all sorts of stock. In his own county the damp years had almost stamped the sheep out of the country. After the cattle disease became prevalent they took to rearing sheep, and in the dry years they did well, but when the wet years came on, the sheep became diseased, and at the present time not one farmer in ten grew sheep who formerly did so. But they were now turning their attention to the rearing of young stock, and he thought this might be done now to a greater extent than before, but it should be upon a very different system. The cause of the increase in the cattle from Ireland was to be found in the fact that Ireland was the best cattle growing country in the world. It had the most suitable climate; the absence of cold in winter and the peculiar soil of the country. What they had to do in England instead of trusting to other countries for rearing stock, was to have covered yards, and to rear their own stock. That was what he had done recently. He had 500 acres in his own hands and he had done a great deal under paper sheds last winter. There was one remarkable fact about it—he had tried the rearing of cattle under sheds of slate and also under paper, and he found that those reared under the paper had done by far the best. He attributed this to the fact that the paper was warmer than the slate. He could say with confidence if these paper sheds would only last seven years, they would repay their cost over and over again. It was a very small outlay in the first place for paper, and they were perfectly portable. They all had the opportunity of seeing what it was, because the whole of the temporary sheds in that Health Exhibition were covered with paper. He must enter one protest against Mr. Duckham's paper. He thought that gentleman had taken causes of a limited character, and attributed to them wider effects than there was reason for. Three causes were mentioned why the farmers in England were not as fortunate as formerly; the first being that the crops were destroyed by game; the second was the cruel laws of distress; and the third, that they had no security for the capital invested.

Mr. DUCKHAM (interrupting) said these were the minor causes.

Lord EGERTON OF TATTON said these reasons were put in the forefront, and he did not believe that either of these three causes affected Cheshire; but he would say that the three other causes mentioned in the paper, namely, the increase of local taxation, the increased wages for less labour performed, and the bad seasons had no doubt had something to do with it.

Mr. FREDERICK BANKS (Christchurch, New Zealand) said he did not attend that meeting for the purpose of addressing it, but from what he had heard he thought it likely that the few remarks he would make would be of service in connection with importation of foreign meat from New Zealand. Having been a Director of the first Frozen Meat Company which was started in Canterbury, New Zealand, he was well acquainted with the frozen meat trade, and he might state that the public in England might depend thoroughly upon the quality of the meat imported. They had engaged one of the most experienced managers of stock in the Colony, and had given him the most stringent instructions that the sheep sent to be frozen were to be inspected very particularly, and any which he did not approve of were to be rejected—that was before they were killed. Then, again, after they were killed their carcases were to be again inspected, and any then not up to the mark were to be rejected. Hence he could say to the consumers in England that the meat imported was of the best. He did not agree with the last speaker, that English meat might be relied upon as better than frozen meat. He believed that the frozen meat would soon take the leading place in the favour of the consumers. When he visited some of the leading butchers' shops in London, he found the carcases hanging up there, the meat being in a warm state, and covered with flies ; but that was not so with the imported meat. People in the Colony were fast giving preference to the frozen meat. Personally, he had kept some for three months, and then had had it properly thawed and put on his table, and both himself and his visitors gave it the preference over meat killed in the Colony. There was another matter of importance alluded to by Mr. Harris, who stated that arrangements were being made for distributing the meat throughout England. He had been down to the docks himself, and had spent nearly a day looking at what was being done in this direction. He had hoped that in a city like London things could have been done far better than they could do them in the Colony, but he saw the meat landed and placed on trucks which had been used for other purposes. Now, in the Colony they had special trucks constructed for sending this meat about in, and he did not think the trucks used by the Dock Company were at all suitable for the work. It would tend to send the meat to the consumer in a state that was hardly fair to the imported meat. The whole thing was very simple, but the system of doing it was a haphazard one, and the importance of doing everything in the best way was not considered. The trade was in its infancy, and had not yet been worked in a way which practical men would work it. It needed improvement considerably. Then again it was said that their charges were moderate. Those in the Colony did not think so ; they thought they were excessively high. It was true the Dock Company were making chambers for the reception of the frozen meats, and had very nice engines and apparatus for keeping it frozen, but he thought they were attempting to pay for all this in the first year or two, instead of allowing it to be distributed over a period of years, and he hoped that they would soon modify their charges. Mr. Harris had said that a penny per pound was a moderate charge; but he considered it very heavy. A sheep in New Zealand would be worth 18*s.* for a 72lb. sheep, and a penny per lb. would equal 6*s.*, which was at once one-third of the cost of the sheep; he considered that that was too heavy a charge altogether.

Mr. HARRIS, M.P., said he was very glad to have heard this gentleman's remarks, but it must be remembered that the Dock Company with which he was connected had only just commenced; he would represent to his brother directors what had been said, and if some cheaper way could be devised he should be very glad. At the present time they did not make much profit out of it, and they must, however, first of all pay themselves.

Mr. BANKS said he was very pleased to hear Mr. Harris's interpolation, but he thought practical men would make suggestions which would be useful to the Dock Company. He had himself seen a small army of men waiting idle to receive the meat from a steamer that was discharging. These men had the ordinary trucks that had been in use for perhaps a century past. If he had been asked what to do instead of using these trucks, he would have said, have a small travelling railway, and two or three men could then do the work which it would take twenty men to do with these trucks. These things could not be improved and worked up to in a day. He was, however very glad to hear Mr. Harris say that it was the intention to try and improve matters as far as possible.

Mr. C. H. LATTIMORE said he ought to apologise for taking up time any longer after the wearisome discussion they had had, but it did seem as if the last speaker was such an advocate of New Zealand frozen meat that he thought that there was nothing else in the market equal to it. For his own part, he would leave that question to the house-wives of England, and to those who consumed the meat, for they were the best judges ; but they had so many advocates of frozen meat just now, that you might have thought it was a privilege to be born to eat it. They had met to discover how to increase the amount of home-grown stock. This question was brought forward as if this disease and diminution of stock was a thing of yesterday, but it had been going on, to his own knowledge, for at least forty years. Disease came in a slow but a steady manner ; it followed the trains and the fairs of the country. Farmers could never buy imported cattle without a risk of foot-and-mouth disease. A hundred sheep could not be brought from the north to the south without falling lame, and depreciating in value. The grazier's occupation was gone in this country, for he could not buy good raw material, and when it was bad it was liable to disease, and when he brought it into market, he met with these New Zealand gentlemen, who came in with their frozen meat, and tell you there was nothing like it. What was wanted was to increase first the quantity of store stock. There were two means of doing so : to improve the condition of the farmer, and to keep out foreign disease. The cause of the diminution of English stock had been going on, to his own personal observation, gradually but surely, and it had come to this—that meeting the vicissitudes of uncertain seasons, floods, and foreign disease had knocked down many a farmer, and destroyed his portion of the stock. Others had been diminished and limited in their quantity, and the result was that foreigners sent in no foreign stored stock. Therefore it was necessary to improve the position of the farmer, to keep out the disease, and for the landlords to give the farmers security and encouragement. With respect to the quality of the stock, it was possible they might so improve it as to come up to the standard even of the New Zealand meat. He did not think that the abolition of the malt duty in England had been taken sufficient advantage of. Malt was one of the finest articles to improve the quality of meat, and when they got it fairly into use, he believed it would increase the supply of stock, which would improve the condition of the farmer to a very sensible degree. Then with regard to pasture land, what was the position? The low price of wheat had driven men to abandon its growth, and land was laid down in pasture; but what would that land produce? It would not give the same quantity of meat as if root and corn crops were combined. Give him stock and corn together, and that would cope with all the competition in the world. Now the proportion of wheat grown in the country to that imported was in the last few years as 9 to 25; taking the consumption at 25 millions, and we produced only 9 millions, and he believed there would be still less. The proportion of meat grown here was 90 to 10. They had been told that disease was not introduced from abroad; that it was indigenous to the soil and to the stock in this country. He denied that. Mr. Harris had told the meeting that they had no disease where they had no importations. He warned the meeting that whatever they might think of the foreign meat at the present time, when the foreigner felt that he could hold the market he would raise his price, and the consuming public would be thrown on the mercy of the foreigner; but he would tell them that—

> "Self-dependent power can time defy,
> As rocks resist the billows and the sky."

The Conference resumed at 2·30, when Colonel Kingscote, M.P., took the chair, Lord Suffolk having been called away.

HOME-GROWN MEAT SUPPLY AND THE INCREASED PRODUCTION OF HOME-GROWN MEAT.

By JOHN CLAY, Kerchesters, Kelso, N.B.

IN dealing with this most important and national question there are two vital points to be considered, and these are—*first*, The causes of the short supply of home-grown meat ; and *second*, The remedy for its increase and further development.

It is not my intention to do more than merely allude to some of the more prominent causes of the short supply in this Paper, because I understand that another Paper entering fully into that subject is to be read to you. I will, therefore, only mention here what appears to me to be the principal causes of the falling off in the supply of home grown meat before proceeding with the remedy.

There can be no doubt that one of the chief causes of the diminished supply of home grown meat has been the contagious diseases, such as "rinderpest" and "foot-and-mouth disease," from which our cattle and sheep have suffered so much of late years.

The bad seasons which have been experienced for the last ten or twelve years have likewise had a very injurious effect, for the wet summers have kept the grass from being nutritious to stocks in general, and have also caused fatal disease amongst sheep ; whilst the severe winters and cold summers have greatly curtailed the food supply of stock.

These causes alone have undoubtedly had the effect of diminishing the average yield of beef and mutton per acre over the whole country of late years.

It appears to me also that sufficient attention has not been paid to the breeding and rearing of cattle in this country for the last twenty years, which is chiefly owing, I believe, to the risk of the introduction of contagious diseases, such as the foot-and-mouth disease, to the breeding stocks, and the great losses which the breeders sustained by the importation of disease from abroad.

With regard to the *second* point, viz., the remedy for increasing the supply of home-grown meat, it appears to me that the first thing which should engage our attention is the production of a greater supply of stock by breeding, for that is the only method by which stock can be increased. It should be made a rule with farmers in this country never to sacrifice a good heifer to the butcher until she has produced at least two calves. On the great cattle breeding ranches in America, which I lately visited, this rule is in constant practice, and I am glad to say that in one or two districts of this country the farmers are alive to the value of keeping up a good breeding stock, for in Cumberland and Westmoreland, when cast cows are sold for dairy purposes, the vendors generally stipulate that all heifer calves shall be returned to them by the purchasers—no doubt for breeding purposes.

There are two methods which may be successfully pursued for increasing the supply of stock on arable and pasture farms, and these are : first, when the farm consists of partly arable and partly good pasture, with outlying rough grass-land, by the keeping of a herd of heifers and suckling the calves ; and, second, where the farm consists of ordinary arable and grass-land, by the rearing of calves by the hand.

As an example of the first method, I may be allowed to describe the system which I have myself pursued for many years past, and which has enabled me to produce as much stock as have been required for feeding purposes on my two large arable farms. I keep a stock consisting of 150 Shorthorns, and Polled Galloway, breeding heifers, partly on my hill farms, and partly on my arable farms, and these heifers are put to the finest pedigree Shorthorn bulls which I can get. These heifers are divided into three classes, with reference to their ages. First, 50 one-year olds, which are put to the bull at about 15 months old, and produce calves in their second year. Second, 50 two-year-olds, which have had one calf, and produce calves in their third year also. The steer and heifer calves of these two classes are all retained on the farms, the heifers for breeding and the steers for grazing, and afterward feeding. Third, 50 three-year-olds which have produced calves in their second and third years, and will also produce calves in their fourth year. The calves of this class in their fourth year are suckled by their mothers in summer on the best quality of grass-land, and in winter the calves and their mothers are brought into the cattle-courts and feeding-boxes. Here, they are liberally supplied with turnips, meal, and cake, and they are both fed off together and sold to the butcher in the following spring. The cows managed in this way fatten well, averaging about 65 stone, and the suckling calves average in weight about 40 stone, of 14 lb. to the stone, at 14 or 15 months old, and are sent to the market at the same time as their mother.

With regard to the second method, viz. the rearing of calves on ordinary arable farms by the hand. Formerly it used to be the custom to bring up more calves on farms by the hand than what are now reared, and calves for this purpose could be more easily and cheaply obtained than now, for in the border counties nearly every farm-servant and many villagers kept cows, the villagers having grazing in the neighbourhood of the village. About twenty years ago a movement took place on the part of many of the servants, and also on the part of many of the farmers, to substitute money payments in the place of the keep of the servants' cows, and this considerably diminished the number of cows kept in the district, the consequence of which was that fewer calves were bred. The demand for veal, which had been gradually increasing, became greater than the supply, and it was found to be more profitable by the farm-servants who still had cows, to feed the calves, in a few weeks for veal, than to sell them to the farmers for keeping stock. My own practice is to supply all my servants' families with cows of my own, to enable them to keep their families supplied with good milk, on condition that for the loan of the cow I receive the calf yearly. I find this to be not only a profitable arrangement but it is also a good one for the servants, and it gives me a supply of calves for rearing by the hand, which I could not otherwise obtain.

If landlords could arrange to supply each village on their estates with a grass park for the grazing of cows, making a charge of so much per head for each one grazed, in place of the common grazing land which, in most instances, the villagers formerly enjoyed, it would not only increase the number of stock obtainable for feeding purposes, but also tend to make the villagers more comfortable and healthy, and better satisfied with their position of life than at present.*

A certain number of cows are required on every farm, and I would advise that as many as possible should be kept, so that they may produce calves for the supply of feeding stock. My experience is that with the use of calf-meal and other ingredients the milk of one cow can now be made to go further in the bringing up of calves than formerly; and I have no doubt that with a little extra attention and care nearly double the number of calves could be reared upon each farm than at present. No doubt there are certain high-class farms upon which it will not pay to keep cows, but those are the exception and not the rule; until more attention is paid to the rearing of calves by our farmers, this country must continue to suffer from a deficiency in the supply of home-reared cattle for feeding. With reference to the subject of feeding, there are several points to which I would wish to allude, and these are, 1st, Summer-feeding; 2nd, Winter-feeding; 3rd, Accommodation in Farm-Buildings for Feeding Cattle; 4th, Increase of Sheep; and 5th, the General Cultivation of the Farm.

* I would strongly recommend all who are interested in this subject to study Mr. Henry Evershed's able paper on "Cowkeeping by Farm Labourers," in the 'Journal of the Royal Agricultural Society' for 1879 and 1880.

1. *Summer Feeding.*—At the present time the usual method is to turn the cattle out into pastures in early summer, where they remain without any other food but the grass until the autumn, when they are taken into the cattle-courts or sold for feeding. In many cases the grass is not of sufficient quality to keep the cattle in an improving condition, especially for the last few years, owing to the cold and wet seasons and the gradual deterioration of the condition of the land. A remedy for this is the supplying of the cattle on the grass with cake and other feeding stuffs, for these not only fatten the cattle, but also greatly improve the condition of the pastures. The soiling of cattle, by which is meant the supplying of cattle in courts with cut grass and other green food such as beans, peas, or tares, &c., is coming more into use, and by this mode of feeding along with the liberal use of cake and meal the cattle are speedily and profitably fattened for the autumn markets ; and where there is a superabundance of straw it is a valuable mode of converting it into manure of the first quality for the farm. More attention must also be paid to the laying of land to permanent pasture, where it is found that the cultivation of cereals is not remunerative. It is becoming more and more apparent that the farmers of this country cannot successfully compete with countries such as America, India, and Australia in the production of grain crops. Any one who has seen the vast extent of the wheat producing countries in America, and is acquainted with the cost of carriage of grain from there to this country, must be convinced that the more the British farmer turns his attention to the breeding and feeding of stock the better will he be able to hold his position ; for it is admitted that he has a considerable margin of profit in this department when in competition with the foreigner, for that eminent agricultural authority Sir James Caird, in his Report on British Agriculture, published in the Journal of the Royal Agricultural Society of England for 1878, states that, "under any circumstances, the English producer has the advantage of at least a penny per pound in the cost and risk of transit against his transatlantic competitor, an

advantage equal to £4 on an average ox; of this natural advantage nothing can deprive him, and with this he may rest content." The ordinary cereals of the farm might in many cases be more profitably employed in the feeding of cattle than by the disposing of them in the usual way in the corn market; and it appears to me that a great omission in the Agricultural Holdings Act is the want of a clause to give compensation to farmers in the event of their using their own grown corn for feeding purposes on their farms, and it is the interest of all concerned that this omission should be speedily remedied by the legislature of the country, so that the tenant farmer may with freedom use the cereals grown upon his own farm for feeding purposes, and the production of beef and mutton for the market, and thereby not only benefit himself but also increase the fertility of the farm.

2. *Winter Feeding.*—It is well known to all practical farmers that the better the condition in which cattle are when they are brought into the cattle-courts from the grass, the sooner they take kindly to their new quarters and begin to lay on beef. There are several modes of feeding in use. Some farmers give the cattle a full supply of white turnips as soon as they are put into the courts, and nothing else. The cattle do not improve satisfactorily when they are subjected to this system of feeding, and a much better plan for fattening the cattle and economising the use of the turnips and green crop on the farm, is to give the cattle a very limited allowance of turnips to begin with, when they are newly taken into the courts, along with a supply of cut hay and straw, mixed with a little meal and cake. After the cattle have become accustomed to their new diet and winter quarters, the allowance of turnips can be increased with benefit. The general experience of farmers is, that it is much more profitable to employ fewer turnips and a larger proportion of meal and cake, &c., in feeding, than they used to do. My own mode of feeding is to supply the cattle sparingly with turnips when they are first brought into the courts from the grass, supplementing the

turnips with dry food in the shape of cut hay and straw, meal, and decorticated cotton cake. After they have become accustomed to the change of diet, they each get an allowance of about 84 lbs. of sliced turnips, with 4 lbs. of decorticated cotton cake in a dry state, also a mixture of steamed cut hay, barley, and wheat chaff, meal, treacle, and linseed oil, with a little salt. Of this mixture each animal is allowed as much as it can eat. When the cattle get nearer the butcher, the supply of turnips are increased to 112 lbs. per day. With an allowance of good linseed cake, the steamed food is also made richer in meal, &c. The animals not only eat the mixture greedily, but it soon tells favourably upon their condition ; and I find that by adopting this system I can feed a greater number of cattle profitably, and turn out a larger supply of beef to the consumer than by the old system. It may also be remarked that the manure made from this system of feeding is much more valuable than where turnips form the main food of the animals, and the condition of the farm is thereby improved. Pulping turnips has been found by some farmers to be of advantage, but, as a rule, the expense and the unsuitable accommodation of many farm buildings, with the cost of labour, militates against its general adoption.

With regard to the subject of silage as a feeding material, I have not had sufficient knowledge to speak with authority upon it, for it has only recently been introduced to the country, but from the perusal of Mr. Jenkins' exhaustive report on the subject in the 'Journal of the Royal Agricultural Society' of England for 1884, it appears to me to be likely to form a considerable adjunct to the feeding materials of the farm where turnips and other feeding roots cannot be profitably grown. It will, in my opinion, be more valuable to the dairy farmer and our young wintering cattle than to the stock feeder.

3. *The Accommodation of Farm Buildings.* — Without suitable accommodation, in the shape of improved farm buildings, it is impossible to feed stock profitably. Many

of the proprietors in the border counties have been so liberal as to supply their tenants with the best accommodation for this purpose, by erecting covered yards, and well-sheltered courts and feeding-boxes, which have been constructed on the most improved principles to economize labour and food ; for it is found by experience that comfortable quarters have a most beneficial effect on the feeding of cattle, and the increase of the supply of beef. My experience on this point is, that when suitable and comfortable accommodation for cattle-feeding is provided, there is a saving of labour, and an increase in the production of beef of something like ten per cent. over the old method in open, unsheltered yards. It would be wise of all landlords who have not already turned their attention to this subject of covered yards and comfortable courts to do so without delay, as the tenant-farmer who suffers from a deficiency in feeding accommodation cannot carry on the profitable production of beef, nor give the consumer the utmost quantity which he could produce under more favourable conditions.

4. *Increase of Sheep.*—Having dealt with the subject of beef, I would now wish to make one or two remarks on the subject of the production of mutton. Of late years there has been a most serious falling off in the number of sheep in this country, there being no less than nearly four millions fewer at the present time than there were in 1879. This deficiency has been in a great measure caused by the ravages of fluke and of foot-and-mouth disease, combined with the effects of the recent severe winters in Scotland and the North of England. As much attention as possible should be paid to the breeding and feeding of sheep, in order to increase our supply of mutton. The drainage of our pasture, and the more frequent use of lime and bones on grass lands for sheep, is also a subject which requires every attention. I am convinced that with more attention to the breeding, feeding, and general improvement of our stock on both arable and hill farms, and also by our increasing the quantity and quality of our grass and root

crops, we can produce a much larger supply of mutton for the market than we do at present. Sheep cannot be confined to a limited supply of turnips in the same way as cattle, but a liberal use of our home-grown corn and cotton and linseed cake will enable us to keep many more sheep per acre than we do at present. The use of these feeding materials, in addition to the turnips, is one of the very best systems for improving our pastures and the general fertility of our farms. The more feeding-sheep that can be kept on a farm per acre, the greater will be the profit to the farmer, and the better will the fertility and condition of the land be maintained.

5. *The General Cultivation of the Farm.*—The production of beef and mutton, according to the large or small production of food produced per acre from grass or root-crops, as to the increased quantity to that of increased food that you can grow per acre, and also the more comfortable, warm and clean you can keep the animals, so will be the after turn-out of beef and mutton for the consumer, and considerable profit to the producer. The quality and quantity of an article is just in accordance with what you put into the manufacturer's hands to produce that article; put inferior wool in, you get inferior cloth out; so with the manufacturer of beef and mutton—quality and quantity, according to what you make the land produce. There can be no doubt that the maintaining of our farms in high condition is the very foundation of their meat-producing powers, for unless grass-land is laid down in high condition, and maintained so by the use of cakes and feeding stuffs consumed upon it by cattle and sheep, it very soon becomes deteriorated. The present circumstances of agriculture in this country, and the low price of cereals, with the small prospect of improvement on that price, and the expense now involved in their production, forces me to the conclusion that it will be more profitable to increase the acreage of green crops on farms for the future, and also to lay more land down to permanent pasture. Mr. Faunce de Laune, of Sharsted Court, Kent, deserves the very greatest credit

for the valuable papers which he has published on the subject of the laying down of land to permanent pasture, and he has proved by experience that good perennial pasture can be much sooner produced by the use of perennial grass-seeds without any mixture of rye-grass, than by the old system of laying down with so large a quantity of rye grass-seed. *Every landlord and farmer* interested in the laying down of land to permanent pasture should study Mr. Faunce de Laune's papers, and also, if possible, pay a visit to Sharsted Court, to see the results of Mr. De Laune's practice. I would also direct general attention to the result of the researches of the celebrated Sir John B. Lawes, which are of incalculable value to agriculture. In conclusion, I may add that it appears to me that, unless landlords and tenants bestir themselves to keep our agricultural practice advancing with the times, so as to enable us to meet the competition from abroad and the altered condition of agricultural matters generally, the value of land for farming purposes must continue to fall. The sheet anchor of the British farmer is now the increased production of beef, mutton, and dairy produce, and with energy combined with skill, the co-operation of the landlords, and the rent of land so adjusted as to give the tenant farmer interest for labour and capital invested, I am confident that he will yet be able to hold his own against the foreign producer.

DISCUSSION.

Mr. THOMAS BELL said, to him the most striking fact brought out by the paper was, that whilst our population had been rapidly increasing, the home supplies of meat had been steadily decreasing ; and the question to which attention ought to be turned most especially, was how to remedy this evil. Many causes had been referred to, the importation of foreign diseases being one of the principal ; but another, to which sufficient importance had not been attracted, was the effect of the seasons of extreme wet and drought. The wet seasons had had the effect of developing the fluke disease amongst the flocks, and the result had been that millions of sheep had been destroyed; on the other hand, the effect of drought was, though not directly to kill the sheep, to cause a very large number of them to be prematurely slaughtered; and, consequently, the prospect of a future home supply was materially diminished. He had some hopes that the system of ensilage would assist in tiding over these seasons of extremity. He had been much surprised to hear Lord Egerton question the statement made by Mr. Duckham, that the want of security for farmers' capital invested in the soil had limited the produce considerably. Surely when the Legislature were convinced that an Act of Parliament was necessary to give increased security to the tenant for the very purpose of increasing the produce—and there could be no other reason why Parliament should intervene—that was a sufficient proof of the accuracy of Mr. Duckham's statement. Again, Mr. Duckham had also referred to ground game and the law of distress, and what he had said in regard to them was also proved in the same way, for Parliament had recently passed laws for the very purpose of modifying those evils. He had also been surprised to hear Mr. Harris say that rents, instead of being too high, were too low. He was the more surprised to hear him say that, immediately after he had told them that the result of steam and cool chambers had brought the produce of the most distant countries to England at almost their cost price. Surely, if the produce of the soil of those countries were to be equalised, the value of the soil that produced those products must, to a certain extent, be equalised also. The law of supply and demand would regulate the price of land, as it did that of all other countries. He had also some hopes that we should soon be rid of foot-and-mouth disease, and there would assuredly follow an increase in our home-bred animals, with a better supply of meat to the consumer, possibly at a lower, but certainly a more regular price, which would bring greater profit to the producer.

Mr. MALLOWS, referring to the observation of Mr. Duckham, that the British agriculturist showed want of energy, said that he might be cast down, and might be hard pressed, but he thought the British farmer was an Englishman still, and would not lack in anything. Mr. Duckham had lamented over a loss of 5 or 6 million sheep to the country, and he quite agreed with him on the point. He knew what the fluke was, and what the foot-and-mouth disease was, which had taken off hundreds; but there was another disease in the country from which he came—West Suffolk—which was still worse, and that was the low prices. Many had been obliged to sell half their sheep to pay their way, so that in fact now the keeping of sheep was a luxury, which only a few men in that county could afford, owing to the price of corn being so low, that he was a lucky man who could pay his expenses. Rather than sink, they would sell off their sheep and cattle, and they had not money to buy them back again.

Mr. MITCHELL HENRY, M.P., could not help congratulating his friend and former colleague, Mr. Clay, on the extremely practical and encouraging Paper he had read. All agriculturists, whether in Ireland, England, or Scotland, had suffered greatly from imported cattle disease; Ireland, however, as they knew, had been spared the infliction of the cattle plague, or its condition would have been far worse than it was. He thought great encouragement might be drawn from this circumstance, that great improvement in the hygienic conditions of human beings, owing to greater knowledge, had greatly increased longevity, and where epidemics arose they were much better dealt with than in former times. He thought agriculturists might follow the same lines. He was not anxious they should believe that it would ever be possible to entirely stamp out epidemic disease amongst cattle; by better regulations they would no doubt be reduced to a minimum, but they could never hope to be entirely free from diseases. At the same time they could do a great deal towards strengthening the animals which were subjected to them. Every one's observations showed that if you had healthy parents, and took good care of the young, seeing that they were well sheltered and well fed, and protected from the influences of cold, and, what they were better able to withstand, the attacks of disease. It was a marvel to him how many cattle, especially in Ireland, lived at all. In many parts they were driven out into the open from their earliest days, and there they remained without hardly anything to eat, and there they were sold in the fairs, and brought either into the feeding grounds of the middle parts of Ireland, or to this country, where, for the first time, they tasted really nourishing food. His farming was almost entirely on land reclaimed from the waste, and as the result of twenty years' work, he could say that he could rear cattle, not finish cattle, as profitably and as healthy as were to be found in any part of England, Ireland or Scotland, simply by adhering to the common-sense principles which had been laid down so ably by Mr. Clay. It was necessary to learn this lesson, because now that the Bill for putting further restrictions on the importation of disease, which he had always supported, was passed, they ought to turn their attention to other matters. These diseases might be stamped out, but they would never be got rid of unless cattle were fed and housed differently to what they had been. Mr. Clay's paper, was, therefore, an encouraging antidote to some of the rather alarming though very useful statistics of Mr. Duckham. They had lost millions of sheep and vast quantities of cattle, but happily they were beginning to recover them, and if they only learnt a lesson from what had passed, and took better care of the young and sheltered the elder ones, and paid more attention to the breeding of cattle, all their difficulties might yet be surmounted.

Mr. SHOOLBRIDGE (Member of the Legislative Assembly of Tasmania) said he came there as a perfect stranger, having only just come from Tasmania. His father, who was a farmer in Kent, left England in 1821, and he had been in Tasmania ever since. It was one of the finest climates in the world, and formed part of the British dominions; it was eminently calculated to support a vast population, and afford a supply of food to an over-populated country, such as England appeared to be. The suggestion he would offer was that the sons of practical farmers in England should go there and occupy lands which were becoming now comparatively useless for the want of labour. The means of bringing the meat raised there to this country were now such that it could be brought at a very nominal price. He spoke from experience, his whole life having been devoted to agricultural pursuits, though recently he had been growing principally hops and fruit. When he came away he left over 800 people picking hops on his land, and he had adopted for years past the plan Mr. Clay had recommended, of supplying his work people with a cow; there were over 100 cottages occupied by his people, every large family had a cow, they had their gardens and their pigs, and he considered the calves he got in return an ample recompense. The returns from agricultural pursuits were more certain in Tasmania than any other part of the world. He had just spent six weeks in America, and it appeared to him that it did not compare for one moment with Tasmania as a home for English people. Every one who went to that colony still remained a British subject, a friend, and a brother of those he left behind; and there was no place in the world where he could get so comfortable a home, or find such good land, which could be purchased from the Government at a low price, with a long period for payments. Some time ago Sir Henry Lefroy, the late Governor, wrote to him a letter by the hand of a practical farmer who wished to settle there. He had employed him, and he was gaining colonial experience, and learning how to cultivate the land. He had already purchased a piece of Government land, and was about to employ other men to go and clear it for him, and make it ready for his future home. He could bring forward hundreds of similar cases. Tasmania was especially adapted for rearing stud-stock for the neighbouring colonies, and it was no exaggeration to say that they got from 50*l.* to 500*l.*, or even 1000*l.* for a stud sheep. He believed that would continue to perpetuity, inasmuch as the other colonies were much hotter, and had neither the climate nor food so well adapted for rearing good stock. They were now introducing blood-stock into New South Wales, Queensland, and Victoria. It was thought some years ago that that land would not do for sheep, but Sir Roderick Murchison settled that, for he showed that it was at a higher latitude than other land of a similar climate, and the wool did not deteriorate into hair; it did deteriorate to a certain extent, and for that reason those other colonies constantly required stud stock from Tasmania to keep up the quality.

THE MEANS OF SECURING THE SUPPLY OF MEAT TO LARGELY POPULATED CENTRES.

By S. B. L. DRUCE, Barrister,
Secretary of the Farmers' Club, London.

THE last paper which it has been decided should be submitted to this Conference is by no means the least important; for however much the British and Irish farmer may increase the number of his live stock, and however great may be the production of live stock in foreign countries, it is, comparatively speaking, of little interest to the mass of the population of the country, unless the means exist by which that Home and Foreign Stock can be brought to the consumer in good condition and at a reasonable cost. And this problem is every day assuming greater proportions, because of the vast rate at which the population of the large towns of this country is increasing. Above all places, this is true of London, for there the population has of late years increased, and is still increasing at such an enormous rate that there are now about 4,000,000 persons in it, the population of a country rather than of town. And this vast population, or at all events the greater part of it, requires to be supplied with meat, and that meat must be fresh and good. It is indeed wonderful, when one thinks of the requirements of London, that it is supplied with meat as well and as economically as it is.

I propose in this paper—the preparation of which I regret should not have fallen into the hands of some one more capable of exhaustively dealing with the subject than I am—in the first place, to put before you as minutely as I can the modes by which London and our large towns are now supplied with meat, and in the second place to consider whether those modes of supply may be improved, and if so, how. My observations will refer to London more than to our large provincial towns, for it is the supply of London that has especial interest, not only to us who live in the Metropolis, and are consumers of the meat that is supplied to it, but also to very many of our farmers who send up the meat they manufacture for sale in its vast markets. Nor, indeed, have I been able to lay my hands on any official statistics, if there are any, of the quantities of meat that are consumed in the large provincial centres of population, such as Liverpool, Manchester, Birmingham, Leeds, &c.

Our sources of supply are two—Home and Foreign—and each of these sources comprises two distinct classes: (1) Live animals and (2) Dead meat. I propose in the first place to consider our Home supplies, which, as has been so clearly pointed out by my friends, Major Craigie and Mr. Duckham, in the papers they have read before you this morning, are so vastly in excess of, and therefore of so much more importance than our Foreign supplies; and first, of the live animals which our British farmers send to our Metropolitan markets. In order to understand and realise this part of the subject, let us trace the history of a single bullock from its birth on a breeding farm until it, or rather a part of it, reaches the actual consumer. Our calf, we will suppose, is born in one of our breeding counties in the West of England—let it be a Devon from Devonshire, a Shorthorn from Gloucestershire, or a Hereford from Herefordshire. The farmer who breeds it keeps it till it is some eighteen months or two years old, during which time, after it has been weaned, it has eaten but little more than the natural food of the district of its birth. At two or two and a half years old it is bought by a dealer, and forms one of a drove, which is sold, perhaps after it has passed through more than one intermediate purchaser, to, let us say, a Leicestershire or Northamptonshire grazier, who lets it run on the rich pastures of those favoured counties, and when it has become fat and ripe for the butcher, from feeding on the luxuriant herbage those pastures produce, assisted perhaps with artificial food, the bullock is sent to the Islington Market consigned to the London cattle salesman; or instead of passing its summer in happy contentment on the Midland pastures, our bullock is taken in the autumn of the year to Norwich Hill, and there sold to a Norfolk farmer. In this case the animal, after having been comfortably housed in a Norfolk farmyard, with its good deep sheds to shelter the stock from the cold winter winds, but with an open space in which, when the sun shines, the stock may luxuriate in the warmth; and after having been well fed with the best of hay—may I say "Ensilage"—roots and artificial foods, finds its way, as in the former case, to the Islington Market and the London cattle salesman. In either case it is brought up by train to the Islington Market, and the cattle salesman sells it in that market to the wholesale meat salesman. The cattle salesman charges the Leicestershire or Norfolk farmer a commission on the sale, and, deducting that from the price he receives, pays the farmer the balance. So far, then, five, if not six persons have made, or expect to have made, profits on our bullock since its birth—first, the breeder; second, the drover; third, the grazier, summer or winter as the case may be; fourth, the railway company, or companies, who have carried him perhaps to the grazier, and certainly from the grazier to the cattle salesman; and lastly, the cattle salesman himself. But the bullock has yet by no means reached the consumer. The cattle salesman sells him to the wholesale meat salesman, who perhaps sells him direct to the family butcher, who himself slaughters the bullock, and sells his carcase by retail to the actual consumer; or, as is far oftener the case, the wholesale meat salesman slaughters the bullock and sells the carcase to the retail butchers in the Smithfield Dead-meat Market—the best parts of it, the "prime," as it is called, to one class of such retailers, the inferior parts to others. For every part of the carcase—the prime, the inferior, and the offal—finds ready purchasers in London, and no part is wasted. The retail butchers at last, whose carts we may see in the early morning being driven from Smithfield to their shops in the various parts of the Metropolis, cut up the carcases or half-carcases which they have bought in that market, and sell them in joints—"ribs," "sirloins," "silversides," "aitch-bones," "pieces for gravy," &c., &c.—to the actual consumers. Here we have two more profits, those of the wholesale meat salesman and the retail butcher, to add to the five or six before enumerated. Thus, altogether at least six, and more commonly eight, profits have to be made off our bullock before the unfortunate consumer, out of whose pockets, be it remembered, all these profits come, is able to place his joint of beef on his table.

Leaving for the present the consideration whether it is necessary or expedient that all these stages, and consequent profits, between the producer and the consumer should exist, I pass on to consider the number of live animals that our own country sends to us in London. These numbers are given annually in the agricultural returns, and for the following years were as follows :—

Year.	Cattle.	Sheep.
1864	218,894	1,196,411
1874	186,992	999,185
1881	165,920	628,030
1882	156,665	514,490
1883	124,730	465,450

I omit the pigs because they are, comparatively speaking, but few in number. The number of cattle and sheep sent alive to the London Market shows, it will be noticed, a decided diminution during the last few years. Two causes account for this—(*a*) the diminished number in the country, and (*b*) the increase in the home dead meat trade.

Secondly :— How is the home dead meat brought to London, and in what quantities is it brought? The dead meat from our own country is brought to London mainly, but not entirely, by the railways, for two shipping companies bring some dead meat from Scotland. Of the railways, the London and North-Western and the Great Northern bring by far the greater portion. These two companies, indeed, pay about half the total amount of the tolls which the various railway companies having termini in London pay to the City Corporation for the dead meat which they convey into the Central Meat Market for sale. A part, perhaps, of the quantity which the former of these companies brings to London may be American, which has been taken from shipboard at Liverpool, but this is only a small part, and by far the largest part, indeed almost all, is brought from Scotland and the various parts of England served by the two companies I have named. This meat is brought in vans specially constructed for the purpose, and is delivered, as a general rule, in good, sound, and healthy condition. From the reports of the Central Markets Committee of the Corporation of London, we find that the supply of country killed meat was 101,643 tons in 1882, and 106,391 tons in 1883; and that in each of those years it constituted very nearly one-half of the whole quantity of dead meat supplied to the Metropolis through those markets, which was in 1882, 211,461 tons; and in 1883, 223,085 tons. The increase in the supply of the home dead meat brought to London is very apparent from the statistics of the tolls which the railway and shipping companies pay to the Corporation for such supply. The authorized toll is one farthing for every 21 lbs. of weight, and this, on the home dead meat, produced in 1869 (the first year when the Central Market was opened)

	£7,172	from the	Railway	Companies
	221	"	Shipping	"
In 1874	£9,619	"	Railway	"
	113	"	Shipping	"
In 1882	£10,763	"	Railway	"
	402	"	Shipping	"
In 1883	£11,321	"	Railway	"
	410	"	Shipping	"

or an increase per cent. on the first year of 31 in 1874, and 51 in 1882, and 58 in 1883.

II. The Foreign Supply.

I divide this into two divisions, just as I divided the Home Supply, that is to say—

(*a*) The Live Animals.

(*b*) The Dead Meat.

As you are aware, all the foreign live animals, whether intended for the supply of London or other part of the Kingdom, must by law be landed at special Foreign Animals wharves or markets. In the case of London, this special market is that at Deptford, though it does not follow that all the animals that are landed at that market are consumed in the Metropolis; some of them supply other parts of the country; but still, the majority of the foreign animals that are landed at Deptford undoubtedly are consumed in London.

Deptford Market belongs to the Corporation of London, by whom it was established in the year 1872, for the purpose of carrying out the provisions relating to foreign animals contained in the Contagious Diseases (Animals) Act, 1869, which Act was passed because of the outcry which was raised in the country against the unnecessary risk to which our home stock was subjected when it was brought into contact in the same market with foreign stock. Deptford Market is well and suitably built, and, like every official institution of the City of London, is well maintained, well kept up, and well conducted. The area of the Market covers some thirty acres. On one side it abuts on the Thames, on its other three sides it is completely walled in. On its river side are piers and wharves. It comprises lairs and abattoirs, as well as ordinary sheds. It has its offices and houses for some of its officials within it, and, one may say, is complete in itself. Its ventilation is good, its drainage admirable, and its water supply excellent—hot and cold water being laid on in abundance, with convenient taps for its use.

As in considering our home supply of live animals we have taken the case of the bullock being brought to the Islington Market, so in considering the foreign supply of live animals let us suppose a vessel to arrive at one of the piers of the Deptford Market. In the first place, no persons except the officers of the Market are allowed on either the landing stage or the vessel itself, and the men who are so allowed are dressed in waterproof leggings and smocks, which are always disinfected after use. Before a single animal is permitted to be landed from a cargo, the whole cargo is inspected beast by beast by the Veterinary Inspector or his deputy. If the cargo is healthy, the animals are at once driven into the lairs in the Market; but if any animals are found in it suffering from foot-and-mouth disease, those animals are taken directly into special disinfected slaughter-rooms (not the ordinary abattoirs), and there slaughtered. The flesh of animals suffering from foot-and-mouth disease is sold for food, but the hides and offal of such animals are wholly and effectually destroyed by being boiled down in huge steam tanks with the most powerful disinfectants known to chemistry. And the carcases of animals suffering from more serious diseases are treated in the same way—that is to say, they are boiled down, and so wholly destroyed. "Suspects," that is, animals not actually diseased, but which, from contagion with diseased animals, or otherwise, may become diseased, are placed in separate lairs, and carefully watched till they are killed. All beasts are slaughtered, as a rule, within ten days of being landed. A fortnight, it is said, is an exceptionally long time for a beast to be kept in the Market. The hides, horns, fleeces, and offal of all animals, no matter how healthy the animals may have been, and also all manure and spoiled litter, are carefully disinfected with carbolic acid and lime before they are taken away from the Market; and the latter are shot into lighters at one special pier, and each load is sprinkled with quicklime.

The Market is large enough to accommodate some 4000 bullocks, besides sheep and pigs, at one time. The actual number of foreign cattle and sheep that have been landed at it in the following years is as follows :—

Year.	Cattle.	Sheep.
1872 (1st year)	38,426	122,601
1882 . . .	128,676	783,449
1883 . . .	126,510	734,911

(*b*) The *Foreign Dead Meat* supply.

In the preparation of this part of my paper I have been very materially assisted by information which has been supplied to me by one of the best authorities (Mr. H.

Moncrieff Paul, F.S.S.) in reference to the trade in Australian and New Zealand frozen meat, who on this particular question says:

For some years attempts, more or less futile, were made to solve the problem of bringing from the Australasian shores to the markets of this country, fresh meat in carcase, in a thoroughly marketable condition. With the arrival of the steamer *Strathleven* from Australia, upwards of three years ago, it may be said that the trade in Colonial frozen meat was successfully inaugurated. Its development during the past three years, although gradual, has been sure, so much so that it may be safely predicted that the importations from the Australasian Colonies during the year 1884 will be more than twice the aggregate of supplies received thence during the three preceding years. Coincident with this increase of supplies, there has been an improvement in the condition in which they have reached the market. In the earlier stages of the industry, sufficient care and attention were not paid to the selection of sheep most suitable for slaughter; to the butchering and preparation of the carcases for refrigeration; to the safe transit and stowage on board the carrying vessel, and to the due maintenance of the requisite temperature during the passage to this country. Gradually these various links in the chain have been successfully welded, and recent statistics show that the percentage of arrivals of shipments not in good condition is quite nominal.

The foregoing remarks apply almost exclusively to shipments of frozen mutton and lamb. Those of beef have been received in such small quantity and at such irregular intervals as to preclude any reliable conclusions being derived as to the prospects of the Australasian dead beef trade. The reasons for this may briefly be stated to be: (*a*) irregularity in supply and consequent unsatisfactory outturn, and (*b*) the competition which those engaged in the casual ventures made had to face from supplies directed hither from European and American sources of production under more favourable transit conditions. While there is no doubt but that in time frozen beef will become a regular import, not only from Australia, but from New Zealand, in the immediate future the supplies of frozen meat from these colonies will consist almost entirely of mutton and lamb. While during the years 1880 and 1881 shipments of frozen mutton were received from Australia, it was not until the year 1882 that the Colony of New Zealand appeared as an exporter. The two shipping ports in Australia were, and still are, Sydney and Melbourne, and it is significant to observe that whereas the mutton from the former consists almost wholly of merino, that from the latter is cross-bred, and therefore better adapted to the requirements of British consumers. After the commencement of operations in the South Island of New Zealand, these were gradually extended to the Northern Island. In consequence of the various points of supply, a variety in the character, quality, and size of the carcases shipped has not unnaturally ensued. In consequence, too, of these divergencies, considerable fluctuation in values, even at any one time, has been manifested to such an extent, that in the Smithfield Meat Market, on the same day, a difference of *2d.* per pound has been found to exist between the highest and lowest price obtained for New Zealand frozen mutton imported by the same vessel. As an outcome of this result, considerable discussion has been provoked, both in the English and Colonial press, as to the most profitable style of sheep to be reared in the Colonies for the production of carcase-mutton to be shipped in a frozen condition to the mother country. The general consensus of opinion points to the conclusion that a cross between a Hampshire Down ram and a merino or cross-bred ewe will best meet the required end *quâ carcase*, although the fleeces may not be so remunerative to the sheep-farmer as those shorn from animals bred under other conditions. In regarding the prospective development of this industry, the ability to produce the most suitable kind ofcarcase for the markets of the mother country is an all-important question. Viewed superficially, it may be argued that, because within the Australasian Colonies there are in round numbers about 77,000,000 (millions) of sheep, the annual increase, after making due allowance for deaths and other contingencies, and ample provision for the wants of a population, all told, of some 3,000,000, should be sufficient to warrant the export of a large number of carcases each year, a number far in excess of the probable receipts either during the present or succeeding year. A closer examination of the subject, however, reveals the fact that the area of country within which it will be profitable to produce the class of sheep required for refrigerating purposes is comparatively limited, and that if the export is to be tangibly or largely increased, it must be so by the shipment of carcases not exactly suited to the existing requirements of British markets. If it be asked why the merino type of sheep so largely produced in the Australasian Colonies, and the various grades of cross-bred reared in Victoria and New Zealand, should not be prepared in greater numbers for shipment hither, the answer can readily be given that neither are profitable carcases for the British consumer, the former because it is more affected by the process of refrigeration than the frame of the larger sheep, and the latter because the meat is too gross and yields an undue proportion of fat. It is possible that the existing drawback to the more extended consumption of merino mutton may in time be overcome, but this can only be done by its successful introduction amongst those classes of the population who now consume Welsh and other kindred varieties of small mutton.

In addition to the supplies of Australasian frozen mutton, shipments have also been received at irregular intervals from the River Plate. These have consisted in great part of carcases of merino type, in many instances much too small for the purpose. They have realised correspondingly lower values. With the large number of sheep produced in South America, it is not unlikely that more extensive and more regular supplies will gradually be received from the River Plate; and even although these are not quite adapted to our wants, the conditions of production there are such that, favoured by lower transit charges, River Plate mutton can be sold here profitably to the producer at 4½*d.* per lb. wholesale, while for Australasian shipments it is necessary that 6*d.* per lb. should be secured. The impetus which the development of this industry will give to prices of stock at the various centres of production being considerable, the tendency will be in the direction of enhanced cost; and for purposes of prospective calculation it may therefore be assumed that a selling price on average here of 6½*d.* per lb. will be requisite to attract increased supplies from the Australasian colonies. There is still much to be done in disseminating this meat throughout the provinces. While ample refrigerating chambers for the storage of shipments on arrival have been provided by the leading Dock Companies in London, no such appliances are to any extent to be found at provincial centres. Nor has the trade yet assumed sufficient proportions to induce the various Railway Companies to provide specially constructed refrigerated vans or wagons for the transit of the meat from the London Dock Companies to provincial markets. The transit is at present effected by means of ordinary meat vans attached, in the case of one or two railway systems, to passenger trains. While this secures rapidity in transit, it is attended with considerable expense.

The following statistics of the quantity, condition and price of Australian and New Zealand frozen mutton and beef are especially interesting just at the present time:—

AUSTRALIA.

	Consignments.		Number of Shipments.	Condition on Arrival.		
	Carcases. Mutton.	Qrs. Beef.		Good to Perfect.	Irregular to Fair.	Unsatisfactory.
1880 . .	400	a quantity	1	. .	1	. .
1881 . .	17,275	1,373	6	2	2	2
1882 . .	57,256	1,033	13	5	4	4
1883 . .	63,733	753	16	11	3	2
	138,664	3,159	36	18	10	8
1884 to 31st May	51,110	. .	12	8	2	2
	189,774	3,159	48	26	12	10

New Zealand.

1882 . .	8,839	..	2	2	..	..
1883 . .	120,893	728	15	10	4	1
	129,732	728	17	12	4	1
1884 to 31st May	120,581	40	13	8	5	..
	250,313	768	30	20	9	1
Total to 31st Dec. 1883	268,396	3,887	53	30	14	9
Total to 31st May, 1884	440,087	3,927	78	46	21	11

Note.—*Marsala* (s.) at Port Chalmers (sailed October, 1882), jettisoned at Java 8,506 carcases mutton.

The following indicates the range of prices for sound Australian and New Zealand frozen mutton and beef respectively during the past year (1883), and to 31st of May last :—

	Mutton.		Beef.	
	Highest reported.	Lowest reported.	Highest reported.	Lowest reported.
Australian . . .	Sheep 7½*d.* per lb. Lambs 9*d.* ,,	4½*d.* per lb. 8½*d.* ,,	5½*d.* p. lb.	3½*d.* p. lb.
New Zealand . .	Sheep 8*d.* ,, Lambs 9*d.* ,,	4¾*d.* ,, 8*d.* ,,	6*d.* ,,	3½*d.* ,,

1st January to 31st May, 1884.

Australian . .	Sheep 6¾*d.* per lb. Lambs 7½*d.* ,,	3½*d.* per lb. 6*d.* ,,	—	—
New Zealand .	Sheep 7*d.* ,, Lambs 9*d.* ,,	4*d.* ,, 6*d.* ,,	6½*d.* p. lb.	4*d.* p. lb.

On the 9th of June, 1884, quotations were as follow :—

	s. d.		s. d.	
Prime English Mutton . .	4 6	to	5 6	per stone of 8 lbs.
Do. Scotch do. . .	5 0	,,	6 2	,,
Do. Town-killed Foreign Mutton	4 2	,,	5 0	,,

	s. d.		s. d.	
Prime English and Town-killed Foreign Beef	4 8	to	5 0	per stone of 8 lbs.
Do. Scotch Beef	4 8	,,	5 4	,,
Do. New Zealand Mutton	3 8	,,	3 10	,,
Do. do. Lamb	5 0	,,	6 0	,,
Do. Melbourne Mutton	3 2	,,	3 6	,,
Do. Sydney do.	3 2	,,	3 4	,,
Do. River Plate do.	——	,,	——	,,

But Australia, New Zealand and South America are not the only foreign countries which send us dead meat. Russia, Germany, Canada, and the United States, send us beef: Holland and the United States, mutton: and Germany, Holland and Belgium, pork in large quantities. This appears from the following Table in which the imports of dead meat into this country for the first four months of last year (1883) are compared with the imports for the corresponding period of the present year 1884:—

Imports of Fresh Meat for Four Months to 30th April.

Imported From	Beef.		Mutton.		Pork.	
	1883.	1884.	1883.	1884.	1883.	1884.
	cwts.	cwts.	cwts.	cwts.	cwts.	cwts.
Russia, North	1,526	14,588	430	2	..	6
Sweden	136	53	..	..	4	15
Norway	4	18	..	..	..	..
Denmark	131	120	5	1	440	4,032
Germany	13,685	5,392	241	61	1,237	6,459
Holland	184	30	29,021	49,869	11,404	6,728
Belgium	..	..	2	162	8,896	10,585
Channel Islands	393	42	..	..	4	44
France	38	170	93	..	1,672	1,144
Portugal	95	250	..	..	..	..
Spain	..	17	..	..	..	2
Italy	..	..	..	..	10	1
Austria	..	..	7	..	5	11
Victoria	..	..	6,414	10,307	..	..
New South Wales	587	..	5,752	13,681	..	..
New Zealand	30	136	9,016	49,742	14	..
Canada	..	15	20	3	1	..
United States, Atlantic	269,824	278,262	22,383	13,912	..	100
United States, Pacific	..	..	..	..	2	..
British West Indies	..	..	..	..	2	1
British Guiana	..	..	..	..	..	5
Uruguay	12	..	..	8,415	..	..
Argentine Republic	..	..	..	3,369	..	..
	286,645	299,093	73,396	149,524	23,693	29,134

Our foreign supply of meat seems to be improving, because, contrary to what was anticipated by some public speakers during the recent discussions in Parliament and elsewhere, on the alteration in the laws with reference to the prevention of the importation of animals from countries affected with foot-and-mouth disease, the supply of dead meat is increasing, and appears to be taking the place of the importation of live animals. The Customs Returns for the past month (May) show this increase very clearly, for whereas the United States on the Atlantic Seaboard sent us 62,786 cwts. of beef, and 2458 cwts. of mutton in May 1883, they sent 99,620 cwts. of beef, and 83,815 cwts. of mutton in May 1884; and whereas New Zealand sent us 3662 cwts. of mutton in May 1883, that country sent us 15,242 cwts. of mutton in May 1884; and Victoria and New South Wales, which sent us no mutton in May 1883, sent us 3200 cwts. in May 1884.

And from the same returns we find that the following quantities of foreign dead meat were imported at the following ports in Great Britain in the two corresponding months of May 1883 and 1884.

	Beef.		Mutton.	
	1883.	1884.	1883.	1884.
	cwts.	cwts.	cwts.	cwts.
London	10,729	25,766	3,958	19,079
Liverpool	44,507	57,752	1,847	2,207
Glasgow	11,259	21,035	325	1,003
Total quantities imported at the above and other ports	66,544	104,639	7,212	26,344

This is only a repetition of what has happened elsewhere. The dead-meat trade of Paris, I am told, grows in a similar proportion; and so in America, where the dead-meat trade from the Western States to the cities in the Eastern States has quite cut out the trade in live animals from those

Western States. That this trade will go on increasing seems fairly certain, and as its tendency is to lower the price of meat to the consumer, we as consumers must rejoice at it, although it may perhaps render the English farmer's position even more difficult than it has been. But let him remember that there is no stock in the world like our Home stock, and that as the foreigner and colonist find a market for their meat in England, so it is to England that they will look to supply them with sires and dams to produce that meat.

To sum up, we may, I think, conclude that the best means of securing an adequate supply of meat to largely populated centres is by the system of dead meat, and that that system is by far preferable to the system of bringing in live animals and slaughtering them in the localities in which they are consumed. Amongst other reasons which appear to tell in favour of the dead-meat system are the following:—(*a*) It is cheaper; (*b*) As regards the population, it is more healthy; (*c*) It prevents the risk of spreading disease amongst the live stock; (*d*) It causes no suffering to the animals in transit. The sufferings which animals, and especially fat animals, endured in transit in former times were very severe; and although their sufferings are far less now because of the greater care that is bestowed upon them in consequence, partly perhaps of the requirements of recent legislation, and partly perhaps of the more considerate treatment with which all animals are treated nowadays, yet even now they suffer. Take for example the animals that had to be destroyed, or that were injured in the Transatlantic passage between North America (including Canada) and this country in the two years 1882 and 1883:—

In 1882, there were	3,130	Cattle and Sheep	lost	or	injured.
In 1883 „	10,286	„	„		„

The dead meat, again, cannot bring contagious or infectious diseases to healthy animals in the country into which it is imported, but, as the English farmer knows from past sad experience, diseased live animals as they travel from one part of the country to another, or as they come in from foreign countries to our own country, spread disease amongst healthy animals with which they may be brought into contact.

And the dead-meat system is more healthy as regards the population. When the meat is slaughtered in country districts, the inconveniences and nuisances caused by the disagreeable sights and smells of the slaughter-house, which must *ex necessitate rei* exist—however stringent the regulations respecting the slaughter-house may be—affect only a small number of people, and the illnesses which may arise to human beings when they are congregated in large numbers round the slaughter-houses are avoided.

But above all the dead-meat system of supply is cheaper than the supply by means of live animals. This is true of both home and foreign supplies, but especially of the latter. The cost of these is not restricted to freight alone, but to that cost must be added the charges and expenses incidental to bringing to port, shipping, landing, and preparation for and transport to market; and I am told, and can readily believe, that the rate of insurance is much higher for live animals than for dead meat. Then, again, in both cases, the home and the foreign, the live animals require food during their journey to market, and food means expense; but the dead meat does not. The live animals, too, lose in weight very severely during their journey. I cannot say how much exactly, but it is estimated that our home fat bullock loses 16 lbs., a calf 8 lbs., a sheep 2 or 3 lbs., and a pig 6 lbs. in their respective transits from the farm to the metropolitan slaughter-house; and it is a well-known fact that in the case of animals sent to the Smithfield Cattle Show, the decrease in the weight from the time when they leave the farm to their entrance into the Agricultural Hall is very considerable. Further, the dead-meat supply system does away with some at least of the middlemen to whom I referred in the earlier part of my paper; and so to this extent again cheapens the supply to the consumer.

But even in regard to dead meat, I cannot help thinking that we in London pay far too high a price for our meat. The farmer certainly does not get a high price for what he sells, but we consumers have to pay a high price for what we purchase. Let me put the following figures before you, which are not altogether imaginary. A farmer kills some 10 stone sheep, which he sends as dead meat to the Metropolitan Market. The meat salesman pays him (let us say) 5*s*. 6*d*. per stone for them—a good price:—

10 stone at 5*s*. 6*d*. a stone . . . =	55*s*. per each sheep.
But we have to deduct salesman's commission, 1*s*. a sheep.	
Carriage by rail, 1*s*. a sheep.	
Which reduces the price to . . .	53*s*. „
And the salesman also deducts (say) 2 lbs. off the weight, which, at 8*d*. per lb. (say) further reduces the actual sum received by the farmer to	51*s*. 8*d*. „

This is the utmost the farmer receives.

Now what does the butcher receive? The present prices for mutton are—

Chops	1*s*. or 1*s*. 1*d*. per lb.
Loins and Legs	11*d*. per lb.
Shoulder	10*d*. „
Neck	9*d*. „
Breast	7d. „

call it 10*d*. a lb. all round.

The sheep *ex hypothesi* weighs 10 stone or 80 lbs., and as we are dealing with dead meat and not the live animal, what is known as the fifth quarter does not come into our calculations. So we have—

80 lbs at 10*d*. a lb. =	66*s*. 8*d*.	Butcher's price.
But	51*s*. 8*d*.	Farmer's price.
Leaving to the Butcher	15*s*.	per sheep.

Out of this, not a very poor amount, the butcher has to pay his rent, rates, taxes, interest on capital, time, bad debts, &c.; but allowing for all these, one would imagine that the amount leaves a good margin for profit. Of course the profit may, as I have before pointed out, have to be divided between the meat salesman, who pays the farmer, and the butcher who supplies the consumer, or the wholesale butcher may step in for his share before the retail butcher. But, however divided, or subdivided, or not divided at all the profit may be, the unfortunate consumer has to pay it.

Finally, I would ask, Is it either necessary or expedient that there should be this great difference between what the producer receives and the consumer pays? Is not this state of things artificial? Cannot some at least of the middlemen be dispensed with? Is it not possible to establish stores or depôts for meat, to which the farmers could send the meat, not the live animals, and from which the consumers might be supplied direct. These questions, I know, are not easily answered. Some such stores have been tried and have failed; and I am aware that it is said that if you do away with slaughtering in London altogether, you deprive a very large class of the consumers of the more inferior parts of the animals, which are the only parts that class can afford to purchase. But I would ask in reply, is it absolutely necessary that this should be so? Is it not possible, with improved methods for transit and storage, to send these parts to London, and so continue their supply to the class which requires them? Surely if they are so necessary, they can be brought in some better and more convenient form than as part of the live animal! I can but express the hope that the result of this conference will be to improve the meat supply of London, and that, while no class may be deprived of its meat supply, and while the farmer's receipts may be no less, the general mass of consumers may have their meat supplied to them at a cheaper rate than it is now. And if that should be the result, this conference, I feel, will not have been held in vain.

DISCUSSION.

The CHAIRMAN (Col. Kingscote) said he should be obliged to leave, but could not do so without saying a word or two on this important subject. He agreed cordially with what Mr. Druce had said, and he trusted this conference might tend very much to mutual confidence between the producer of meat and the consumer. The supply of meat was as important to one as to the other. During the controversy on the passing of the Cattle Diseases Bill he had felt himself that all he really wished for was protection from disease; it was not a question of producer against consumer, it was a question which affected both, for keeping disease out of the country would make meat cheaper to the consumer. That was the spirit in which he took the matter up individually, and in which he believed most agriculturists did, and anything which would tend to cheapen the supply of meat would, in his opinion, also put money into the pockets of the consumers. If they could now act on the views which had been put forward so clearly to-day and devise ways and means of rearing calves, sheep and young animals of all sorts more carefully and cut down the various steps between the producer and consumer, so that there should not be so much made by the middleman, and at the same time disease could be kept out of the country, it would be an immense benefit for all concerned.

Mr. MITCHELL HENRY, M.P., then took the Chair.

Mr. T. B. WOODWARD said some excellent advice had been given them by various speakers, though it was not all unanimous. One gentleman came from Tasmania and recommended them all to go there, whilst the noble Lord recommended them to stop at home and put up paper sheds; again Major Craigie and Mr. Duckham had dealt with the statistical side of the question; and although he had the highest respect for statistics, he was afraid it was not really the side of the question which would help much in the present state of affairs. In December last, at the Farmers' Club, Mr. Geo. Street, a practical farmer, introduced a very interesting question on this subject, and the views he put forward were that the principal cause of the decline of the gross production of meat in this country was the decrease in the area of arable land. That opinion in the course of discussion was controverted by another practical farmer from the other side of England; but from his own experience he was entirely disposed to support Mr. Street's view. Putting aside entirely the question of profit and loss, because they were not called upon to decide whether it paid to plough up land, the one important question before them was the cause, or one of the causes which had checked the development of our home production of meat. He believed any practical farmer, if he were asked whether he could on a certain area of land produce a greater weight of meat, whether as live stock or as butcher's meat, simply from grass, or if he had as much as he liked under the plough, he would reply under the plough system. If he were right in that statement, the Conference would next have a very serious question to decide, viz. what were the reasons why it did not pay to plough the land. A practical friend had just remarked to him that the principal reason was because the price they paid for store stock was too high. His answer was, why not breed stock themselves? He had been connected with farming the greater part of his life, and for twenty or thirty years hardly bought an animal; all the pigs, horses and cattle, and everything else being bred on the place. If ever there were a time when it was desirable to bring before the British agriculturist the idea of breeding and being independent of middlemen it was the present. There was one observation in Mr. Duckham's paper which very much strengthened his argument. He stated that in the year 1868 our sheep stock reached its maximum. Now setting aside again the question of profit and loss, and the question of disease, he would ask Mr. Duckham, whether about that year, 1868, there was not the largest area of land under the plough this country had ever seen. If so he thought that evidence was very strong to support his argument. His next suggestion in regard to rearing stock was as the result of his observation that not one farm in twenty in England was properly and sufficiently supplied with the necessary accommodation, either for the feeding or rearing of cattle. His own experience had been that in precisely the same style of husbandry and the same style of land, if you turned your old barns into cattle sheds, put up outlying fold yards with proper sheds, you could with more economy in the style of agriculture and in using straw and provender produce 20 per cent. more live stock. He had heard it stated in public, though he did not vouch for it, that in this country there were 15 millions of acres not cultivated at all. What was the remedy for this grave state of things? To make agriculture a free industry, to let the British farmer be in a position to make the most of his land, then, depend upon it, his good sense, his pluck, his enterprise and his skill would meet the occasion.

Mr. DUCKHAM, in reply to the question asked by the last speaker, said that in 1868 there were 30,711,396 sheep and 17,737,627 acres of arable land; in 1872 there were 27,921,507 sheep, and 18,351,283 acres of arable land.

Dr. C. R. DRYSDALE said it had given him great pleasure indeed to come to this Congress, because he, being himself a medical man, having nothing to do with agriculture, considered that the question now being discussed was most important from the hygienic point of view. Medical men were continually discussing the causes of disease at different times, but it was forgotten that the most important point of all was that people should have enough to eat. This Conference, it appeared to him, was endeavouring to solve the most vital question the human race had ever endeavoured to solve, how to get sufficient meat supplies. It was quite possible to get supplies of starchy food, such as grain, from all parts of the world; you could buy it at 40*s*. per quarter in London, but the great difficulty was to get the most essential part of human diet, animal food. Animal food was the most important element to the greatness of a nation. No nation living on vegetable food ever showed great energy, and those who adopted that diet were always conquered by others. When one looked at the quantity of meat consumed here, and compared it with that consumed in Italy, the importance of keeping up the supplies of animal food would be at once seen. It was assumed that at present Englishmen consumed 100 lbs. per head per annum, but in Italy they only consumed 18 lbs. per head.* The supply of home grown English meat was supposed to be one million tons, and that imported about 470,000 tons; so that we were fast coming to the point when we should be obliged to import as much animal food as we grew at home, which was to him most appalling; and it seemed to him we were fast approaching the time when we should become like the Chinese and Hindoos and have to live almost entirely on vegetable food. Every day 1,000 people were added to our numbers, but he believed the amount of animal food capable of being produced had almost reached its limit. At the present moment, there were only 28 millions of sheep and 10 millions of cattle and so many millions of pigs; in the year 1868, which Mr. Duckham had spoken of, there were far more sheep, but there were only 8 million of cattle, so that if added together he thought there would be about the same total weight of animal food in 1868 as at the present time. It was the same story throughout Europe. All over the Continent there was what might be termed a meat famine. In some countries they could only consume 18 lbs. per head per annum, and in France it was 70 lbs. The vital importance of this question lay in this that our length of life greatly depended on what we lived upon. The richer classes, who got far more to eat, and far more meat, had an average life of 55 years; but if you took the poorer classes in Bethnal Green, the average age at death was not above 30, so that there was a difference of about 26 years between the life of a well-fed and an ill-fed person. One great reason of

* 'Armeé und Volks- Ernührung,' by Dr. Meinert. (Berlin, 1880.) 2 vols., p. 151.

that was that the working classes had to work with far too little nitrogenous food; and he wished to point out the extreme danger to a nation of what had been lately styled vegetarianism. There were people who said that our food difficulties would vanish if we simply gave up animal food, and took to eating cereals, but he entirely objected to this doctrine, which he considered most pernicious. The reason of this was that the nitrogenous parts of food were very much more easily digested when taken in the shape of animal food than in the shape of vegetables. The nitrogen contained in 1 lb. of meat was almost entirely taken into the blood, only 2½ per cent. passing out of the body undigested; but if the same quantity were taken in peas or beans, or even in coarse bread, as much as 40 per cent. of the nitrogen would pass out of the system without ever entering the blood at all. Consequently, the great point in diet was to take the 4 oz. of dry albumen, which were required every day, not in the shape of vegetables, but in the shape of meat; and it was the greatest mistake for those who had to do energetic work to think that they could live as well without taking animal food. It was a vast mistake in an individual, but in a nation it was a still greater fault, because if a nation did that it would inevitably fall off in its power of endurance and produce fewer great men. If these Conferences were only continued for some time, so as to impress on the public the vast importance of this subject of food, it would do more to increase the longevity of mankind than any other hygienic measures.

Mr. THOMAS POOLE said in a great deal of what he should have said he had already been anticipated by Mr. Woodward, especially with regard to buildings on farms. He thought landlords would have to do a great deal more before the tenantry could much improve in stock raising. With regard to Mr. Druce's travelling bullock, they must recollect that Londoners only took the best beasts out of the country, and they would always have to pay a little extra in the carriage of the best meat which was produced and picked out for their use. A good deal had been said about arable land versus pasture-land, and that all they had to do was in the direction of seeding more land down for permanent pasture, but that will not help farming unless the greater portion of it is first well drained. The Agricultural Holdings Act had done something, but that has not gone to the bottom of it yet. The Act was of great benefit to the best farmers on good arable land, corn and cake users; but there was nothing done by that Act for farmers on cold lands all over England, and the advice which must still be given to farmers of that class was, farm it as low as you can, for you would get nothing at all for improving it. There was no compensation for farming arable land well at present, and until something was done in that direction they would not get much more meat produce from that class of land. Besides all this, there was a great deal of land unoccupied which ought to be made use of in growing food, &c.

The Rev. THOMAS FLAVELL (Christchurch, New Zealand) said he was neither a farmer, grazier, nor landlord, and though he was a shepherd, his sheep lived 12,000 miles away. Some hard things had been said about frozen mutton that morning, and he had heard some depreciatory remarks made on the appearance of the Australian mutton in the Exhibition. He had heard one gentleman say, "We can show better than that at Christmas." Undoubtedly that was so, but the mutton was not prize Christmas meat; it was simply the ordinary production. He did not want to depreciate English mutton in the slightest degree; of course it was superior to mutton all over the world, and it would be a disgrace to England if it were not so, considering the many years during which attention has been devoted to the science of agriculture and to the breeding of sheep in this country. Still, there were several reasons why the mutton grown in New Zealand should be nearly, or quite equal to, that of England. In the first place the farmers there imported the very best stud sheep, and paid large prices for prize rams. Secondly, the food was equally good, if not better; for they had

English grasses which grew there luxuriantly, and sheep and cattle fed on them. Thirdly, they had perhaps the most beautiful climate in the world; and besides that there was no foot-and-mouth disease, no fluke, and very little scab; so that, on the whole, he did not see why New Zealand mutton should not be as good as English. He should also say that the utmost care was taken in selecting and choosing the meat which was prepared for exportation, and special means were taken to convey it from the freezing place to the ship's side. There were, on the other hand, several obstacles to its general use; one was that the storage price was too great, and he had been very glad to hear that morning that that was being reduced. He should send out the information by the next mail to New Zealand, where he was sure it would be received with much gratification. In fact the storage absorbed the very profit which the sheep farmers in New Zealand wanted. Moreover, the mode of distribution here in England required more attention. In New Zealand special trucks were used to convey it, and the same should be done here. Again, the proper mode of thawing did not seem to be understood; sufficient time was not given to it, and it was often not properly cooked. If these things were attended to, and a fair trial given, he was quite sure it would grow rapidly in public favour.

Mr. MALLOWS said he thought the freezing took all the taste and quality out of the meat.

Mr. HUGH CLEMENTS said this question of meat supply was of very great importance, and affected the consumers even more than the farmers. He fully concurred in the conclusions which Mr. Druce had arrived at, that it was far more profitable to import dead meat than live cattle, which was undesirable for many reasons. When the animals arrived they were often weak and upset by the journey, and therefore were in an unhealthy condition. The amount of dead meat imported annually was only 450,000 tons, whilst the live meat was 1,200,000 tons. He believed the average amount of meat produced in England remained about the same from 1868 to the present time, but at some periods there were more cattle, at others more sheep, and at others more pigs, but the average still remained the same, about 1,200,000 tons. When cattle and sheep went down, pigs went up, because they were more easily reared. He did not think the produce of meat could be much increased, at any rate until there was greater security given to the tenant farmer.

Mr. JACOB WILSON said if that meeting had proved one thing more than another, it was that figures and statistics, when taken alone, were highly misleading. Some recent speakers might be very eloquent and able in figures, but he feared they lacked that knowledge of practical agriculture which this subject required. It seemed somewhat extraordinary to be told that as soon as sheep began to die pigs begin to live. A few years ago when bacon was imported very largely into this country, it was due to the tremendous crop of American corn which caused more bacon to be produced. One thing had been thoroughly shown by the discussion, and that was that those who had for some years past been advocating further restrictions in the importation of disease into this country, had been fully justified in saying that the interest of the consumer and the producer were identical. The importation of foreign meat had been brought much to the front, and he had been somewhat struck by the tone in which the subject had been treated. They were told in the morning that English people behaved exceedingly ill to Australians by not giving them proper opportunities for placing that meat before the public, but it appeared to him that if there was one person more than another who reaped a benefit from that importation it was the exporters in the colonies, and he should have expected that they themselves would have endeavoured to afford such facilities in this country as would have distributed the food most profitably, and to the greatest benefit to the public. He had paid many visits to the docks, and seen the meat in all its stages until it reached the stalls in the market, where it was sold at about 6*d.* a lb. But that meat did not find its way to the poor working man. Why did not the Australian exporters furnish small depôts all over London, so that the poor man might have the benefit of that meat at a cheap rate? He protested against gentlemen coming and saying that the colonists only wanted fair play—the English farmers only wanted fair play too; but thank God they had it now, and he trusted that they would have no further importation of foreign diseases. They would welcome foreign cattle dead or alive to feed the people, but they did not want any foreign diseases. He, along with other farmers, viewed with great satisfaction the improved condition of their flocks and herds. They had by the most stringent regulations reduced the number of diseased animals almost to a minimum—and matters had now arrived at a stage when he thought it the duty of the Government to take advantage of the powers they possessed, and by slaughtering those few animals to exterminate the disease altogether. Why the Government did not put those powers into operation he could not conceive, and he thought the country ought to insist on its being done. It was now so small a question that rather than it should not be done, he would appeal to his fellow-countrymen whether a public subscription should not be got up to do it. One thousand pounds would rid this country of all the foot-and-mouth disease at present existing. When they were told by amateurs and others that they would have a constant recurrence of these diseases from natural causes, he would refer to the important fact that after restrictions had been imposed during the time of cattle plague, the foot-and-mouth disease disappeared, and what could be done once could be done again. In that opinion he was supported by that very eminent authority, Mr. Dunn, the chief constable of Cumberland and Westmoreland, who issued useful statistics weekly, and who was also of opinion that £1000 would be ample to rid the country of the disease. He therefore threw out this suggestion, and hoped it would be taken up, for he knew hundreds of men would gladly give £5 or £10 towards such an object. He congratulated Major Craigie and those who had been instrumental in getting up this Conference, and trusted it would be the means of keeping this important subject before the public and prove a great benefit to the country at large.

Dr. G. E. NICHOLAS, M.O.H. (Wandsworth), desired to say a word or two with regard to that portion of animal food which was introduced into this country in tins. Numerous complaints had of late years reached him, and many of which had been within his own knowledge, of serious consequences resulting from the consumption of tinned meats. These ill effects were attributed by some to the formation of salts of tin through the use of hydrochloric acid, which was employed in soldering; but there could be very little doubt that they were really the result of decomposition; that the air which was supposed to be excluded by hermetically sealing was not really so, but that it still remained although in an attenuated form, and in process of time decomposition took place. Now the public had no means of ascertaining the age of the contents of these tins, and he thought it was worth considering whether some means might not be devised by which the purchaser might be secured against these inroads upon his health, possibly by requiring the date when the tins were prepared to be marked upon them.

Mr. W. LIPSCOMB proposed a vote of thanks to the three chairmen who had presided during the course of the day. Mr. Mitchell Henry had mentioned one of the most important of all the items which to his mind lay at the bottom of the future prosperity of British farmers, in pointing out the desirability that Irish store stock should be abundant and cheap. In that lay the kernel of their hopes for making the margin between the lean and fat animal large enough to produce the profit which for many years they had lost. If there were any hopes for them at all it lay in the direction of breeding stock being largely increased. Over and over again in the West Riding he he had been insisting on a point which was often overlooked, namely, that the foot-and-mouth disease produced barrenness; they were told by some people that this disease was not of much importance, because the meat was none the worse, but if the females upon whom they were dependent for future increase were no longer capable of breeding, how could they expect the numbers to be kept up, still less increased? *ex nihilo nihil fit.* For store cattle they looked mainly to Ireland; and there, with all respect to Mr. Mitchell Henry, there was a very much larger margin between the capabilities of breeding cattle, and the present state of things, than existed either in Scotland or England. There was greater mismanagement there. He had often been there, and was delighted to see the improvements effected by Mr. Mitchell Henry; but the question which as a practical man he had been watching throughout all the discussions with regard to Ireland, which had mainly turned on political matters and not on the material prosperity of the country, was, where was the capital to come from for the improvement of those lands and buildings? All who had been there knew how little improvement there had lately been in either, because there had been so little capital devoted to it, and that was the main thing required to develop and increase the prosperity of the country.

Mr. F. S. POWELL, in seconding the motion, said his pleasure in doing so was greatly increased by the circumstance that Mr. Mitchell Henry had occupied the chair during a portion of the proceedings. He had witnessed the improvements which that gentleman had made, and if there had been more Irish landowners who had had the same financial means, knowledge, and ability, that country would have been in a much more happy and prosperous condition than it was; and as had been already remarked, Ireland was one of the most important sources of food supply for the great population of this country. As Ireland prospered, so would the population of this country prosper; and this was a remarkable illustration of the manner in which the interests of England and Ireland were in reality entwined together, when one prospered, the other fared well, and when one suffered, both were afflicted.

The CHAIRMAN having briefly acknowledged the vote of thanks, the proceedings terminated.

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THE

DIGESTIVE FERMENTS

AND THE

CHEMICAL PROCESSES OF DIGESTION.

BY

PROFESSOR ARTHUR GAMGEE, M.D., F.R.S.

LECTURES ON THE DIGESTIVE FERMENTS AND THE CHEMICAL PROCESSES OF DIGESTION.

By Professor ARTHUR GAMGEE, M.D., F.R.S.

JULY 1ST.

Professor HUXLEY, F.R.S., in the Chair.

The CHAIRMAN said the lecture about to be given was upon one of the most important topics, by a gentleman of high reputation as a physiologist, competent to give the best information in the most accessible shape, and in the shortest possible time. He need not dilate on the importance of digestion to every one, because probably there were very few who had not had considerable practical experimental evidence upon that point. Without going so far as to say, as a well-known cynic once did, that the two things desired in this life for happiness were to have a good digestion and no conscience, there was no question whatever of the great desirability of having a good digestion.

LECTURE I.

The Saliva and the Gastric Juice, and their Action on Food.

IN the lecture I am about to deliver before you I desire, in as elementary a manner as possible, to direct your attention to the earlier of the chemical processes of digestion, reserving for a second lecture certain other parts of the subject.

In thanking you, Mr. Chairman, for the honour you have done me in presiding on this occasion, permit me to say that your presence makes me wish that I could allow myself to enter on some of the higher developments of the subject: but at the same time it reminds me that you have conspicuously shown that it is one of the functions of the scientific man to take his share in popularising scientific knowledge.

In the short time at my disposal I wish to direct the attention of my audience to the chemical, as distinguished from the mechanical processes of digestion, and particularly to speak of those remarkable bodies, the so-called "*unformed ferments*" of the alimentary canal, and to point out in how many respects they differ from the other class of *organised ferments.* Want of time prevents my speaking, in however elementary a manner, of the food of animals, but I trust that at the present time every one looks upon food as matter which has to be taken, not only to make up for the loss of matter which is continually going on in the case of the animal body, but that which has to supply the animal with the *Energy* which it requires to perform all those numerous acts which together constitute life.

Let us take man as a type of the animal; the food of the animal body comprises solid alimentary substances and liquid alimentary substances; the latter consist almost entirely of water, and the former also contain no small quantity of water; indeed as a rule very much more water than solid matter. These solid alimentary substances may be divided into organic, and inorganic or mineral substances. It is the organic alimentary substances which may be looked upon as the fuel of the animal body, as furnishing it not only with the matter which is needed to make up the loss which the tissues and organs of the body are always undergoing, but the matter which supplies the energy required by the animal body. The organic alimentary constituents are built up for the animal by the vegetable. Even in the case where one animal feeds upon another the organic matter obtained from the animal is primarily built up by the vegetable organism. The organic constituents of the body may be conveniently subdivided into certain groups. We have, in the first place, the group of proteids, or albuminous substances; secondly, the group of carbo-hydrates, which includes the starches and sugars; and, thirdly, the group of fatty matters, or fats. Any diet, in order to support the life of man, and I take man as the type of an animal, must contain, in addition to water and other mineral matters, the proper proportion of proteids, carbo-hydrates, and fats.

The process of digestion is the process by which the solid constituents of food, and to a certain extent, also the constituents capable of being dissolved by water, are by chemical and mechanical means so changed as to be capable of being absorbed into and forming part and parcel of the animal body. In considering the chemical processes of digestion, we shall have to inquire how these various organic food constituents are acted upon in different parts of the alimentary canal. When the solid food is introduced into the mouth it is in the first place, as you are aware, subjected to the mechanical process of Mastication, a process in which the teeth take the chief part and by which the food is broken down into small particles. This mechanical process is in most cases the almost necessary precursor to the chemical processes, which take place at the same time, and which have to follow. We are aware how much the process of solution of soluble bodies is hastened by the mechanical subdivision of the substances to be dissolved, and how very much the action of chemical agents is influenced by their being able to act upon a body in a state of minute subdivision; we are not surprised therefore that the substance of our food has, in the first instance, as a preliminary to the chemical process of digestion, to be subjected to the mechanical process of mastication. With this mechanical process, which I have treated at some length in the Handbook of Digestion, which will in a short time be published in connection with this Exhibition, I have nothing to do to-day, except to say that 't could not go on but for the presence in the mouth of a liquid, to which we give the name of Saliva, the first of the digestive juices. This liquid is the product of the living activity of certain glands which open by ducts into the cavity of the mouth, to which we give the name of the Salivary Glands. The largest of these glands are known as the Parotid Glands; they are situated behind the jaw, in front of the ear, and have a tube or duct passing from them opening into the cavity of the mouth. Next come the Submaxillary Glands, which are beneath the lower jaw, and a third pair of smaller glands, Sublingual Glands, which are found beneath the mucous membrane of the floor of the mouth, and which open by a number of small ducts. These three pairs of glands are the chief secretors of the liquid which we call saliva. The saliva which moistens our mouth has several functions. In the first place it is essential for proper articulation. Were the mouth perfectly dry, the complex movements of the tongue against the inner side of the mouth would be impossible; then again, the saliva helps mastication by moistening the food. It aids the process of breaking down the food; by its viscosity it also tends to knit together the broken down particles of the food, and to mould them ultimately into a so-called bolus or mass. In certain animals, however, and in man particularly, the saliva is a liquid which possesses distinct chemical properties. It is the first of the digestive juices proper. Let me point to a table of the digestive juices and their ferments, and you will find that saliva stands at the head of the first column. In the second column there is a ferment contained in the saliva, to which the name of salivary diastase is given. This has an action on one of the groups of food constituents which I have brought before you,—on the Starches, which belong to the group of Carbohydrates. The saliva in man, in the pig, and in a few animals exerts a chemical action, but in the majority of animals it does not exert any chemical action whatever. From this we gather that the functions of the saliva are in the first instance physical and mechanical, and that its chemical functions are to a certain extent subordinate; yet we must not lose sight of them. The saliva is a liquid containing a large quantity of water. From the analyses of the saliva of man by Carl Schmidt, it appears that out of 1000 parts it contains 989 of water, and a small quantity of solid matter. Of that solid matter much is accidentally present, and is held in suspension, as are, for instance, epithelial cells, which have been rubbed off the surface of the mucous membrane of the mouth ; of the really soluble matters there are but small quantities in the saliva, only $3\frac{1}{2}$ parts in 1000.

What is the nature of the ferment which is present in the saliva, the so-called *Salivary Diastase,* though it is also known by other terms, as for example by the term of *Diastatic Ferment of the saliva,* or sometimes by the term *Ptyalin?* This salivary diastase is the first illustration which I have to bring before you of a so-called *unformed ferment*—of the typical kind of ferment found in the alimentary canal. The bodies which we call ferments, and which include both *organised* or so-called *formed* ferments and *unformed* ferments, are bodies which, looking at them now merely by their chemical effects, possess a power of bringing about changes of very great magnitude in bodies existing in the medium around them : changes incommensurably large when contrasted with the mass of the body which induces them. Take the case of the most widely known of these ferments, of the ferment which brings about the *alcoholic fermentation* in sugar. A few yeast cells fall into a saccharine liquid, and in the course of a certain time very remarkable changes occur. The temperature of the liquid increases, the liquid becomes turbid, bubbles of gas are given off, the smell of alcohol gradually becomes observable, and long before these more obvious phenomena, the microscopist has noticed the abundant development of the minute organism which is the cause of the whole of these changes. This ferment, Yeast, which brings about these remarkable changes in sugar, is a minute vegetable organism, and the changes which it brings about in the saccharine liquid are the results of its nutritive acts. If by the action of heat, or of any poison, you kill the minute vegetable organism, it is quite impossible to make it bring about a change in the sugar. You could not, I may add, from the yeast-plant extract by means of any solvent or chemical agent whatever, anything which, added to sugar, would bring about the alcoholic fermentation, although one might from the yeast-plant extract an unformed ferment; for the yeast-plant does, in development, give rise to one of the unformed ferments (an "*inverting*" ferment) to which I am about to direct your attention.

A formed ferment, then, is a ferment which is absolutely connected with the life of an organism, and whose ferment action goes on only so long as a particular organism lives. What about the unformed ferments? Are they ordinary proximate principles which have nothing to do with life? Not so. The unformed ferments, which possess so much interest to us in connection with digestion, are invariably the products of the activity of living cells, but once formed, the cells which have given rise to them may die, and the ferment does not necessarily cease to exist. They are not absolutely linked with the life of the cell, and they may be extracted from the cell by the action of various solvents. We may, for example, by treating the tissues of a gland which contains a formed ferment,—a salivary gland (for example), with a solvent of its ferment, such as glycerin, obtain a glycerin solution which shall possess all the activity of the original gland cell, and this is a result which could not be obtained in the case of the formed ferments to which I first directed your attention.

There are a great many differences between formed and unformed ferments, but I shall only direct your attention to the most important. The most important, which I have not yet spoken of, is this: the formed ferment, as it exerts its ferment action, seems of necessity to multiply. As the yeast-plant goes on feeding upon sugar, and producing carbonic acid and alcohol, it multiplies. On the other hand, the unformed ferments, as instanced by the ferments of the alimentary canal, in exerting their action, do not multiply. They possess, it is true, an extraordinary power; present in minute quantities, they may bring about changes of very great magnitude, but yet we find that the ferment does not increase as it goes on acting. In fact, the mass of evidence which we have, seems to show that in exerting their activity, even under most favourable circumstances, these ferments do gradually, but slowly and certainly, undergo deterioration and become destroyed. There are other differences, one of which is that pointed out by Paul Bert, as to the effect of compressed air or compressed oxygen upon formed and unformed ferments. He showed that whilst the organised ferments are destroyed in their activity, and annihilated, by exposure to the action of oxygen at a high pressure, the unorganised ferments undergo no such change. Let us now examine pretty closely the action of this Salivary Diastase or Diastatic Ferment. A great part of our food contains starch, generally boiled or acted upon in some way by heat—as, for example, in the case of the bread which we eat, which has been baked—but under certain circumstances unboiled. The saliva, in virtue of this ferment, possesses the power of dissolving and digesting (and we shall see in what the process of digestion consists) starch which has been subjected to the action of heat—cooked starch, we may call it. I have not time to touch upon the almost necessary details which I ought to enter upon with regard to the microscopic constitution of starch; but I may say that solid starch is obtained from vegetable bodies, and is found in the form of granules of a very complex constitution, formed in the interior of vegetable cells. It is simply a compound of the elements carbon, hydrogen, and oxygen. Its chemical formula is not yet perfectly known to us. The chemist tells us that starch is a compound having the composition, $C_{12}H_{20}O_{10}$, or a multiple of that. There are many facts which tell chemists that its constitution is not so simple as that, and that it should be represented thus: $(C_{12}H_{20}O_{10})_n$, the value of *n* not being perfectly known. Some believe that the formula of starch, after it has been acted upon by water, is best represented by the formula $(C_{12} H_{20} O_{10})_{10}$. You all know what the action of water on starch is. If I take solid starch and mix it up with water, I obtain a milky-like liquid; and if I pour, as is usually done in the laundry, boiling-water on this milky mixture, I obtain a gelatinous solid; if I add more boiling-water, I obtain a more and more diffluent starch-paste, but it is doubtful if I ever obtain, by simply mixing with boiling-water, a true solution. Now when saliva acts upon starch-paste, it exerts an action which will be evident to you all. The first action of the salivary ferment is to render the gelatinous starch perfectly liquid. I shall try this experiment, which would succeed very much better if I had taken the precaution of heating the starch-paste. You observe the difficulty with which I succeed in transferring some of this starch-paste from the bottle to this beaker; but on adding to it a solution which contains some ferment, such as is present in the salivary gland, there is almost immediately a remarkable difference in the fluidity of the mass. It does not at once become fluid, and the time which elapses is affected very much by temperature, but still the difference in fluidity is very remarkable indeed. There are, it is true, still some solid lumps, but the great part of the mixture has become perfectly liquid. If, instead of taking quite so coherent a starch mass as I have employed, I take some starch-paste which flows with difficulty, but which is still diffluent, the change produced by this ferment is almost instantaneous. The liquid was viscid, but it is now absolutely diffluent. This action of salivary ferment is only the first of a series of actions. The salivary ferments, like the other ferments of the alimentary canal, act most efficiently at the temperature of the mammalian body—at a temperature varying between 98° or 100° Fahr., or 101° Fahr. At this temperature the conversion of gelatinous into soluble starch is almost instantaneous; and if the quantity of ferment in the saliva be considerable, at once there are certain chemical changes which I must direct your attention to. The starch, under the influence of the ferment, combines with the elements of water, and is converted into a series of bodies called *Dextrins*, whilst at the same time there is formed a variety of sugar, long supposed to be identical with grape-sugar, but now known to be identical with the sugar formed in the process of malting barley, to which we give the name of Maltose. Let me demonstrate these changes induced by salivary ferment. I have a weak solution which contains about 1 per cent. of starch. First of all, I shall show you that this solution possesses properties which allow us to detect starch very readily in it. If to a solution of starch we add a solution of iodine, there is at once produced a very beautiful blue coloration, depending on the formation of an iodide of starch. Now, if we act on starch for a very short time at the temperature of the body by means of the ferment of saliva, we find, on adding iodine to the starch paste, that no blue colour is produced. The starch has ceased to exist as starch; it has given place to bodies to which the name of Dextrins has been given, and to Maltose. Apparently under the influence of the diastatic ferment, the very complex molecule of starch breaks down. The belief at the present time is, as I have said, that soluble starch is an aggregate of ten times $C_{12}H_{20}O_{10}$. The first action of ferment is to cause a combination of a molecule of water with the complex molecule of starch, and to give rise to a body called Erythrodextrin α (which is the first of the series of Dextrins) as well as to maltose. This body, being further acted upon by more ferment, is broken down into simpler Erythrodextrin β and maltose. The starch molecule further undergoes the process of degradation, until we have produced, as the ultimate product of the action of diastases on starch, certain very simple so-called Achroodextrins and sugar. But what is the object of these changes? The essence of the digestive processes is this: they do not merely dissolve bodies which are insoluble, but make them *diffusible*. I have prepared several experiments, which I must pass over for lack of time, but I may just point to them without going into detail. This morning I poured into a loop of the intestines of one of the lower animals a solution of starch, and plunged this bag with intestinal walls in water; shortly before the lecture I took some of the water surrounding the intestine, tested it with iodine, and found that no starch had been able to make its way from the inside of the intestine to the water outside of it—that is to say, I ascertained that starch is indiffusible; that it does not make its way, at any rate with any ease, through animal and vegetable membranes. But, at the same time in another similar loop of intestine, I placed a similar solution of starch, adding to it a certain quantity of ferment identical to that of the saliva, and, as in the first instance, placed the intestine in a jar of water. On testing the water a short time since, by means of a test which enables us to determine the presence of very small quantities of grape sugar or of maltose, I found that there was a considerable quantity of maltose in the liquid surrounding the intestine. By the action of the ferment of the saliva, we have starch not merely converted into dextrins and sugars, but into bodies, for such are dextrins and sugar, which possess the power of making their way through membranes, of passing through the walls of lymphatics and blood vessels, and thus making their way into the blood of the animal fed upon starch.

The changes which take place under the influence of diastatic ferments may be very readily shown, although I hesitate to dwell upon them just now. Almost as soon as you have added the diastatic ferment to starch, you find that the iodine reaction becomes modified, and that sugar is present. If the quantity of ferment added be sufficient, you have a body which merely gives you a yellow tint with iodine, or no tint at all.

The food having in the mouth been subjected to the process of mastication, and a certain portion of the starch having been converted into dextrins and sugar, is then subjected to the process of Deglutition, with which I have nothing to do, a process which has for its object the conveying of the *bolus* or mass of food from the mouth into the stomach, which we look upon as a bag, as a saccular dilatation of the alimentary canal, adapted in a remarkable manner both for the performance of chemical and mechanical functions. I have several diagrams which illustrate crudely one or two of the salient points to which I wish to direct your attention with reference to the stomach. The arrangement of fibres indicated shows the different layers of muscular fibres which constitute one of the coats of the stomach, fibres which have for their function the bringing about of movements of great complexity within the chief organ of digestion. The food, having made its way from the Oesophagus into the stomach, is subjected to very complex mechanical movements, which are almost as essential as the chemical changes which have to take place in that organ. The mechanical arrangements of the stomach are in some animals so powerful and so obvious that, before attention was directed in a proper way to the chemical action going on, many believed that the action of digestion was purely physical,—that it depended merely on the movements of the stomach. Now this saccular stomach is lined, like all parts of the alimentary canal, by a so-called Mucous Membrane—a lining membrane, within which are embedded certain glands, which we call the *Gastric Glands*. In most animals these gastric glands belong to two chief types; indeed, in most animals we can subdivide the stomach into at least two regions according to the classes of glands which are found in its mucous membrane. These glands are in some cases very simple. At first they were described as having the appearance of test tubes, being mere involutions of the mucous membrane of the stomach, but careful examination has shown that the simplest of the gastric glands have in most animals a complex structure. In the stomach of the dog, which perhaps affords the most typical instance of a stomach in which you have two well defined regions, you have at the *Pyloric End*, that is, the end which approaches the small intestine, certain glands in the mucous membrane which used to be spoken of by the older anatomists as *Mucous Glands;* at the upper end of these glands is a single tube, lined by so-called *cylindrical epithelium*, but this leads to secondary tubes, and these secondary tubes are lined by cells, no longer cylindrical, but which may be described as cells of cubical epithelium. These cells were formerly supposed to merely secrete viscid stringy mucous, but we now know them to co-operate, though in a subordinate degree, with the glands of the fundus in secreting one of the most important constituents of the juice to which I have to direct your attention, viz., *Pepsin.* Then at the other end, the so-called *Fundus* of the stomach, in most animals, and in all parts except the pyloric end, we have in the mucous membrane glands of more complex character. In the deeper portions of these glands we have two forms of cells; we have certain ovoid cells, which are situated for the most part peripherally, that is, near the margins of the tubes, and which we may term *Border Cells;* then we have between them and most internally certain cells which we call the *Central Cells.*

What is the object of this bag having a lining membrane possessing a large number of glands. These glands have for their function the secretion of the digestive juice called the Gastric Juice, which is the most important of all the digestive juices. When the stomach is at rest, that is to say, when it is empty, the lining membrane possesses a pale colour, and when blue litmus paper is drawn over its surface it is found that in many parts the reaction is neutral or alkaline. You may ask me how these facts have been discovered. They have been discovered, in great measure, in cases where, as the result of injury or disease, the interior of the human stomach was, as it were, laid bare to the gaze of the investigator. When food enters the stomach, however, the pale mucous membrane begins to flush, little droplets of a liquid having a very acid reaction are observed to exude from all parts of its surface. These little droplets, at first seen here and there, become more and more numerous, and run together, and at last we have pools of the acid gastric juice accumulating in the stomach. It is this gastric juice, acting in conjunction with the mechanical movements of the stomach, and at the temperature of the body, which possesses the power of acting upon one of the chief groups of food constituents, though not upon the group to which I have as yet directed your attention. For a moment let us look at the composition of the gastric juice. On the wall, there is a table showing the analysis of the gastric juice of the dog made by Schmidt; in 1000 parts of fluid there are 973 of water. Of organic matters there are present about 17·13 parts, and you further see that the organic matters contain *Pepsin*, to which body I shall have to direct your attention very particularly. Upon what does the acidity of gastric juice depend. It depends upon *hydrochloric acid.* This fact has been surmised for a long time; it was found by some of the earlier chemists between 1820 or 1830 that when the gastric juice was subjected to distillation hydrochloric acid was obtained in the distillate, but it was pointed out that this afforded no sufficient proof that the gastric juice contained hydrochloric acid, because if the gastric juice contained such salts as common salt, and such an acid as lactic acid, by the reaction of the lactic acid on the common salt under the influence of heat, hydrochloric acid would be produced; further, it was doubted whether this strong mineral acid could be produced by the cells of the gastric glands. The matter was well-nigh settled many years ago by Carl Schmidt, who pointed out that the chlorine which exists in the gastric juice is greater in amount than could exist in combination with the whole of the mineral bases of the gastric juice, and his observations in that respect have been confirmed by a more recent investigator, Charles Richet, who has, however, advanced new ideas as to the nature of the acid of the gastric juice. There are several experiments which indicate in a remarkable way that the acid of the gastric juice is a mineral acid. Not only does it contain more chlorine than would be present except as hydrochloric acid, but it is evident that the acid is a mineral acid because of the action exerted by it on certain colouring matters. I have here an exceedingly weak solution of hydrochloric acid, of about the same strength as the gastric juice, the normal acidity of the gastric juice being equal to about 0·2 per cent. of hydrochloric acid. I have also an alcoholic solution of a very complex organic dye, known in trade as oo-Tropaeoline. When this colouring matter is added to a very weak solution of a mineral acid you observe an exceedingly beautiful pink colour, whilst when the solution contains only a small quantity of an organic acid, like lactic or acetic acid, no such colour is produced. It can be shown that in the normal stomach, and generally even in cases of disease, the acid is one which reacts with this colouring matter as a mineral, but not like an organic, acid. We may, therefore, I think, at present dogmatically state, and I do not believe that our doctrine will be controverted successfully, that the acid of the gastric juice in a healthy stomach in the earlier stages of digestion is hydrochloric acid. It has, I may point out, been stated by Richet that probably hydrochloric acid does not exist in a free condition, but combined with Leucine.

Passing from the acid of the gastric juice to the chief ferment, what is Pepsin? Pepsin is the chief unorganised ferment of the gastric juice, and it is the ferment which possesses the power in the presence of free acid, especially of free hydrochloric acid, at the temperature of the body, of acting not upon starch, not upon fats, but upon the so-called proteid or albuminous constituents of food, that is, those constituents represented to us by the albumen of white of egg, by the casein of milk, and by the gluten of bread. The majority of the proteids which we take in our food—for instance, those contained in meat—exist in an insoluble condition. The meat is broken up by the action of mastication in our mouth, it passes into our stomach in an insoluble condition, and is there acted upon by this gastric juice; it is to a great extent brought into solution, and the agents engaged are pepsin and hydrochloric acid. The hydrochloric acid is there because it is an essential condition that there should be a free acid in order that the pepsin should exert any influence.

I wish to show you the action of pepsin and hydrochloric acid in bringing about the solution of proteids, by an experiment which I trust may be obvious to you. In the first place, yesterday I obtained some fibrin. You know when the blood which has issued from the blood vessels of animals is stirred, there separates round the stirring implement, of whatever kind it may be, a stringy substance belonging to the class of proteids and to which we give the name of fibrin. We may wash this until it is quite free from colouring matter, then dry it and it presents the appearance of the solid contained in this bottle. Now this fibrin is a typical proteid with which we may make experiments on digestion. I placed some in dilute hydrochloric acid of the strength of that in the gastric juice; and the fibrin has swollen very much, but not dissolved. That is one of the facts to which I direct your attention in reference to digestion in the stomach. The proteids have a great tendency, particularly fibrin, to swell, when placed in dilute hydrochloric acid. There is no solution, none whatever. I placed some of the fibrin at the time I dried the portion I showed you, in an ammoniacal solution of carmine; this colouring matter was taken up by the fibrin, and we obtained a red solid, which has been partially but not completely dried. This morning I placed some of this stained fibrin in dilute hydrochloric acid, when it began to swell, and the two funnels before us are nearly filled with a jelly of swollen coloured fibrin. If I pour water upon this red jelly it will not dissolve; if I pour hydrochloric acid upon it, it will not dissolve, and we can tell that it does not dissolve because, if it dissolved, there would pass into solution not merely the fibrin but its colouring matter. Let us try this experiment. Over the contents of one of the funnels I pour dilute hydrochloric acid at the temperature of the body, and pour over the contents of the second funnel a mixture of dilute hydrochloric acid, and pepsin. Before doing so, let me say that this solution does not contain pepsin in a state of purity. We spoke of the diastatic ferment of the saliva as if we had separated it and analysed it, but we have not. We judge of its existence merely from numerous facts as to the influence which it exerts; and the same is true of pepsin. We speak of there being a ferment in the gastric juice called pepsin, not because we have ever obtained pepsin in a state of purity, but because there are a great many facts which show us that such a ferment must exist. Indeed, we could not account for all the facts of gastric digestion without the hypothesis of this ferment. More than that, by acting with solvents on the mucous membrane of a dead stomach, we obtain solutions containing this ferment—solutions of pepsin—which we may employ in experiments on digestion. The researches which have been made on this subject, like nearly all physiological researches, are proving of infinite value to suffering humanity. If there is any knowledge which very soon finds an application, it is physiological knowledge, and for that reason, if for no other, we ought to be slow in throwing hindrances in the way of physiological research. As the result of the researches of which I am giving you an account, solutions of pepsin have been made in different ways by acting by means of solvents upon the stomach, and they have come to be much used in medicine. At the present time, for example, in England, where I believe we have much the best of these preparations, there are at the disposal of the physician such admirable preparations as Bullock's Glycerine Extract of pepsin, a solution obtained by treating the mucous membrane of the stomach with acid and glycerine; we have an admirable solution made and sold under the name of Pepsine Essence, by Messrs. Savory and Moore, and likewise an excellent Liquor Pepticus, prepared and sold by Messrs. Mottershead; all these solutions, which are found in commerce, are the result of scientific work, and are very much used in medicine. I shall employ one of these solutions in this experiment. I take first of all some warm dilute hydrochloric acid, and pour it over the contents of one funnel, then I add a solution of pepsin to the rest of the hydrochloric acid, and cause it to act on the fibrin in the other funnel, and I shall have in a short time considerable quantities of red liquid accumulating in the beaker placed below the second funnel showing that the fibrin is almost instantaneously being dissolved before us, and in large quantities. I may show you this experiment in another way. Two or three hours before the lecture I placed some masses of the stained fibrin in dilute hydrochloric acid. You will observe that the fibrin has swollen up, but that it remains undissolved; some traces have passed into solution, that being due to the fact that my stained fibrin had not been thoroughly washed. Here however is a tube in which I have placed an equal quantity of fibrin with hydrochloric acid and with pepsin, and you will observe that the whole solid mass has passed into solution, giving us a red liquid; the proteid matter of the fibrin has been dissolved under the influence of pepsin and acid. If I had taken pepsin alone, and added it to the swollen jelly, there would have been no solution, as when I took acid alone, there was no solution; but having taken pepsin and acid I obtain a solution of the fibrin.

Now, what are the substances which are produced under the influence of pepsin and hydrochloric acid? The bodies *ultimately* produced under the influence of these agents are termed *Peptones;* like the body from which they are derived, they belong to the group of proteids, represented by albumen, casein and fibrin. The peptones have these characteristics: they are exceedingly soluble bodies, much more soluble than the most soluble proteids and they are also more diffusible than the most diffusible proteids. When albuminous food, then, enters our stomach, under the influence of the gastric juice, aided by the mechanical movements of the stomach, the proteid constituents are brought into solution, and are converted, at any rate in great part, into soluble matters, which have the power of passing through animal membranes, and thus make their way into the lymphatic channels and into the blood vessels.

Now, let me for a moment touch on this question, Is there any other ferment present to the stomach? and the answer is, Yes. Especially in the stomach of young animals there is present another ferment to which the name of *Curdling Ferment* or *Rennet Ferment* is given. In virtue of the presence of this ferment, the Casein, which exists in solution in milk, is curdled or coagulated. This ferment was long ago recognised by the great chemist Berzelius, as not identical with the ferment to which I have referred, namely, pepsin, for the conditions of its activity are different. If you take the gastric juice and neutralise it, it will no longer dissolve proteids; its pepsin no longer exerts its action, but it will yet continue to curdle milk. There are now a great number of reasons for saying that the curdling ferment is quite a special ferment, and it possesses a remarkable power on the casein of milk, not merely coagulating and precipitating it as it would be precipitated by mineral acid, but altering it in a material manner; the action of the rennet ferment is indeed to convert *Casein* into *Cheese*, cheese being perfectly different from the body we throw down from milk when we add an acid to it.

The CHAIRMAN proposed a vote of thanks to the lecturer, which was carried unanimously.

July 8, 1884.

LECTURE II.

Gastric Digestion further considered: Pancreatic Digestion.

In my first lecture, when speaking of the glands which are found in the cardiac portion or *fundus* of the stomach, I omitted to mention one or two very interesting points with regard to their cells and the function of these. You will remember my saying that when the stomach is at rest and empty, on food entering the stomach, there commences to be secreted from the tiny little glands, whose mouths open upon the surface of the mucous membrane, a juice called the *gastric juice*, of very acid reaction, the acidity depending upon hydrochloric acid, and you will remember my bringing before you some of the evidence upon which this opinion is based. You will remember that this juice, besides hydrochloric acid, contains one of the unformed ferments of the alimentary canal, to which we give the name of *Pepsin;* and that in virtue of pepsin on the one hand, and hydrochloric acid on the other, at the temperature of the body, aided by the mechanical action of the stomach, the most important of the operations of digestion is effected—that whereby the greater part of the albuminous or proteid constituents are brought into solution and converted into bodies called *Peptones*. I omitted, however, to mention in my last lecture that the hydrochloric acid of the gastric juice is unquestionably secreted in the glands of the *fundus* of the stomach, and in the cells of those glands possessed of both central and border cells. These glands have come to be called "*oxyntic*," or acid-producing glands, and the acid-producing function is resident in the ovoid "*border*" *cells;* on the other hand, the powerful ferment Pepsin is produced both in the glands of the fundus and in the glands of the pylorus by other cells than the ovoid cells. Between these border cells are many others in the glands of the fundus, and these form pepsin. Again, the deeper parts of the glands of the pylorus contain cubical cells, which form some pepsin. It is impossible to give the grounds for making these assertions which rest on conclusive evidence derived from many different sources.

In the stomach the starchy constituents of the food undergo but very little change. Do they undergo any change whatever? It has been a question whether the saliva which has commenced to act upon the starchy constituents of the food in the mouth continues its action in the stomach, and the discussion on this question still goes on. There are some who say that the moment the food enters the stomach the saliva ceases to exert any action upon it, whilst there are others who maintain the opposite opinion. I shall dogmatically tell you what I think the truth of the matter. There can be no doubt that the diastatic ferment of the saliva can only convert starch into dextrins and sugar when the reaction is alkaline or neutral, or at most but faintly acid. When the saliva enters the stomach in full digestion, *i.e.*, when the gastric juice has been secreted in large quantities, and when the acidity of the juice is great, then it loses its power of acting on starch; but in the very first stages of digestion there can be little doubt that the digestion of starch goes on. For some little time, the saliva, mixed as it is with the crushed up food, continues its action upon the starchy constituents, so that, although there is no conversion of starch into dextrins and sugar at the expense of anything secreted by the stomach, there is a certain degree of conversion due to the continued action of the saliva, favoured by the warmth of the stomach. In the main, however, the starchy constituents of food are not acted upon in the stomach. But what about the fats? The fat which we consume in our food is to a considerable extent contained within the interior of cells; the fatty tissue, the so-called *adipose tissue* which we eat, is found microscopically to consist of little vesicles or sacs, which contain fat liquid at the temperature of the body. A liquid fat itself is not acted upon by the gastric juice, but unquestionably the walls of the fat cells are dissolved by the juices of the stomach, so that indirectly the gastric juice tends to the digestion of fats. The fatty matter of our food under the influence of gastric digestion is in great part set free, so that when it is afterwards subjected to the action of the pancreatic juice, a true chemical action may be exerted upon it. It is thus the proteids or albuminous constituents which are acted upon chiefly in the stomach.

I want to tell you that these proteids are more important than any other constituents of our diet. A man may live without starch and without fat, although he cannot conveniently live either without fat or without starch. But an animal deprived of the proteids must die. We may say that the substratum of our body is proteid, that the framework of our body is composed of matters which in the main are proteid or albuminous in character, that is, akin to the white of egg, to the casein of milk, to the fibrin of blood, or to the matter which makes up the chief part of the fibres of flesh. Now our bodies are always wasting; do what we may, every part of the animal machine is continually wasting. Although we cut off all food from without, and abstain from all external work, still the losses of the body continue, and amongst these are losses always attributable to this proteid part of the organic framework of the body. We are continually losing from our bodies matters rich in nitrogen, and there is only one way in which the body can make up for that loss, and that is by taking into itself stores of nitrogen in the form of the proteid bodies which I am speaking of; for the only source of the nitrogen which the animal body can avail itself of is found in proteids. These proteids, for the most part taken into the body in the insoluble form, are acted upon, as we have seen, by the gastric juice, in virtue of pepsin acting in an acid medium at the temperature of the body, aided by mechanical movements, and are converted into Peptones. A word with regard to these peptones, in addition to what I said in my first lecture. These peptones are very soluble proteid bodies, and more than that, they are proteïd bodies which, like the dextrins and sugars, are diffusible; they can make their way out of the alimentary canal, which in one way may be looked upon as outside of the body, into lymph-spaces, and into the blood-vessels, and so come to enrich the body and supply it with that which it is continually losing.

After the food has sojourned in the stomach for some time, and has been acted upon by the gastric juice, it is broken down and reduced to a pappy condition; the watery parts of the food are absorbed by the blood-vessels of the stomach to a certain extent, and by other absorbent vessels, the lymphatics. The substances which have been formed by the action of the digestive juices—the dextrins, the sugars, the peptones—are in great measure absorbed from the stomach; but there yet remains a pulpy mass, which, when examined under the microscope, is found to be composed of half-digested and broken-down proteid substances and undigested vegetable matter. If the diet has been a mixed animal and vegetable diet, the residual undissolved mass consists of broken-down particles of meat, mixed with yet undigested starch, and indigestible cellulose, and with fat set free from adipose tissue. In the early stages of digestion, the pyloric orifice is closed against the passage out of any constituent of the food, which, by the complex movements of the stomach, is kept in continual motion. For a certain time, every particle of the food is given a chance of being acted upon by the solvent gastric juice. But as the food is broken down under the influence of the gastric juice, and becomes more and more pulpy, the pyloric orifice begins to gape, and gradually the pulpified mass of so-called *Chyme* makes its way through the half-opened orifice into the upper portion of the small intestine, into the so-called *Duodenum*. When the pulpified chyme comes into the duodenum, it is acted upon by two fresh juices, which are poured into this portion of the small intestine from two important glands. One of these juices is called the *Bile*, and is the product of the secretive activity of the liver; the other juice is called the *Pancreatic Juice*, and it is the product of the gland called the *Pancreas*, which in the lower animals is popularly known by the name of the sweet-bread. This pancreas also has a duct or tube running from it, which opens into the intestine at the same point at which the bile-duct opens. The bile used to be looked upon as a very important juice at one time. I have not time to speak at any great length of this liquid, except to say that we now look upon the bile very much as we should upon a by-product, or refuse, of a great chemical factory. The great gland, the liver—the largest gland in the body—performs some most important functions in connexion with the nutrition of the body—it is the seat of some great chemical operations upon which I cannot enter just now; and in the course of these there are formed certain refuse matters which pass out of the liver dissolved in water, and these constitute the bile. The bile exerts no direct action upon food constituents; it contains in most animals no ferments whatever. It contains Colouring Matters, derived originally from the blood-colouring matter. It contains certain Salts of the *Bile Acids*, these bile acids being, as I have already said, by-products of the great chemical operations which take place in the liver; but there is no direct chemical action exerted by the bile on any of the organic food constituents. The bile is, however, an alkaline liquid, and it helps digestion a little in this way. Mixing with the chyme which has passed out of the stomach, and which has yet a very acid reaction, it helps to neutralise it, and, as we shall see, in this way it helps to bring about the conditions so necessary for the action of that marvellous gland the *Pancreas*.

The Pancreas resembles very closely in appearance one of the salivary glands which I spoke to you about in my first lecture; in microscopical structure, also, the pancreas resembles the salivary glands, and it secretes a liquid possessed of an alkaline action, and at first sight presenting a resemblance to Saliva. Indeed, by the Germans, the pancreatic juice has been spoken of as abdominal saliva. Its action on the constituents of food is however infinitely more important than that of the saliva, and in the rest of this lecture I wish mainly to direct your attention to this juice, whose functions have only been properly appreciated during the last few years, and whose action upon the constituents of food we have not yet entirely unravelled. So far as we have unravelled them, we have obtained, however, information of the greatest possible value.

The pancreatic juice is a decidedly alkaline juice. You know that the gastric juice, which is the most important digestive juice, has a strong acid reaction, due to the presence of free hydrochloric acid, and I want you to note that the alkalinity of the pancreatic juice actually depends on the presence of sodium carbonate in that liquid. It is a remarkable thing that in the alimentary canal we should have poured out by the glands of one organ a fluid containing large quantities of a mineral acid, and in an adjacent organ a liquid containing considerable quantities of an alkaline salt; that in one case the mineral acid, and in the other the alkaline salt should be of the greatest possible utility, indeed almost essential, to the digestive processes which have to go on. Now, the pancreatic juice differs from the two juices which I have yet spoken of, to wit, the saliva and the gastric juice, in its power of acting on all three groups of organic food constituents. In all animals the pancreatic juice can digest starches and can convert them into dextrins and sugars. Our great herbivores upon whose tissues we feed, which have to rely so much under certain circumstances on the starch contained in the vegetable food which they consume, have a saliva which exerts no action on starch, but they all have a pancreatic juice, which can with the greatest readiness convert starch into dextrins and sugar. I shall repeat the experiment I showed you last week. We have here a thin starch mucilage, a viscous liquid which does not pour like water, but if I add to this viscous liquid a solution which contains the active principles of the pancreas, the viscidity disappears almost instantly. You observe the liquid now flows like water, and if we had had time we could easily show that it already contains large quantities of sugar, the product of the action of one of the ferments of the pancreas ; for this marvellous gland, the pancreas, secretes a juice containing *three* ferments.

The first ferment is a diastatic or amylolytic ferment, and it is contained in large amounts. The second ferment possesses an action upon fats. What action ? In the first place it was found long ago that when you shake the pancreatic juice of an animal with fatty matter, with oil for example, you very readily emulsify the oil. Permit me to comment on this for one moment ; if I take some olive oil and mix it with water and shake it up I produce for a moment a somewhat milky-looking liquid, but in a very little time the oil floats to the top, and you have the water remaining clear below. When you shake up olive oil with water you do not produce an *emulsion.* But if I take mucilage and shake it up with a little oil, I produce a milky liquid containing fat reduced to a minute state of division. Here, for example, is an emulsion which was made by mixing up almond oil with solution of gum acacia. It is a liquid which closely resembles milk. If we examine it under the microscope we find that it contains little globules of fat. Sooner or later, however, with ever so perfectly made an emulsion there will be a separation of fat in droplets which will float to the surface : but the separation will be slow and incomplete. I have said that it was discovered long ago that the pancreas secretes a juice which possesses in a high degree the power of emulsifying fats. It was discovered at the same time that the tissues of the gland likewise possess the power of aiding the emulsionising of fats. This fact has been made use of for the purposes of medicine in certain preparations for which one of our pharmaceutical firms has acquired great renown. The so-called Pancreatic Emulsion of Messrs. Savory and Moore, which for many years has been used in medicine, is a preparation in which this power of the pancreas of bringing about the emulsionising of fats has been taken advantage of, so as to obtain fats in an extremely fine state of division, in which condition they appear to be most readily absorbed from the alimentary canal. We do not know exactly how it is that the pancreas, and the pancreatic juice lead to this emulsionising of fats, but we do know something of another action exerted by pancreatic juice on fats. We know that the pancreatic juice, and the gland which yields it, contains in addition to a diastatic ferment, a second ferment, which we may call a *fat-decomposing ferment*, and this fat-decomposing ferment, at the temperature of the body, readily decomposes fats to a certain extent. I have not time, and this would not be the place, to enter into a discussion the chemistry of the fats; those of you who are acquainted with organic chemistry know the so-called fats contained in adipose tissues of animals, as ethers of the triatomic alcohol, called glycerin. I am quite aware that that is perfectly unintelligible to the ladies, and perhaps to some of the gentlemen present, but let me add some simpler and more explicit statements. The fats are all, in the first place, composed of three elements, carbon, hydrogen, and oxygen. Further, all the true fats of the animal tissues may by a certain treatment be broken up into glycerin, and a fatty acid; for example, by the action of an alkali, like potash or soda on neutral fats, aided by heat, they can all be broken up into glycerin, and into compounds, of a fatty acid and an alkali; to the latter compound we always give the name of a Soap. Now, the chief fats contained in the animal tissues are three, called Palmitin, Stearin, and Olein, or to be a little more accurate, tri-palmitin, tri-stearin, and tri-olein. Whenever fresh pancreatic juice or fresh tissue of pancreas, comes in contact with a neutral fat at the temperature of the body, these neutral fats are *to some extent* split up into the particular fatty acids and glycerin. I have here an emulsion which has been made by shaking up almond-oil and gum. I shall add to this emulsion some litmus, and from the blue colour which develops, we see that the reaction of the emulsion is alkaline. The emulsion is at the temperature of the mammalian body, that is 40° Cent. I now add to this preparation a preparation made from pancreas, the so-called Pancreatinine of Messrs. Savory and Moore. In shaking up the liquid we at once see that the blue colour has made way for a red colour—that is to say, a decomposition of the neutral fats into fatty acids and glycerin has occurred. This decomposition is brought about by the second ferment of the pancreas, and there is good reason to believe that the setting free of the small quantity of fatty acid plays an important part in the formation of emulsions. There can be no doubt at all that, but for the pancreatic juice which enters the small intestine, the fatty matter would not be emulsified, and would escape absorption by the absorbent vessels of the alimentary canal.

The third and most important ferment of the alimentary canal is a Proteolytic ferment, that is to say, one which exerts an action on the same constituents which are acted upon by the gastric juice. This proteolytic ferment of the pancreatic juice is called *Trypsin*. Though it exerts its action on the same constituents as those which are acted upon by the gastric juice, it is quite different from Pepsin, and the conditions for its activity are very different also. You may say to me, what is the need of there being another ferment to act upon the proteids? what need is there for a gland to pour a liquid into the small intestine which shall act on the very food constituents which already have had the chance of being acted upon in the stomach? The answer is this. However long the process of digestion in the stomach, certain proteids always escape solution in the stomach, and have to be subjected to the further action of the ferment trypsin, so that if possible they shall be made available for the purpose of the economy. Trypsin, unlike pepsin, acts best in an alkaline medium, and that is the reason why the pancreatic juice is alkaline: its alkalinity being indeed equal to the alkalinity of a solution which contains about one per cent. of sodium carbonate. It used to be supposed at one time that the proteolytic ferment of the pancreatic juice acted only in alkaline solutions. That is false. Unquestionably, trypsin does not act efficiently in the presence of a strong acid; it does not act efficiently, for example, in the presence of the acid of the gastric juice, but it can, though feebly, exert its action in the presence of a mere trace of acid, or in a neutral solution. It only acts to the best advantage, however, when the liquid in which it is present is decidedly alkaline.

Now what are the products of the action of trypsin on the proteids? You remember that peptones are ultimately formed by the action of pepsin and hydrochloric acid. Now we have to consider what are the bodies which are formed by the action of trypsin and soda; are they peptones? The answer is, in the first place, that the bodies produced under the influence of the trypsin of the pancreatic juice are peptones, but certain of these peptones are further acted upon and broken up into bodies of simpler constitution than the peptones, to which the chemist gives the name of Leucine and Tyrosine.

Had I time, it would be, I think, interesting to enter in an elementary manner into the points of difference between the action of pepsin and hydrochloric acid and trypsin and soda, but I must pass over all these minute details, and speak of those which I know must possess a greater interest to you. This question is one which is of interest—is pancreatic digestion of great importance? Does the pancreatic juice during life possess the chance of exerting great influence, and so play an important part in the digestive process? Unquestionably it does.

I mentioned the other day that the studies which had been made upon pepsin, and at first with purely scientific objects, have proved of the greatest possible value, and I now have to point out to you the immense value of the studies, at first made for purely scientific objects, concerning the action of the pancreas, and especially the proteolytic action of the pancreas, exerted by means of its ferment trypsin. We have seen that of all the constituents of food the proteids are the most important. We may be deprived of starches and yet live: we may be deprived of sugar and yet live: we may go without fats: but unless we have proteids we must die.

There are conditions induced by disease in which proteids cannot be digested. There are, for instance, affections of the stomach in which the glands of the stomach no longer possess the power of secreting its digestive juice adequately, and then the unfortunate human being is in the position of undergoing a more or less slow starvation. Now I am not going to enter on any painful or unpleasant details: I am rather going to tell you how science has come to the aid of suffering humanity, and afforded us the means of relieving and of nourishing those who under these circumstances otherwise must starve. The ferments of the alimentary canal, as you have been able to gather from the remarks I have yet made, not only reside in their juices, but are to be extracted from the very tissues of the glands which form them. We may, for example, from the salivary glands of an animal which secretes active saliva, obtain a solution which possesses the power of acting on starch; similarly, we can, from the dead stomach of animals, which secrete gastric juice, obtain pepsin; and so medicinal preparations of pepsin are made principally from the stomachs of pigs. From the sweetbread or pancreas of dead animals we may similarly obtain preparations containing the ferments which, during life, pass into the pancreatic juice, and effect the remarkable changes in the alimentary canal to which I have drawn your attention. Scientific men pointed out these facts, and manufacturers, readily followed in the wake, and have succeeded in preparing extracts of pancreas, or solutions of pancreas, with which we can artificially digest. We have only to take certain alimentary constituents, add to them pancreatic preparations, and place them at the temperature of the human body, and digestion will go on as it would in the alimentary canal, and we may obtain those products which are the results of the action of the digestive juices; these products, it is found, can be taken by human beings when all others would be rejected.

I shall illustrate these remarks by speaking to you of the digestion of milk. You are all aware that milk is the most wonderful of all natural dietaries; it contains water, mineral matter and all the various organic constituents—proteids, carbo-hydrates, and fats—which the body requires; and we know that, during an important, although not a long period of life—a period, however, during which the growth of the body proceeds with infinitely greater rapidity than at any other—there is no diet which performs the function of supporting life so perfectly as milk; but then milk, which is supported by most infants and by many delicate invalids, cannot be digested by others. Milk can, however, be subjected to the action of pancreatic ferments, and its proteid matter, which is called Casein, can be altered by trypsin, and can be converted more or less perfectly into peptones, and it is found that Peptonised Milk can almost invariably be supported by the stomach, though it reject all other aliment. Again, from meat we may by similar processes obtain extracts containing all the original proteids in the condition of peptones, which the great majority of invalids can support perfectly well. There are certain cases where meat cannot be partaken of, and in those cases it can be subjected to the process of artificial digestion, so that we may supply to the invalid an already digested meat which the stomach no longer rejects. I bring these facts before you because, in the first place, they are illustrated by a series of preparations in the Exhibition, particularly by those exhibited by Messrs.

Mottershead, of Manchester, and Messrs. Savory and Moore, of London, but chiefly however, because of their immense practical importance, and because they illustrate so admirably the fact which I want to impress upon you, that scientific knowledge is almost immediately applicable to the relief of suffering humanity. Let me perform an experiment to illustrate this peptonising of milk, and the points of greatest difference between it and ordinary milk. Here is some milk which I have heated to the temperature of the animal body by placing it in a bath at about 40° Cent., that is a little over 100° Fahr. Here is a similar milk which I placed at the same time in the bath, and added to it a little bicarbonate of soda, and a certain quantity of pancreatic solution. A great change has come over this milk. In the first place you will see that the peptonised milk has lost some of its opacity, and has become yellow and more translucent; but the chemical change is very marked indeed. I take first of all some of this unaltered milk, and show you by a rough experiment that it contains the proteid matters called Casein. I add acetic acid to it, that is the acid of vinegar, and we find that the milk is curdled. That is one of the properties which milk possesses, that if you add to it an acid the acid curdles it. We know that the milk is also curdled under other influences, as, for example, by the *Rennet-ferment*, of which I spoke the other day, which we find in such large quantities in the true stomach of the calf. I am experimenting with cows' milk; and the acetic acid throws down the casein in large flocculent masses. Now, I take the peptonised milk, and treat it in the same way, and when you come round to look at it after the lecture you will find that no curd has separated; the casein has been converted into other bodies, and a great part of it has passed into Casein-peptone, that is to say, into a body which is not merely soluble in water, but is diffusible, which will be able without any further digestion to make its way out of the alimentary canal of an animal into its blood vessels.

In this process of peptonising there are certain by-products formed. We find, for example, that if the process of peptonising is carried far a very bitter substance is produced. If you tasted the peptonised milk which I have made, you would find it intensely bitter. That is one inconvenience which attaches to the feeding of invalids incapable of digesting milk, or other proteid substances, with peptonised milk, that the process so very readily goes too far, and that there is produced, in addition to peptones, an excess of unpleasant bitter substance. With proper precautions, however, the peptonising may be stopped at a proper point, and then you obtain a milk no longer precipitable by acid, no longer precipitable by rennet, which is found to be almost, if not quite, perfectly digested.

Amongst the products relating to pancreatic digestion, which you will afterwards see on the table, there is one of Condensed Peptonised Milk ; this new and valuable product furnishes us with a preparation by means of which peptonised milk may be at our hand at any time without having to obtain solutions of pancreatic ferment, and without having to go through the careful operation of watching that the process does not go too far. Here is some of this peptonised sweetened milk. When I mix it with water I obtain a liquid almost identical with the liquid obtained by taking any ordinary sweetened milk and mixing with water, only the casein no longer exists as normal casein ; it has passed into the condition of an absorbable peptone. Although this milk has been peptonised to an extent which would render it disgusting if prepared by the ordinary process, because of its extremely repulsive bitterness, it has, by the process of condensation, been rendered perfectly palatable.

I wish to point out to you the importance of these researches on pancreatic digestion in permitting the physician to treat cases of dyspepsia, and of organic disease of the stomach in a way which was formerly impossible ; setting an organ at rest which requires to be at rest, by giving it pre-digested food. The principle, which is illustrated by this peptonised milk, has been carried out in other cases too. You will find in the Exhibition preparations of Malted Foods of various kinds; in these malted foods the starchy constituents have been pre-digested by the action of vegetable Diastase, so that when given to invalids no digestive efforts are required in order to digest the particular constituents which are present in large quantities.

I must now bring these already too lengthy lectures to a close; but before doing so I must say a few words to give you an idea of the relations of the functions of which I have spoken to the process of digestion as a whole. By the influence, then, chiefly of the gastric juice and of the pancreatic juice, aided by the temperature of the body and by the mechanical movements of the stomach, all the groups of food constituents are brought into solution, or nearly so; and, more than that, they are converted into bodies which possess the power of making their way through animal membranes. As the food passes along the very lengthy intestine, the dissolved constituents of the food are brought into contact with microscopic processes of the mucous membrane, which contain minute blood vessels and minute lymphatics. The soluble contents are absorbed; the proteids as peptones, and the starches as sugars, mainly into the blood-vessels; while the fats, which have been reduced to a fine state of division through the influence of the pancreatic juice, make their way into the commencements of the lymphatics, which are contained in the villi of the alimentary canal.

ALCOHOLIC DRINKS.

BY

J. L. W. THUDICHUM, M.D., F.R.C.P. (Lond.), etc.

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WINE.

ALCOHOLIC DRINKS.

WINE.

THE vine grows naturally in the temperate parts of Western Asia, the south of Europe, Algeria and Morocco. In Armenia, and to the south of the Caucasus and the Caspian Sea, it exhibits its quality as a creeper, and ascends high trees, bearing fruit without being either cut or otherwise tended. It grows vigorously in ancient Bactriana, in Affghanistan and Badackshan, and in Cashmir. I have studied it in the Algaida, a forest of about 9000 aranzadas in extent, situated on the south bank of the Guadalquivir, to the east of San Lucar de Barrameda. This forest consists mainly of sea-pines (*Pinus maritima*), but contains also groups of the silvery elm. Almost its entire border, and many small and large open spaces in its interior, are lined with the wild vines first described by Clemente. I found vines covering the whole of large fir-trees, silver elms, oleander bushes, fig-trees, and, together with sarsaparilla in blossom and brambles, creeping up and covering shrubs of lentiscus. These garañonas, as the Spaniards term the wild vines, are really indigenous plants, and not stray children of the vineyard; for all the flowers which I observed had the *stamina recurvata*, which are the characteristic feature of the female type of the *diœcic* wild vine, and no erect stamina (cfs. Thudichum and Dupré's 'Treatise on Wine,' p. 6, Fig. 3). I observed myself, in 1871, the place described by Clemente, where " the vines form impenetrable thickets, magnificent banqueting halls, most graceful pavilions, grottoes, covered walks, winding foot-paths, labyrinths, walls, arches, pillars, and a thousand original and indescribable caprices." The wild grapes here are black, acidulous, but good to eat. The growth of the plant is so vigorous that a one-year's shoot, which I pulled from a tree, measured fifty feet in length.

That the vine lived in Europe in the tertiary period is proved by the evidence of fossils. That it was present in pre-historic times is shown by the occurrence of preserved parts of the plant in various situations. Thus vine seeds have been found in the remains of the lake dwellings of Castione, near Parma, under conditions which show that they belong to the Bronze Age, at least 9000 years before our time; other lake dwellings, such as those at Varese, in the province of Como, and at Wangen in Switzerland, exhibit similar proofs. Near Montpellier, vine leaves were found in tufas, which, like those of Meyrargue in the Provence, are pre-historic, but post-tertiary.

A. de Candolle is of opinion that the idea of producing grape-juice and allowing it to ferment might have originated with different nations, particularly in Western Asia, where the vine abounded, and grew well. It is unquestionable that the Semites, as well as the Aryans, knew wine long before historic periods, and were in a position to introduce it into all the countries to which they migrated, including Egypt, India, and Europe. They could do this the easier as they found the vine wild in several of the countries in which they arrived. As regards Egypt, we have documentary evidence that the cultivation of the vine and the making of wine were practised nearly six thousand years ago, namely under Phtah-Hotep, who lived at Memphis four thousand years before our era. The progress of the cultivation of the vine by Phœnicians, Greeks, and Romans, is well known. A. de Candolle says that towards the east of Asia it seems to have advanced so slowly that the Chinese do not seem to have cultivated the vine before A.D. 122, although several varieties of wild vines are known to occur in their northern provinces. This is, however, at variance with the statement of Welles Williams, according to whom the first cultivation of the vine in China is ascribed to Foh-hi, a ruler estimated to have lived about three thousand years before the Christian era. It is further recorded that about 1120 B.C. wine was considered in the celestial empire to be dangerous to the state.

Each particular district producing a well-characterised wine does so by means of particular well-characterised varieties of vines. These vines must be either indigenous to these districts, or produced in them by natural or artificial selection from indigenous varieties. As we shall see in the consideration of particular viticultural districts, every uniform climatic region has its peculiarly-adapted varieties of cultivated vines, which cannot be so successfully cultivated in other regions, or sometimes cannot be cultivated at all anywhere else.

It is not necessary for our present purpose to investigate the particular steps in the progress of the human intelligence, by which wine, such as we know it now, was discovered. The shepherds of the Algaida gather the wild grapes in earthenware pots, and bury them in the ground under leaves and brushwood, and later on drink the fermented juice at their leisure. From such an original proceeding to the confection of Burgundy or of Champagne there are many stages, to describe which would require a separate treatise. We shall, however, in the following pages obtain sufficient information regarding the main features in the production of the principal varieties of wine to enable the reader to meditate on the subject of the origin of vinification.

Wine is the fermented, purified, and ripened juice of the grape; as such it contains alcohol, acids, salts, extractives, and those principles which give to it its particular colour on the one hand, and its particular flavour, smell, or bouquet on the other. While some of the ingredients can be accurately described and isolated, others are accessible to a definition by the sense of smell only. The conventional value of wine is determined less by its principal ingredients than by the prominence of the specific character termed bouquet, and the absence of certain faults. Dietetically, most wines are of equal value, provided they are the products of a favourable season, are pure, and free from the faults produced by parasitic fungi.

The principal alcohol in wine is alcohol strictly so called, or spirit of wine, the chemical composition of which is expressed by the formula C_2H_6O. In rare cases there is some butylic alcohol, $C_4H_{10}O$, and in others some amylic alcohol, $C_5H_{12}O$, so-called fusel oil, present. The latter alcohol we shall have to consider more particularly in connection with alcohols produced by the fermentation of grain or malt, and distillation of the resulting liquid. The quantity of alcohol present in wine can be estimated by distillation, and ascertaining the amount of spirit in the distillate by the determination of its specific gravity, or by ascertaining the specific gravity of the wine, then driving away all spirit from it, and, having again brought it to its original bulk by the addition of water, ascertaining its specific gravity without the spirit. Other methods are less accurate. The quantity of alcohol present in natural wines from the grape varies between 6 and 12 per cent. Unsound wines may contain some aldehyde, C_2H_4O, produced from alcohol by the loss of hydrogen.

The acids present in wine are those naturally present in the grape, namely tartaric, malic, and tannic ; and those produced during fermentation, namely acetic, formic, succinic, and carbonic. In addition to these there are nearly always traces of the more complicated fatty acids, such as propionic, butyric, and œnanthic acid present. Tartaric acid, $C_4H_6O_6$, occurs in must as acid potassium salt, or so-called tartar, and is in part precipitated during fermentation, as it is less soluble in spirit than in water. During the ripening of wine, tartaric acid forms with alcohol tartaric ether. The tartaric acid most commonly found in wine turns the plane of polarised light to the right, and is therefore called dextro-tartaric acid. Some wines, however, *e.g.* Italian, contain also tartaric acid, which polarises to the left, levo-tartaric acid, always, however, combined with the dextro-tartaric acid, forming what is known in science as racemic acid. All three acids have one and the same chemical composition expressed by the formula $C_4H_6O_6$. Sherries contain no tartaric acid, as it is removed from the must of Jerez grapes by gypsum or plaster of Paris.

Malic acid, $C_4H_6O_5$, is not only present in grape-must, but in the juices of many varieties of fruit, which we shall have to consider—apples, cherries, plums, currants, and the red berries of the mountain ash.

Tannic acid is present in most varieties of wine, and is derived from the husks and kernels mainly; more rarely contained in the juice of the grape. Red wines contain more of it than white wines, because they are always fermented with the husks and seeds.

Succinic acid, $C_4H_6O_4$, in wine is one of the results of the fermentation of grape-sugar, which, in that process yields about a half per cent. of its weight of that acid. When the formulæ of succinic, malic, and tartaric acid are compared, it will be perceived that they all contain the same number of atoms of carbon and hydrogen, but not of oxygen, of which latter element succinic acid contains four, malic acid five, tartaric acid six atoms.

Acetic acid, $C_2H_4O_2$, occurs in wine and other fermented liquids, principally as the result of the oxydation under the influence of the air, of some alcohol. When the entire amount of alcohol in a fermented liquid is transformed into acetic acid, vinegar results. Vinegar from wine preserves some of the flavour of wine, and those accustomed to its use are therefore not inclined to exchange it for the more common vinegar made from fermented malt, or from acetic acid obtained by the fiery decomposition of wood. In good natural wine the amount of acetic acid does not exceed 1·78 per thousand, but is ordinarily only about a half per mille; in spoiled wine its amount may rise to 3·63 per thousand.

The œnanthic acid, to the ethylic ether of which most wines are supposed to be indebted for their characteristic smell, has the formula $C_{14}H_{28}O_3$, and does, therefore, probably not belong to the same series of acids as acetic, propionic, and butyric acid.

In good, sound wines the total amount of free acid varies between 0·3 and 0·7 per cent; wines with more than the latter amount of free acid taste excessively sour, and are not easily digested.

The ethers in wine are aceto-ethylic, which contributes much to the general flavour of the wine; aceto-propylic, butylic, amylic, caproylic; further butyro-ethylic, caprylo-ethylic, capro-ethylic, and pelargo-ethylic; and the tartaric ethers. The characteristic smell of the œnanthic ether distinguishes all kinds of wine from every other fermented liquid. The flavour or bouquet, however, by which wines from different vines and vineyards are distinguishable from each other, is produced by substances which are already present in the grapes, and the effect of which is only heightened by fermentation. The volatile ethers in wine mostly surmount the fixed ethers in quantity. The alcohol obtained by the decomposition of all the ethers is rarely more than 0·06 per cent. of the wine.

Wines may contain more or less of sugar of one kind or another. Must contains a mixture of sugars, of which one polarises to the right, and is therefore termed dextrose, while the other polarises to the left, and is in consequence termed levulose. If wine contains cane-sugar, it has been added, *e.g.* to Champagne. Even added cane-sugar is under the influence of the natural acidity of the wine, gradually transformed into the mixture of dextrose and levulose; this mixture also goes by the name of invert sugar. Some wines, *e.g.* Sauternes and old sweet Rhine wines, contain also a peculiar sugar, occurring in flesh and brain, namely, inosite. All sugars in must and wine have the chemical composition expressed by the formula $C_6H_{12}O_6$, but differ in properties. They are, therefore, not identical, but, as it is termed, isomeric with each other.

Another sweet-tasting substance occurring in wine and all other fermented liquids is glycerine, $C_3H_8O_3$, originally known as one of the constituents of animal and vegetable fats. During fermentation it is formed from sugar; 100 parts of cane-sugar, or 105·26 parts of grape-sugar, yield on an average 3·69 parts of glycerine, or one-fourteenth part of the alcohol produced by the same fermentation.

The colouring matters of wines are either natural constituents of the grape, or produced in must and wine during and after fermentation. Of the latter kind are most yellow and amber colours of natural so-called white wine. They are not rarely the result of the oxydation of astringent or tannic acids. But the red colouring matters are mostly contained in the husks, and dissolved only by the concurrence of the alcohol formed during fermentation and the acid naturally contained in it. The grapes from which some of the best red wines, *e.g.*, Burgundy or Médoc wines are made, yield an almost perfectly colourless juice if pressed before fermentation. But some rarer vines, and those yielding inferior wine, have, like the black currant, a coloured juice. Some of the red colouring matters contain iron as an essential chemical ingredient, and are therefore supposed to make the wines in which they are contained particularly wholesome.

Wine contains traces of ammonia, present in all vegetable juices; also albuminous matters, which are supposed to make the wine liable to undergo decomposition more readily. Wine also contains some substances which remain when it is evaporated to dryness, and are termed extractives. They have an agreeable smell and taste, and contribute to the smell and taste of wine in the same manner as the extractives of meat contribute to the smell and taste of meat and broth. Wine further contains a certain amount of inorganic or mineral ingredients, potash, soda, lime, magnesia, and phosphoric, sulphuric and hydrochloric acid in combination with the former. Sherries contain a large excess of sulphate of potassium, due to the treatment of the must with plaster of Paris, of which the results will be described under the paragraph relating to Jerez.

Wines of France.—The wines of France may conveniently be considered in five groups, those of Burgundy being the oldest known. Next to them, and from the same grapes, are produced the wines of the Champagne. In the south-west of France, in the valley of the Garonne and Gironde, are grown the wines commonly called of Bordeaux; and in the south, in the provinces on the Mediterranean, the ancient Languedoc, are grown the wines termed in French "Vins du Midi." French wines are never treated with brandy to the same extent as the Spanish and Portuguese wines, and the highest qualities are never treated with any brandy at all. Plastering is only practised in the southern districts, and is applied more particularly to red wines. Sweet, or so-called liquorous wines, are produced in the southern departments, in the Sauternes district, and in the Champagne, but they differ in kind among each other, and the only wine that has any resemblance to the heavy Peninsular wine is the red wine of Roussillon. The art of producing wines of natural composition and strength is more developed in France than in the Peninsula. It is owing to this that France produces not only wines of eminent *finesse*, such as the Médocs and Burgundies, and that peculiar wine effervescent Champagne, but large quantities of wholesome low-priced natural wines and useful beverages, which, like the effervescent Saumur, do duty for Champagne.

Wines of the Bourgogne.—Burgundy is the oldest viticultural country in central Europe, and thence migrated the art of making wine to other parts of France and to Germany, Bohemia, and Moravia. In the Middle Ages Burgundy was the regular wine on the tables of the great and mighty of the world, but the place which it formerly occupied in society is now taken by Champagne. That part of Burgundy which produces the best wines is named the Côte d'Or, or "golden hill-side." It consists of a series of hills about thirty miles in length, which stretch from Chalon on the Saône to Dijon, in the direction of N.N.E. to S.S.W., their cultivated inclination and exposure being consequently towards the east. They have a height of from 200 to 300 feet, and consist of a loose limestone mixed with a little clay. Burgundy has a mixture of vines in its vineyards, termed Passe-tous-grains. The black grape peculiar to the Bourgogne, the pineau or noirien, is dominating along the Côte, but in the ordinary situations, and in small vineyards, white and red grapes are found among the black. There is another vine, with larger berries, namely the Gamay, which dominates in the Mâconnais and Beaujolais, bears more abundantly, but gives a wine of inferior quality. Of white grapes the most frequently cultivated is the Chardenay, which prevails in the northern part of Burgundy, yielding among others the wine of Chablis. The vines are small, rise about a foot from the ground, and carry annually from three to four canes. The vintage takes place in September or October, the earlier vintages, being those of good years, generally yielding a better wine. The grapes are crushed and thrown into high vats to ferment. During fermentation, the husks and stalks rise to the top, and form the "chapeau." When the fermentation is completed, this top is distributed in the wine by mechanical means, to extract all the colour from the husks. Lastly, the wine is withdrawn, the murk is pressed, and the united liquids are placed in barrels to complete their fermentation. The barrels are pièces of 228 litres each, feuillettes of 114 litres, and quartants of 57 litres. The so-called great wines of Burgundy are produced in nineteen communes of the arrondissement of Beaune. We abstain from enumerating particular growths, as much abuse is practised with names. The best Burgundy wines are generally exported to Holland and Belgium, and the traveller in these countries may frequently obtain a bottle of good Burgundy when other wines are not to be had, or are of inferior quality.

We quote, after the late Dr. Druitt, some passages from Armstrong's 'Art of Health,' written about a hundred and fifty years ago, which are supposed to show how much Burgundy and other natural wines were esteemed at that time. When speaking of wholesome wine, he praises

> "The gay, serene, good-natured Burgundy,
> Or the fresh fragrant vintage of the Rhine."

He further describes Burgundy as the drink for gentlemen, and port as an abomination :—

> "The man to well-bred Burgundy brought up,
> Will start the smack of Methuen in the cup."

The last line refers to the port wine imported into England under the Methuen treaty made with Portugal in 1703, whereby the wines of the latter country were favoured by a low import duty, whereas the trade in French wines was impeded by an import tax amounting to more than double of that imposed upon Peninsular wines.

Armstrong already reprobates the mixing of wine with brandy, which seems to have been at his time, if not a new, at least a newly-revived practice. In describing a man's sensations on awakening after having drunk port wine the evening before, he says :—

> "You curse the sluggish port, you curse the wretch,
> The felon, with unnatural mixture, first
> Who dared to violate the virgin wine."

Champagne.—The wine which from the country of its origin is termed Champagne, is one of the most essentially French inventions. It is so remarkable that a wit included it amongst the three inventions which alone were worthy of the powers of the human spirit, namely, foil-fencing, the Jesuits, and Champagne. It is made mainly from the same grapes from which red Burgundy wine is made, particularly from the black pineau. It is colourless, because it is fermented without the husks, whereas red Burgundy, like all red wines, is fermented with the husks. The culture of the pineau vines in the Champagne may be termed viticulture by constant rejuvenescence. The vines are every three years sunk into the ground, and one year's wood only is allowed to project from the ground and from the new vine. This gives to the Champagne vineyards the aspect of constant youth, and much of the character of the wine is no doubt determined by this peculiar mode of growth. Harvesting and vinification in Champagne are very clean and perfect processes. The expressed juice of the grapes is fermented in casks. In ordinary years the whole of the sugar is fermented away, and yields about 8 or 9 per cent. of alcohol; but in very good years a small quantity of sugar escapes this first fermentation, and remains in the wine, to yield, by a second fermentation in the bottle, the effervescence which is desired. The wine, which has lost all its sugar in this first fermentation, requires therefore an addition of sugar to it before it can acquire the *mousse* in bottle. Two fermentations, therefore, are required in the production of *mousseux* wine: one in cask, to decompose the bulk of the sugar and produce wine, and one of the young wine in bottle to produce effervescence. The process is exactly the same as that which leads to effervescent bottled beer, or cider, or perry, or gooseberry wine.

The particulars of the steps which lead to perfect *mousseux* are the following: The young wine is clarified with isinglass previous to its being drawn into bottles. Then the acidity and sugar of the wine are carefully adjusted, so that the former may not exceed a half per mille, the latter 2 per cent. This sweet wine, termed "clairet," is now filled into the ordinary bottles, and corked in the manner in which we see the champagne corked when it is quite ready for use. The bottles are stacked in rooms of rather a high temperature, and their contents begin to ferment, as indicated by their becoming turbid, and by a few bottles breaking here and there with some explosive violence. When this stage is reached, the bottles are carried to a cooler cellar, where they complete their fermentation and deposit the yeast. When the wine has become quite clear again, and all the yeast is collected on the side of the bottle, the latter is so manipulated that all the yeast settles in a small lump upon the cork. This has now to be removed by a skilful operation termed disgorging. The wires and strings which hold down the cork are cut, and the cork is allowed to be expelled by the internal pressure, together with all the yeast and sediment. The loss of wine caused by this is filled up with some clear wine, and with a solution of sugar in wine termed "liqueur." For the wine, when disgorged in the effervescent state, is what is termed quite dry, that is to say, not in the least sweet, but tastes rather rough and unpleasant, from the mass of carbonic acid dissolved in it. The liqueur which is used for common wines contains also brandy and flavouring materials. The quantity of liqueur introduced varies between 10 and 28 centilitres per bottle of about 80 centilitres. For special, or so-called extra-dry Champagne, such as is preferred by some consumers in England, a lesser percentage is taken. The wine thus cleared and treated with liqueur is again corked, and prepared for sale in the well-known shape.

The manufacture of Champagne, though theoretically simple, is nevertheless a complicated mechanical operation, requiring above all cleanliness, skill, good taste, capital and good cellars. The latter, in the Champagne, are frequently dug into chalk rocks. Here the average temperature of the earth's crust nearly always prevails, and the wine, being never disturbed by fluctuations of temperature, attains that brilliancy which is the main cause and condition of its stability after disgorgement. The most dangerous and common disease of Champagne used to be viscosity or ropiness. Against this disorder, tannin from nut-galls, from catechu, or from grape husks and kernels, is used.

The wines of the Maconnais and Beaujolais districts are red and white. The red varieties are esteemed in France, as they are sufficiently coloured and acid to be suitable for being mixed with water for use at meals. The better varieties are heady in a manner which, according to our experience, is by no means explained by their alcoholicity only. Many of these wines are also manufactured into effervescent wines, including even red-coloured varieties. Much white effervescent wine is made upon the banks of the Loire, at Saumur, and sold at lower prices than Champagne of similar quality. Other parts of France, *e.g.* the Rhone valley, also furnish effervescent wines, all of which find their billets somewhere in the world.

Wines of the Gironde or of Bordeaux.—The Gironde is a beautiful and rich viticultural province, situated upon the lower reaches of the Garonne, Dordogne, and their estuary the Gironde. Its most valuable part is the Médoc, situated south-west of the Gironde, between it and the Gulf of Gascony. Here, on gravelly hills, grows that beautiful twin pair of vines, the carbenet sauvignon, and the carmenère. These vines are kept low on the ground, trained to espaliers not above a foot high. The tillage of the soil is mostly effected with the plough. The vintage is in September, and vinification is quick and simple, and is almost exclusively directed to the production of red wines. These are of very uniform character, though greatly differing in quality. They are divided into classified and non-classified wines. To the first rank of the classified belong those great properties termed "châteaus," from the habitation attached to them, under whose names so many substitutions take place. The details of these and the other classes may be read in works which treat of the Médoc, by W. Frank, by Cocks, or by Armailhac, or in the chapter of the 'Treatise on Wines' already quoted. The wines which do not belong to any of the five classes are termed "citizens" and "peasants." The first of these have again degrees of quality, namely: superior, good, and ordinary citizens, but the *paysans* are mostly held to be of one quality only.

Among cheap wines, those of Bordeaux are as a class tolerable beverages for the price, say at half-a-crown a bottle. Their alcoholic strength is mostly natural, and does not rise above 20 per cent. of proof spirit. They are perfectly fermented, and free from sugar.

Immediately surrounding Bordeaux is the district of the Graves, so termed, it is said, from its gravelly soil. It produces both red and white wines, of which the former resemble those of the Médoc. The white wines resemble those of Sauterne, but are much less esteemed on account of a peculiar objectionable surtaste, which is termed flinty or earthy. To the south-east of the Graves, and bordering upon the River Garonne, is the district of Sauterne. Here all the hills and slopes are covered with the twin pair of vines, the semillon and the sauvignon. These grapes have the peculiar faculty of becoming very sweet without passulation, or shrivelling to raisins, so that, while yet plump, they yield a must which does not during fermentation lose the whole of its sugar, but remains sweet, and sometimes greatly so, without the addition of any spirit. The collection of the grapes is effected in several stages, so that three qualities of wine are produced from the same vineyard. The finest and ripest berries yield the wine called head, *tête*, a sweet liquorous wine, which is consumed principally in Russia. The second quality, or the less saccharine berries, yield a wine which after fermentation contains no sugar, and is termed the middle, *milieu*. This is Sauterne, commonly so called in England. All the grapes which have not been used for the former two qualities are thrown together, and the wine made from them is termed tail, *queue*. When the three varieties of wine are mixed, the result is called *ensemble*. The production of sweet wines for Russia has depressed all qualities of dry Sauterne. On the right bank of the Garonne there are extensive vineyards producing red wines, which are exported from Bordeaux under the name of the town. They have no great peculiarities, and are therefore frequently mixed with some Médoc wine, and exported as such. On the low marshy ground is the peninsula formed by the confluence of the Garonne and Dordogne, which is termed *Entre deux mers*, large quantities of wine are grown. They are termed marsh wines, *vins de palus*, and in warm years attain considerable quality. But the viticulture of this district is mainly intended to produce quantity, and this is attained by the cultivation of medium-sized grapes, such as the verdot and the merlot, on espaliers which allow to each vine two or three tiers of bearing branches.

To the north-east of the Garonne are yet some districts which produce much wine: those of Libourne, St. Emilion, and the hills along the banks of the Garonne called "Côtes." The St. Emilion wines are fine, but thinner and paler in colour than the Médocs. The wines of the Côtes are white; they are eagerly bought by the Bordeaux trade, mixed with deep-coloured wine of Narbonne, and sold as red wine to Transatlantic markets, sometimes at such low prices as 9*s.* the dozen, cases, bottles and corks included. In purchasing Bordeaux wine it is advisable to disregard entirely the names, which dealers affix to bottles, and simply to select the wine according to taste and value intended to be expended.

Wines of Germany, Austria, and Hungary.—The principal wine-producing districts of Germany are the valleys of the Rhine and its tributary rivers. Austria also produces some wine, of which a small quantity is exported, notably wines of Vöslau. Rhine wines are characterised by a peculiar bouquet, the product of the Riessling grape. About half the vines in the Rhine valley consist of Riessling plants, and it is probable that this vine is indigenous to the Rhine valley. In the Palatinate the Riessling is frequently accompanied by the Traminer. The third variety of vine frequently grown on the Rhine is the Sylvaner, or Austrian. These three vines give, the first highly-flavoured, the second round bodied, the third spirituous wine, and in given cases the mixture of the fruit of the three produce an excellent wine. In Baden much wine is made from the Chasselas, there termed Gutedel. The black or blue varieties of grapes grown on the Rhine are all descendants of the Burgundy pineau. Ingelheim and Asmannshausen are the centres of their production, of which much is now used for the manufacture of effervescent wine. The wines of Alsatia are nearly all white and genuinely German, and are much used by the Swiss. The Palatinate produces about 800,000 hectolitres of wine. The wines of Rhenish Hessia are similar to those of the Palatinate on the one hand, and those of the Rhinegau on the other.

The vineyard south of the Liebfrauenkirche at Worms produces the "Liebfraumilch," a Riessling wine of some bouquet. The wines of the Maine are mostly very acid, Stein and Leiste excepted; Stein is sold in peculiarly-shaped bottles called "bocksbeutel;" much Palatinate is sold under this disguise. The Rhinegau, a district north of the Rhine from Hochheim to St. Goar, produces the finest wines in Germany. The entire Gau produces in good years about 10,000 stück, equal to nearly 20,000 butts, or four-sevenths as much wine as the sherry district proper. With regard to hock it is also advisable never to listen to a name, as these are frequently used with the same disregard of truth as the names of the Médoc. Sparkling hock finds much favour in this country, and with regard to this the playing with names has been abandoned. The Moselle wines are mostly lower-class wines, and possess as little flavour as the Franconia wines, but are made with much more care. Sparkling Moselle is a nice product of art, and derives its conventional flavour from the elder flower. The white wines of the Rhine are distinguished by never containing added distilled spirit; they are never coloured, plastered or boiled; and in these respects are equal to the best produce of the Gironde. For these reasons they are equally wholesome to drink; they produce none of the inconveniences of the brandied wines of Jerez and Oporto.

Tyrol, *Styria*, *Dalmatia*, and *Croatia* produce much wine, but it is mostly so badly made that it finds no consumption except in the localities. The vines of Istria and Görtz are grown much like the Italian vines, high in the air, and their product is without quality.

Hungary produces much wine of a low class; viticulture is very imperfect, the treatment of wines in the cellars very bad. Only some wine-merchants treat a certain portion of Hungarian produce with the skill necessary to make it a commercial article. There are two dominant vines peculiar to Hungary, the Furmint or Tokay, with white grapes, and the Kadarka with black grapes. The Furmint is sweet and strong flavoured; it becomes passulated on the vine;

it is from such raisins that Tokay essence, Ausbruch, and Maszlacz are made. These wines are syrupy, unfermented or little fermented. The fully-fermented Tokay is termed Szamorodny. Rust and Menes wines are made similar to those of Tokay; the most celebrated Tokay, therefore, is not properly a wine, but a highly concentrated grape-juice, in which alcohol is not essential to preservation, and is mainly an accident of some slight fermentation, which occurs slowly during the keeping of the wine. Old Imperial Tokay contains so much grape-sugar that it forms sometimes a sediment of crystals in the bottle. We have an exact counterpart to Tokay in the tintilla de Rota, which is made at Rota on the Gulf of Cadiz. This tintilla is also mere juice of raisins and boiled must, and is not intended to ferment or contain alcohol. But it sometimes does ferment slowly and slightly, and forms up to six per cent. alcohol. Latterly, however, both Tokay and tintilla are not rarely mixed with spirit, and have thereby become changed, and as we think, lost in character.

Wines of Spain.—Spain produces a great variety of wines from the worst to the best, red and white, dry and sweet; it has even been attempted to produce effervescent wine in that country, but the attempt failed, from the same disregard of the principles of œnological science which causes so much wine to be spoiled either by diseases peculiar to southern climates, or by brandy and plaster. The most beautiful vineyards of Spain, perhaps of the world, are those of Jerez de la Frontera, near Cadiz; they are situated on undulating hills, and in gentle valleys between them; the hills consist of tertiary limestone much mixed with clay and sand; the white clayey limestone, albariza, gives the best soil; the second best soil, consisting of quartz mixed with limestone and sand, and coloured by ochre, is termed barros. The vines grown in Jerez are all large-berried and large-bunched, such as only ripen in the very hottest climates out of the tropics. Most remarkable amongst them are the palomino, which is most frequently cultivated on the albariza soil; the mantuo castellano, which prevails on the sandy barros territory, and the Pedro Ximenes, which is grown on any soil for its great sweetness. The climate of Jerez is characterised by great heat and long-continued drought; autumn and winter consist of a rainy season; snow has fallen in Jerez only twice during this century. The labours in the vineyards are all performed by men, and are very important and severe. Thus in autumn each vine is surrounded by a square excavation and rampart, whereby the water is collected and compelled to sink into the ground. This process amounts to a real flooding of the vineyards; besides its main object, the thorough moistening of the land to enable vegetation to survive the rainless season, this practice attains the destruction of all vermin, so that the phylloxera can never live in a well-treated Jerez vineyard. The vines are kept quite low on the ground, and receive no supports; only the branches bearing nearly ripe fruit are slightly raised from the ground by short forked supports of reeds. The vintage begins about the 8th of September, and ends about the 20th. A vineyard of about an English acre in area, if of albariza, will produce from 1½ to 2 butts of wine, if the soil be dark or sandy from 4 to 5 butts. The Jerez vineyards produce about 36,000 butts of wine of all qualities each year. The grapes are spread on the platform bearing the press (lagar) and dusted over with plaster of Paris; they are next trodden and pressed; the resulting grape-juice or must is not more saccharine than that of any of the principal vineyards of France or Germany. As the average of more than a hundred experiments, I found the specific gravity of the must to be 12·39° Baumé. This would yield a wine with about 22° of proof spirit. Fermentation is conducted as rapidly as possible; the wine when clarified is racked, and now has about the same alcoholicity as other wines, *i.e.* from 18° to 24° of proof spirit. Brandy is now added at once to it, so as to withdraw it from the influence of a second fermentation, and of the principal abnormal ferments or so-called diseases, which, under the name of nube, scud, or viscosity, are known to spoil so many wines either for a time or for ever.

In its natural state Jerez wine ripens quickly, but the addition of brandy retards its maturation, and alters its character. It is owing to this that sherry is rarely obtained by the consumer in anything like a natural state. Not only is more brandy added to all varieties, but some qualities receive an addition of boiled must, or must concentrated to the state of a syrup, *arrope*, and then mixed with spirit, so-called *vino de color*, and others receive, besides arrope, an addition of the juice of sun-dried raisins preserved in spirit, so-called *dulce*. (Of this we have treated under the paragraph referring to liqueurs.) These processes produce a compound brown sherry, which is wine only in part, and is found to be less wholesome than the simpler vinous beverages. Pale sherry is a purer wine, if not blanched by animal charcoal; the principal objection to it is that it is still plastered and brandied. The principal effect of the plastering is that the wine has lost its natural tartaric acid, and has become impregnated with sulphuric acid, which remains combined with the potassium from which it has displaced the tartaric acid. Sherry therefore contains sulphate of potassium instead of the tartar which it ought to contain, and this anomalous ingredient causes to delicate constitutions inconveniences in the functions of digestion and circulation, which compel them to abandon the use of sherry. Some common qualities of sherry contain much more sulphuric acid than can be introduced by the process of plastering, and this is introduced as sulphurous acid or brimstone vapour after the must has been pressed. This latter acid remains to some extent in the free state, or becomes in part sulphovinic ether after a long time, while the acid introduced in the process of plastering remains combined. Thus we can understand why some descriptions of sherry should contain from three to five pounds of sulphuric acid per butt. In return for the unquestionable disadvantages of this practice, there must be conferred by it, we are ready to assume, some advantages, which the viticulturists obtain without being able to define them. We believe the principal advantage to be the removal of tartaric acid at a period when it can serve as food to the viscosity or scud bacterium; this fungus decomposes tartaric acid so as to liberate some acetic acid, and this just spoils the finesse and flavour of the wine; this development of acetic acid from tartaric must not be confounded with the development of acetic acid from alcohol under the influence of the vinegar fungus. The absence of tartaric acid from the sherry does not protect it from the inroad of the scud or viscosity fungus, but only from one of its casual effects; the other effects of viscosity or scud mostly remain in one shape or another, which may be summed up as general deterioration of the wine. We thus perceive that a fungus, by the ruinous changes which it is capable of producing in young wine, is the cause of the proceedings intended to avoid these changes, namely, plastering, sulphuring, and brandying. It remains to the future to supplant these primitive processes by better precautions, and to restore to sherry that natural beauty, purity, and vinosity, by which it would excel all other wines of the world. Sherry, during maturation in casks which are not quite full, so that air has constant access to a considerable surface of wine, is liable to undergo an advantageous development by the formation on its surface of a kind of fungus termed flor; it assumes a taste which forty years ago was considered to have spoiled the wine, but is now highly valued, namely the so-called taste of amontillado. This change is as yet a matter of mere accident, and cannot be produced at the will of the wine-producer. Only a small number of casks become amontillado, while the great number remain indifferent wine, or become sick, or spoil altogether. The average price of freshly-fermented wine, so-called *mosto*, at Jerez is about £12 per butt, but good amontillado, or *fino*, fetches several times that amount, and, after adjustment for the wants of the trade, is sold at high prices.

In Jerez, and generally in Spain and Portugal, there are no cellars, the wines are always made, fermented and kept in buildings above-ground, constructed for the purpose—

mere sheds, termed in Spain bodegas, in Portugal adegas These sheds are subject to all the variations of temperature of the air, and the wine in cask is constantly influenced thereby. Under these conditions wine would necessarily soon become vinegar, were it not heavily brandied. We thus see that not only fungi but also bodegas are amongst the causes which either spoil the wine in their own way, or cause it to be spoiled in a particular way by the additions necessary to prevent spontaneous decomposition.

The vineyards of San Lucar de Barrameda are situated on albariza hills near the mouth of the Guadalquivir. The wines are mostly listanes, the same as are termed palomino at Jerez. Vinification is the same as at Jerez; plastering, vino de color, dulce and brandy are used to make up the semblance of sherry. But there is a specialty produced at San Lucar, which may be termed the parallel to the Jerez amontillado, namely the so-called manzanilla de San Lucar. This wine has a particularly nice, though thin flavour, while young; with age it becomes very dry and somewhat bitter. It has the character of all wine made from somewhat under-ripe grapes, and becomes passado at less than one-third of the age of genuine sherries. The manzanillas de San Lucar are generally sold at less than half the price of Jerez wines, and, like them, they are always suffocated in spirit before shipment.

Rota, a village on the north side of the Gulf of Cadiz, produces, on sandy soil, some varieties of viticultural products, of which the tintilla de Rota is the best known. It is a syrup made from passulated grapes by maceration with must concentrated by heat; it ferments a little, so as to form about 12 per cent. of proof spirit, and thus acquires some vinosity and flavour; it is an agreeable sweet liqueur, but it is now frequently spoiled by dealers adding brandy. Wines of the Val de Peñas are imported into England at the almost natural strength, containing less than 26 per cent. proof spirit; they are both white and red, and of good quality at their price.

Catalonia, Aragon, and *Valencia* produce some beautiful wines. Red Catalan, sweetened and brandied, is now imported into England under the title of Spanish port. The Valencia wines are perishable, and have no great reputation except for distilling brandy from them. Alicante is distinguished by producing in great perfection the vine which bears the name of the town throughout Spain and the south of France, but at Alicante itself is termed tintilla; its juice forms the basis of most Spanish red wines. Granada also produces a few thousand butts of wine, of which those produced at Malaga are the best known; they are mostly exported to America. The wines of Catalonia, Aragon, and Valencia, white as well as red, are almost all plastered, and several Spanish œnologists have strongly protested against the practice, which they term an adulteration and a fraud. Some wines are accidentally plastered by being kept in underground cisterns of masonry, of which the building and lining material is plaster of Paris; the stones also are gypsum now and then, and stones of gypsum, gathered from the fields, are not rarely used to keep the murk submerged in the fermenting wine. It is likely that the practice of plastering arose out of some such accidental observation.

On the whole the wines of Spain are by nature generally excellent, but are easily and quickly spoiled, in part by diseases, in part by unskilful and unscientific treatment. The admixtures effected to counteract these accidents are more or less objectionable, because unwholesome to the consumer. It ought therefore to be impressed upon œnologists that if they desire to see their industry rise from the depression from which they complain that it suffers, they must prepare natural pure wines, and avoid the accidents and admixtures described in the foregoing.

Wines of Portugal.—The principal wines of Portugal are those grown in the Alto-Douro district, and exported from Oporto, and hence termed port wine. The district is a mass of rough mountains formed by clay schist, similar to the Grauwacke of the Rhine valley. It is the vine, and the vine alone, which has made the Alto-Douro a cultivated part of the earth's surface. The vineyards are constructed with so much labour in the face of so many difficulties, that they may appropriately be termed "the vineyards of Hercules," while those of Jerez, owing to their soft undulating beauty, deserve the name of "the vineyards of Venus."

The district between Oporto and the Alto-Douro is the province of Entre Douro e Minho, and is remarkable on account of the many semi-wild vines which grow here upon trees, and furnish the material from which the natives produce an awful drink, termed vinho verde.

The vineyards in the Alto-Douro are all arranged in terraces constructed with stones. Sometimes a mountain side may bear as many as one hundred and fifty terraces and walls. The Douro vines have this peculiarity in common, that their fruit is not large-sized like the grapes of Andalusia, nor small-sized like the grapes of Burgundy or the Rhine; but medium-sized like those of the paludal or Sauterne vines of the Gironde. The Verdeilho yields a fine peculiar wine; the Mourisco gives a very sweet wine, with much body and colour; the Bastardo produces fine wine, but with little colour. The vintage takes place between September 20 and October 10; that is to say, as late as is compatible with the safety of the crop, in order to let the juices become as concentrated as the sun will make them. The vintage labours, as indeed all the vineyard cultivation, are effected by workpeople of both sexes from Gallicia, hence termed Gallegos. The grapes are trodden by men on platforms, and the murk and juice are removed to stone-built vats, lagares. When the fermentation has so far proceeded that the amount of alcohol formed has dissolved all the available colouring matter, the mixture is agitated, and the wine drawn off. The mixing and agitating is effected by men standing in the vats. These act as living stoves to keep the wine up to the fermenting temperature in cold weather. In good years, when the wine contains more sugar than can be decomposed by a first fermentation, the addition of brandy to newly drawn wine completes the first preparation; but in years in which sugar is deficient, this as well as alcohol have to be supplied. Sweetness is supplied frequently in the shape of concentrated grape-juice preserved in spirit; this is called jeropiga. Port wine mostly contains so much colouring matter that it can bear the addition of white jeropiga; it very rarely will require increase of colouring matter, so that the stories about elderberries in port wine do not seem to have much foundation in fact. These wines are never plastered, and the only extraneous addition which all of them receive is brandy. The minimum is three gallons to the pipe; but the so-called rich wines contain from fifteen to seventeen gallons of adventitious brandy in each pipe of 115 gallons. Thus dosed up to 40 per cent. of proof spirit, port wine becomes undrinkable for many years; but keeps. Port wine with less than 34 per cent. proof spirit, is liable to undergo a second fermentation, and to deteriorate by acquiring an acid flavour; but with proper arrangements port wine of natural strength can be made and preserved, and this is a fine, dry, full-bodied, full-flavoured beverage, which is more like the finest Burgundy than like the manufactured traditional hot and sweet port; but has a bouquet which is quite unique. Such a wine, which we examined, showed only 14·91 per cent. of alcohol by weight in volume of wine, therefore only about two-thirds of the alcohol contained in ordinary varieties; of this, from 1 to 2 per cent. was probably added. Perfectly natural port wine has 9 per cent. as the lowest, and 13·8 per cent. as the highest limit of alcoholicity, therefore, the same as Médocs, Burgundies, hocks, and sherries.

Genuine port wine is easily recognised before the spectroscope by a single absorption band overlying the D-line. Elderberry juice, on the other hand, has four absorption-bands, one in red, a broad one in yellow and green, and two in blue.

A low-priced, natural, dry, red wine, termed consumo, meaning a wine for ordinary use, grown in the Douro valley, is now imported into England; it contains only 10·91 per cent. of alcohol, and thus keeps close to, but slightly above the full quantities of Burgundy. A variety of port was formerly made from white grapes, and much favoured in Ireland. But it is rapidly going out of use there, as elsewhere.

Other Portuguese wines are those of the neighbourhood of Lisbon, which are mostly sugared and brandied; those of Bucellas, made from the Arinto grape, supposed to be identical with, but probably only resembling, the Rhenish Riessling; those of Carcavellos: the last two wines are almost traditions only, as the vineyards are almost entirely destroyed by the oidium. Much red wine is made in the Torres Vedras valley, and all exported to France to be sold as Bordeaux wine. Collares is grown below Cintra, and is mostly consumed at Lisbon. The rest of Portugal is teeming with wine; but it is so badly made that it is unfit for trade. The Government of Portugal has, however, taken great pains to spread information amongst the cultivators of the soil, to improve vinification; and the reports of their commissioners are most important documents in the history and literature of œnology.

Wines of the Atlantic Islands.—Madeira is an island of tertiary limestone, overlaid by the eruptive products of an extinct volcano. The vines here cultivated came from Candia; most important is the so called malvasia, which yields the best Madeira wine so called; the vidogna is, perhaps, cultivated on a larger area than the malvasia, it is similar in appearance to the chasselas, and yields dry Madeira. But the vine prevailing in the new plantations is the verdeilho. The vines are mostly grown high on espaliers. The grapes are trodden and pressed, and the must is fermented in barrels. It is then racked, mixed with brandy, and matured in magazines which can be heated to 140° Fahrenheit, so called estufas (stoves). Unfortunately the wine is not always heated early enough, so that much of it retains traces of the diseases to which it is liable, particularly scud, viscosity, and mouse-taste. Most

Madeira is dry, *i.e.*, free from sugar; the sercial grape imparts to it some astringency, and with it lasting qualities; it can therefore be preserved with less brandy than sweet wines. Before 1852, Madeira produced 20,000 pipes of wine annually; between that year and 1857 all vines were destroyed by the oidium. In 1878 about 13,000 pipes are stated to have been produced; but the exportation in 1881 had only risen to 3,447 pipes.

The Canaries are a group of seven islands, the principal of which is Teneriffe. All have volcanic soil, and produce wine from the malvasia, vidogna, and verdeilho grapes. Canary sect of former times is said to have been the sweet white wine of these islands, "vino secco," or "seccato," so called because it was made from grapes which had been dried or passulated to a certain extent before vinification.

The Azores produced about 5,000 pipes of wine annually; the present production is small. Most of the wines from the Canaries and Azores are vatted with and sold as sherry.

Wines of Italy.—A great variety of wines is produced in Piedmont. Those of Asti and Chaumont have acquired a reputation. We have obtained a number of wines from Turin; but found that the effervescent ones (spumantes), all became viscid, and formed furs of fungi in the bottles, while the red ones were all in a state of fermentation, and, when this was over, retained a peculiar biting taste not dependent upon carbonic acid. Grignolino, so called from the grignoli grape, a relative of the carmenet of the Gironde, seemed to us to have a future, provided it were prepared with scientific accuracy.

The best Italian wines are produced in Tuscany. Of vines, the aleatico, or red muscat, is extensively grown at Monte Pulciano, between Sienna and Rome, and other places. The wine is liquorous, purple in colour, sweet (extract rising to 21·88 per cent.) and slightly astringent. A good red wine is made at Chianti, near Sienna, from a peculiar grape. The nobles of Florence, like those of

Vienna, sell their wines in retail from their palace cellars, in flasks of the shape of the well-known oil-flasks, containing about three quarts each. These bottles are not stoppered; but the wine is covered with a small quantity of oil, which is removed before the wine is poured out The wines of Lombardy and Venetia are common and unfit for export. Central Italy produces the wine of Orvieto, and the liquorous muscats of Albano and Montefiascone. Of South Italian wines, those growing round Naples have alone some quality. On the whole, wines in Italy are badly grown, badly made, and strangely flavoured with resins and extracts. But Sicilian wines, which are reared by English enterprise, are remarkable for quality and low price. Only one variety is exported in large quantities, namely, the light amber or brown wine which goes under the name of the town from which it is exported—Marsala. It is situated near the western termination of the northern coast of Sicily. The vineyards extend along the coast towards the east and west, over an area of upwards of twenty square miles in length, by twelve in breadth. The soil is a chalky clay. The varieties of vines are many, and the grapes are all of inferior quality. All the wine shipped from Marsala to England is strongly brandied. Much of it is sold as such; but large quantities are transformed into sherry so-called. The total quantity of wine grown in Sicily is not known; less than 300,000 gallons of it are consumed in England.

Wines of Greece.—The Kingdom of Greece and the Greek islands of the Mediterranean sea are very favourably constituted for the production of wine; but the opportunities are not made use of so successfully as could be wished. The production of wine, which was considerable at the time of the Venetian supremacy, has sunk to a relatively insignificant amount. Most of the vines are cultivated for the production of currants; the principal variety producing them is termed *Vitis Corinthiaca*, also called *apyrena*, the stoneless, and, from its product, *Uva passa*. Another Greek vine is the Greco, a third the Cipro. The most important vine for the small islands seem to be the assyrticon, which forms the great majority of the vines of Santorin. It would be impossible to enumerate the various Greek wines made; they are mainly used in the locality, or exported to the East, latterly also to France. Some are of good quality originally, but are spoiled by bad management. The so-called Hambro, or Elbe sherry, is made from Greek wines, both dry and sweet, exported by a German company from Patras, in English ships, to Hamburgh, and there mixed with refined potato spirit; the coloured and flavoured preparation is superior to sherry in this particular, that it is not plastered; but it only ranks with the lowest sherries in price, as it possesses only little vinosity. The wines described by various travellers are interesting, and may in the future obtain the mercantile success which they deserve.

The wines of Cyprus are of two kinds, fermented and liquorous. The Commandery wine is made in vineyards near Paphos, in the district of Orni. It is fermented and matured in about 40,000 earthernware vessels, of the ancient shape of amphoræ, of which each holds from 10 to 12 litres. The wine is of a dull colour, and becomes tawny by age; it is a little sweet, with an astringent taste, and a peculiar flavour, reminding of bitter almonds, and supposed to be imparted to it to a certain extent by extraneous spices. It is still mainly consumed at Venice and Livorno.

In *the Crimea* much good wine is made, partly on the Imperial Russian estates, partly in vineyards belonging to private persons or companies. The products are consumed in Russia, and form no article of Western trade.

Asia produces splendid grapes, and in some parts of its vast expanse excellent wines, *e.g.* at Schiraz. As they are at present prepared, they do not suit the European taste. The wines of Schiraz are sold by weight. A Persian proverb considers them essential agents of happiness: "Who will live merrily should take his wine from Schiraz, his bread from Yesdecast, and a rosy wife from Yest"

Some Schiraz wines travel as far as Hindostan, China, and Japan.

Africa produces wines in various parts. The best known are those of South Africa or the Cape of Good Hope. The vines grown there were all imported from Europe about 1650. Fully fermented wine is made from the black Burgundy, and the Riessling grape; but the constantia, a liqueur wine, is made from the muscat of Frontignan.

Madagascar possesses an indigenous vine which the inhabitants declare to bear poisonous fruit.

In *Morocco* and *Algiers* excellent grapes grow, and some wine is made. In Algiers viticulture is expanding; but in Mahommedan lands it meets with many difficulties.

In *America* many indigenous vines have been discovered, and cultivated either as found, or after crossing with other varieties. The most remarkable of these are the Catawba, the Cape grape, the Isabella, Bland's Madeira, Ohio, or cigar-box grape, Lenoir, Missouri, Norton's seedling, and Scuppernong. From the black Catawba an exquisite effervescent wine is made, which has a most characteristic bouquet. Of this, about 200,000 bottles are annually produced. The wines from the other varieties are in course of development. Cincinnati is the centre of viticulture in North America.

Wines of Australia.—Viticulture was begun in Australia in 1830, and is now of some importance. It is said that most of the wine-growers in that colony are gentlemen of property, who are desirous rather of producing fine and creditable wines than of obtaining large or immediate profit. The effect of this interest taken in the subject by a few respectable growers must be to establish the character of the wines, and render their production a permanent and remunerative interest. New South Wales, South Australia, and Victoria, all produce wines, which are mostly fully fermented; some are a little brandied; some are prepared as liqueur wines. A few varieties are imported to and sold in England.

British or Domestic Wines.

When we speak of British wines, we thereby signify fermented liquids made after the manner in which wine is made in viticultural countries, but with fruit juices other than that of fresh grapes, or with saccharine matters derived from other parts of plants, or from animals. Before the reduction of the wine duties in 1860 much wine was made in this country from imported fresh grapes, and at Reading, *e.g.*, there existed a manufactory owned by an intelligent and enterprising French wine-cooper, where genuine black Burgundy or Champagne grapes, imported from France, were transformed into wine, and this ultimately into Champagne. Similarly, London wine-makers made Champagne at their British wine manufactories. These effervescent wines differed from genuine Champagne only in this, that they were manufactured in England, but in all other respects they were genuine wholesome wines, of fair quality at their price. This manufacture was profitable as long as the heavy import duty on French wines was levied, but ceased to be so as soon as natural wines could be imported into this country at the import duty of 1*s.* per gallon. Fresh grapes continue to be imported into this country for the production of British wines of various qualities. They serve, however, mainly as the ferments of larger quantities of saccharine matters, mostly cane-sugar, and the products are, as far as we are aware, mainly sweet wines, some being flavoured with aromatics, spicy, or bouquet-imparting ingredients, without addition of spirits, while others are mixed with spirits and coloured, so as to resemble common varieties of port and sherry. We cannot exclude the latter from notice, although we do not approve of imitations of any kind. But most of the British wines which we shall have to notice are so peculiar and so good, so original in their taste, when properly made, and owing to their cheapness so useful to many classes of the people, that we think it just and patriotic to put their merits properly before the public in these pages.

*Apple Wine or Cider.**—This beverage is made in considerable quantities in South Germany, Brittany, and several counties of England: Gloucestershire, Worcestershire, Monmouthshire, Devonshire—more particularly Herefordshire. In the latter county the apples which are more particularly suitable for the production of cider bear the following names: Foxwhelp, Skyrmer Kernel, Red Must, White Must, Styre, Red Streak, Kingston Black, Royal Wilding, Golden Pippin, and Woodcock. (Dr. Robert Hogg: communicated to the author on the occasion of the Apple Congress at the Royal Horticultural Society's Garden at Chiswick.) These apples are not often fitted for the table. They are required, says Booth, to be juicy, of an acid, tart, and aromatic flavour, with a certain degree of astringency. (Cf. Knight, on the 'Cultivation of Apples and Pears.') The Styre or Stire apple is, however, a tolerably good eating apple, while it is esteemed far superior to the other cider apples. Stire cider frequently fetches four times the price of common sale kinds. Coccagee cider is famous in Devonshire, and in this county the farmers are said to have a belief that the finest old fruit-trees were originally brought from Normandy; but the varieties are many of them kernel-fruit, that is fruit from seedling stocks which have never been grafted. Of these Marshall, in his 'Rural Economy of Gloucestershire,' 1789, speaks with enthusiasm of the Hagloe crab, which would appear to be superior even to the Stire. In general practice, cider is made from a mixture of apples which ripen at the same time. Some make their cider from apples and pears jointly, and others from sweet apples mixed with common wild crabs; but these are chiefly for home consumption, where what strangers would term insufferable harshness is accounted a good property. The rough cider of the farm-house is a beverage against the use of which the urban palate rebels.

* Cider, Fr. *cidre;* Arm. *cistr;* ciderist, cider maker or seller; ciderkin, the last pressed, or poor cider. Stum: must, or unfermented wine; also new unfermented wine, which is poured to old. To stum: to pour new must to old wine, to sulphurise.

The apples must be carefully gathered, without being bruised, during dry weather. They are then put in heaps of ten or twelve inches thick in the open air, exposed to the sun and rain, and uncovered, except in severe frosts. In these heaps they are left to mellow, that is to say, to increase in sugar and decrease in acidity, and acquire the highest possible flavour. They show the state of perfect ripeness by the deepest yellow colour which can be acquired without discoloration of the rind by decay. All green or decayed apples are picked out and removed.

The apples may now be pounded with wooden pestles, covered with nails (Cornwall, Ireland), or they are crushed under a stone, which is moved in a semi-circular or circular trough by human or animal power. Such a trough is fed with about two bushels of apples at a time. The ground apples are termed pommage. A man, having a female or a boy to assist him, usually grinds, with one horse, between two and three hogsheads of pommage a day, whereas with the hand-mill, which is much in use, three men can scarcely make a hogshead.

The pommage is allowed to rest about twenty-four hours, and is then pressed in the cider press. The pulp is wrapped up in hair-cloths, which are folded up square. They are laid one upon the other to the number of ten or twelve, and then pressed: slowly at first, strongly afterwards. On an average two hogsheads of fruit yield one of juice. The specific gravity of this varies between 1040 and 1060, which is equivalent to from 14 to 21 lbs. per barrel, as weighed by the brewers' saccharometer. The use of this instrument has not yet penetrated to transactions in cider-juice between farmers and dealers. The cakes of pressed pulp, provincially called cheeses, are re-ground with water, and these washings, as they are called, are again pressed, and yield a weaker must, which is fermented apart for the use of the servants. The fruit sufficient for three hogsheads of cider is generally allowed to make one hogshead of washings. These washings show nearly the same specific gravity as the original must.

The turbid must is placed in barrels for fermentation. The barrels are mostly made bung full; some, however, leave some ullage. The thermometer is not used to watch the fermentation. The manufacturers of sweet cider endeavour to check the fermentation as far as they can by exposing the cask to the cold open air (Knight). If the fruit be imperfectly ripened, and the weather warm, fermentation will commence in less than twenty-four hours, while with ripened fruit and juice of great gravity it will occasionally remain without any appearance of change for a fortnight, especially in cold weather. If the must be now racked from the lees, and sulphured, fermentation will be at a minimum; and if this process be repeated, a sweet liquid with little alcohol will be obtained. In some parts of Normandy, the juice, after having undergone for about three days a tumultuous fermentation in large tuns, is drawn into casks, and then left to complete its fermentation without further racking.

The casks are now and then filled up during the winter. In March the cider is mostly found clear and fit for being racked. Now the ciderists mix the wines of various colours, to produce uniform products. The highly-coloured cider made from the Jersey, or the luscious sweet apple, is mixed with the pale-coloured cider from the poor or sour apples. After this spring racking and mixing, the casks are bunged and laid to rest in a cellar. Cider which remains turbid must be fined with isinglass or with blood. The latter finings make the cider very pale, so that it is desirable to colour it again by caramel. Rarely the cider remains sufficiently sweet to please the palate, particularly of the London public; it is therefore mostly made sweeter by the addition of sugar syrup.

It has been proposed to reduce the acidity of apple must by the addition of water and sugar, say to one volume of must, according to its acidity; one volume or two or three volumes of sugar solution containing 20 per cent. of cane sugar. The addition might be regulated, so that the product should contain from 2 to 3 per mille of acid.

Such a product would, however, be different from natural cider or apple wine, and particularly would be much more alcoholic. This would be favourable to its keeping qualities, but involve a different use by the population.

Apple wine contains alcohol, sugar, pectin matters, gum, glycerine; of acids, malic, tartaric, amaric, acetic, tannic, oxalic, succinic, lactic, mineral matters, and ethers, which latter form the bouquet. Malic acid predominates over all others. French and English apple wines contain on an average—alcohol, 5·35 per cent.; malic acid, 0·342 per cent.; acetic acid, 0·111 per cent.; sugar, 3·27 per cent.; extractives, 4·75 per cent.; ash, 0·26 per cent.; its specific gravity is 1·0118. Swiss apple wine gave 7·35 per cent alcohol, 0·57 per cent. malic and acetic acid, 1·85 per cent sugar, 3·53 per cent. extractives, and 0·43 per cent. ash Apple wine contains more calcium than grape wine.

In Devonshire a spirit used to be distilled from the fermented must, and the grounds and lees of cider, by means of a porridge pot, with a tin head over it, and communicating with a pipe passing through a hogshead of water. It was drunk in a recent state under the name of "necessity," and was considered to be more particularly the remedy for colic brought on by the inordinate use of rough cider.

Perry.—Perry is wine from pears, and is made in Herefordshire, Gloucestershire, Worcestershire, and Monmouthshire. The pears selected must possess some degree of astringency (according to Knight, 'On the Cultivation of Apples and Pears'). This quality is so necessary, says the author, that he never knew a single instance in which perry made from fruit without astringency did not become sour before the middle of the succeeding summer. Pear-juice, which does not naturally contain astringency, may have it imparted to it by admixture of some juice from the crab-pear. The pear preferred in Herefordshire is the squash-pear, which, according to Marshall's 'Rural Economy of Gloucestershire,' 1789, "has probably furnished this country with more Champagne than was ever imported into it." It is described as remarkable for the tenderness of its flesh, which bursts if the fruit is allowed to fall ripe from the tree.

Two hogsheads of pears yield about $1\frac{3}{10}$ hogsheads of juice. The fruit is ground and pressed in the same manner as the apples, but the pulp is usually taken directly from the mill to the press. The management of the liquor is more precarious, so that good perry is always higher in price in the London market than cider.

The tumultuous fermentation is not so marked in pear-juice as in apple-juice, for the cider-juice carries a head, whereas the perry presents little or no scum, and remains more or less muddy when the first fermentation is over. The after fermentation is prevented by racking, sulphuring, and particularly fining with isinglass. Perry is liable to mishaps during the first summer of its existence, and to avoid these the casks containing it were not rarely bound strongly with hoops and ropes, and sunk in a deep pond. Late in autumn the casks were raised, and the perry was now found clear and effervescent.

Besides great astringency, the pear-juice to be used for perry must possess much saccharine matter; while the fruit yielding it cannot be eaten, the juice once pressed becomes agreeable to the palate by the influence of mere contact with the air. It contains much less malic acid than apple-juice, but more sugar and tannin. Good perry is much more similar than cider to the white wines of the grape. It is said by Booth that, without any mixture, good effervescent perry has often been mistaken for the best quality of effervescing Champagne. An amateur, quoted by Booth, advises that the pear-juice should be concentrated by heat, during several hours, at 160° to 200°, while the feculencies as they arise should be skimmed off. The juice is now to be transferred into a wooden vessel, and allowed to cool to between 110° and 130°. It is then to be racked off, and to undergo a second coction; and, if the harshness is not then completely gone, a third coction is to take place. The must, thus purified and concentrated, is to be put into a cask, bung uppermost, but not quite full. It should then be bunged up close, while a peg-hole should be left for the escape of gas. The fermentation sets in quickly, and becomes tumultuous, on account of the warmth of the liquid and the great amount of sugar. The silent fermentation which succeeds produces a clear and strong perry, which has the advantage of keeping, and of improving with age.

A pear-tree in Herefordshire is recorded to have attained the circumference of 18 feet, and to have yielded 7 muids (French) of perry annually. The ancients knew perry as well as apple wine, as is evident from the passage of Pliny (lib. xiv., c. 19): "Vinum fit e pyrorum malorumque omnibus generibus."

Raisin Wine.—Macculloch, and after him Booth, states that the manufacture of raisin wine has never been successful in this country. This is, however, somewhat in contradiction with the fact admitted by them, that such wine is made on a very large scale by the makers of "sweets." British wines, so-called, are made by special traders; their produce is not subject to any excise impost, except as to the distilled spirits which they use for fortifying it. British wines, containing as they do a very large amount of sugar, mostly of the cheapest kind, are classed by the alcoholic excise with sweets, and hence their immunity from taxation. But we are not aware that British wine-makers are makers of any other truly so-called sweets beyond these wines, which we discuss shortly in the following.

We describe the production of raisin wine after Booth. Having made choice of good and well-preserved raisins (for in this case, as in every other fermenting process, everything depends in the first instance upon the quality of the first materials), they are to be carefully separated from their stalks, and minced into small pieces; these are put into a tun, or tub, according to their quantity, and covered with soft water at 150 to 160° Fahrenheit of heat, and well stirred. The fruit swells and imbibes the water. In this mixture is put a quantity of cream of tartar, previously dissolved in a portion of water, equal to the two-hundredth part of the weight of the picked raisins employed. When the whole has cooled down to 60 or 70 degrees, the raisins are taken out by means of a sieve, and broken, bruised, and pressed more completely, when they are returned again into the liquid, and left to ferment. When the fermentation is nearly complete, as indicated by the falling of the head, the wine is put in casks to complete its fermentation; and, this over, is bunged and allowed to clarify in the usual way. From five to seven pounds of picked Malaga raisins to the gallon of water ought to make a good ordinary wine. Eight or ten pounds to the gallon would probably make a sweet wine, which would require a lengthened fermentation in the cask. It is to such wine that spirit is added to stop the fermentation and clear the liquid. But this spoils the product for at least a long time, and as a dietetic drink for ever. Raisin wine requires to mature for a year in cask before it is fit for drinking. It has generally a natural flavour, which causes it to be an agreeable beverage. But, as met with in trade, it is too often spoiled by being flavoured with elder flower, to imitate the muscat or muscadine perfume.

In the present day very large quantities of raisin wine are made in France from raisins imported, particularly from Smyrna.

Currant Wine: Red, and White, and Black.—Currants are eminently qualified to produce a good wine, provided that the must is corrected by the addition of water until its acidity is reduced to about 5 per mille, and by the addition of sugar its dissolved solids are raised to about 20 per cent. Booth maintains that currants are benefited by coction, but admits that the flavour of the wine may be thereby diminished. Black currants lose greatly in flavour by any degree of coction, and a syrup made from their juice, which is sold by a celebrated fruit-syrup maker, and is quite genuine, tastes only of the acid of the black currant, and has no flavour whatever left, so that no one could by mere tasting diagnose the origin of the syrup.

It is therefore probable that the good effect of coction upon currants, in some respects, may be counterbalanced by a loss in other respects. The good effect could probably be secured without drawback by coction in hermetically-closed vessels. We have made excellent currant wine from all three varieties of currants; the wine, in every case, was free from fault, full of taste and alcoholicity, of great characteristic flavour, and in the case of black currants of immense flavour and deep red colour. The ripest and best fruit should be chosen, cleaned, and crushed. To it should be added a quantity of warm sugar water, containing twenty pounds of white cane-sugar, in one hundred parts of solution, to be made therefore by dissolving one part by weight of sugar in four parts by weight of water. Booth gives a description of a laborious method of making currant wine, which in this country would yield a very acid product. He says that it was probably for the purpose of guarding against this *slightly acidulous* flavour that all the receipts for making currant wine, which have found their way into cookery books, or among the receipts of private families, recommend to mix a large proportion of water with the juice, making up the deficiency of strength with sugar, or, more directly, with spirit. He terms this a heterogeneous mixture, which usually required the yeast of beer before it will ferment, and judges that this produced a species of shrub, rather than wine, to which it bore scarcely any resemblance. This account shows that it is written without any experience on the subject, and that the records of ages reveal a correct practice. The adjustment of acid and sugar-water to the proportions above given imitates those of the best wine-must, and the mixture, containing the crushed fruit, ferments readily without added yeast, and completely, and furnishes a product which is in every respect *a wine*, and bears the unmistakable flavour and colour of the fruit from which it is made.

Gooseberry Wine.—The constituents of gooseberries in the ripe and unripe state are stated in Muspratt's Chem. Dict., 1st edition, "Domestic Wines," to be as follows:—

	Unripe.	Ripe.
Green colouring matter (chlorophyll) . .	0·03	..
Sugar	0·52	6·24
Gum	1·36	0·78
Albumen	1·07	0·87
Malic acid	1·80	2·41
Citric acid	0·12	0·30
Lime	0·24	0·29
Lignin or cellulose, with seeds . . .	8·45	8·01
Water	86·41	81·10
	100·00	100·00

It will be seen from this that during the process of ripening the percentage of the acids does not only not diminish, as is frequently supposed, but increases considerably. The main accession, however, is that of sugar, which rises to a little above 6 per cent. Now if a wine were made from such ripe fruit, it would contain only about 3 per cent. of alcohol, and 2½ per cent. of acid; and although a fluid with so little spirit might with due care be preserved in a sound state, yet it would be far too acid to be agreeable for drinking. For it is a well-established rule of taste that any fermented liquid of the wine class should not contain more than a half per cent. of free acid. One hundred parts of ripe gooseberries therefore, such as were analysed in the above-given experiment, contain sufficient free acid to impart the proper acidity to 500 parts of liquid; 100 parts of such gooseberries therefore would have to be diluted with 400 parts of water to produce a liquid of the proper acidity. On the other hand, 100 parts of unripe gooseberries, with 1·9 per cent. free acid, would require less than 300 parts of water to produce a liquid of the proper acidity. To each 80 parts of the latter liquid 20 parts of sugar would have to be added, while to each 80 parts of the diluted liquid made with ripe gooseberries only between 18 and 19 parts of sugar would have to be added to produce a must fit for correct vinous fermentation. The excellent quality which gooseberry wine not rarely attains has given rise to the fable that it served for the manufacture of *British Champagne*, an imitation which was often substituted fraudulently for the original. This is no doubt the largest of the gooseberries which do service as the subjects of little paragraphs at that time of the year when the people cannot be incited to peruse current literature even by sensational news. Truth is, that the wine from gooseberries becomes more easily effervescent in bottle than other wine, but it is untrue that it could be substituted for champagne, for its flavour is so unmistakable of the gooseberry, that any person of taste and experience would at once recognise it. The gooseberry succeeds well in northern latitudes, and those grown in Dundee, Aberdeen, and Inverness, are said to be superior even to those grown at Edinburgh. It is said that the gooseberry, particularly the yellow variety, which on account of its juicy quality is chiefly employed in making wine, has a period of maturity beyond which the juice loses its flavour and becomes insipid. It is further assumed that on this account so many English recipes for gooseberry wine recommend making use of the gooseberries before they are ripe, and make up for the want of their natural sweetness by an increased proportion of sugar. We agree with Booth that every unripe as well as overripe berry should be picked out of the fruit from which it is intended to make wine. We then adjust acidity and strength by the addition of water to the crushed gooseberries, and of so much sugar that the solids in the filtered juice amount to at least 20 per cent., and ferment the entire mash, without straining the juice from the husks. Immediately after the fermentation is over the wine is strained, and the murk pressed in a flannel bag or horse-hair cloth, such as is used for pressing apple murk. When the wine has become clear in cask, it may be put in Champagne bottles, and treated as is usual when it is intended to make effervescent wine. If the gooseberry wine was clear it will make so slight a deposit of secondary yeast that no disgorgement is required. Gooseberry wine as met with in English country places is too frequently acid, syrupy, or highly brandied; that is to say, the good old prescriptions, such as I have seen them in cookery books two or three centuries old, have been discarded for newer recipes intended to produce imitations of the sweet and brandied sherries which were so common in the early part of this century. It is the deplorable effect of this change which has brought gooseberry wine into discredit and into disuse.

Elderberry Wine.—This wine is remarkable by its colour, flavour and mild taste. The berry contains so little acidity that to make the wine agreeable some tartar has to be added to it. Booth prescribes to submit the berries to a preliminary coction, by heating them to at least 170° F. It seems that this is intended to make the juice more concentrated. After the preliminary repeated heating and cooling, the juice is to be expressed; to each gallon three pounds of sugar are to be added, and the solution is to be allowed to ferment in a covered vessel. The wine which will result from this operation is distinguished by no quality attractive to the taste, but may be mixed with every sort of grape wine, to which it will give body, an agreeable perfume, and a brilliant red colour. It is owing to this quality of the elderberry that it has been used for making a liqueur which in France was used to make or improve red wines, or rose-coloured wines, namely, the so-called Vin de Fîmes, made in the town of that name. There has been much idle talk about the colour of port wine being derived from elderberry, but we know from personal inspection that the grapes of the Alto-Douro are dark enough to furnish the deepest coloured wine, and that in the same district there are no elder bushes to be met with.

Elderflower Wine.—Raisin wine is flavoured with tincture of elder flower. While, therefore, the elderberry wine is deeply-coloured red, elderflower wine derives no colour from its flavouring ingredient. The elder wine of the British wine makers has a fundamental fault, namely, that it is too strongly flavoured with the elder flower. They should take an example from the makers of sparkling Moselle, and put elderflower tincture rather sparingly into their raisin wine.

Brambleberry, Raspberry, and Strawberry Wine.—Wines can be made from these varieties of fruit, but they have only the value of curiosities. Brambleberry wine has no attractive flavour at any time. The fine flavour of the raspberry evaporates almost entirely during fermentation, and the resulting wine is a liquid without any specific aroma. Strawberries behave similarly, and their aroma, in a fermented liquid, may make room to a heavy, repulsive odour. Both raspberries and strawberries are, moreover, too valuable as fruit for eating and for jams to become popular for any other use.

Wines from Cherries, Prunes and other Stone Fruit.—From stone fruit wine may be made by a process similar to those described in the foregoing. Much cherry wine is actually made by British wine makers, but is too often denaturalised by excess of sugar and addition of spirit. The fruit is rubbed in a wicker basket, until pulp and juice have passed into the tun below; the liberated stones are cracked and thrown into the pulp, to impart their peculiar bitter almond flavour to the liquid to be prepared. Although cherries give juice of a higher quality than most other varieties of fruit, they still require an addition of saccharine matter if wine be intended to be produced; in that case also it is desirable to add to must of very ripe cherries a proportion of cream of tartar. Morella cherries are usually preferred, but the black cherries of the variety called in France "la guigne," in Scotland "geen," are also used. In the Vosges, the Black Forest, and in Dalmatia, the marasche cherry is used to make a fermented liquid, which is, however, not used as wine, but distilled immediately after fermentation, and produces the excellent spirit called "Kirschenwasser," or maraschino. Prunes are said to be improved by coction, previous to fermentation, but we doubt whether the application of heat, originally undertaken to increase the percentage of sugar, may not disperse much of the aroma.

Orange Wine.—We have known good orange wine to be preferred by ladies at a dinner-table bearing a selection of expensive grape wines. It had been made from 100 sweet oranges, 20 lemons, 32 lbs. of loaf suger, 5½ imperial gallons of water, 2 bottles of white wine, and half a pint of good yeast. The water and 28 lbs. of the sugar should always be boiled, and the expressed juice of the oranges and lemons be added while the mixture is hot; the yeast is added when the mixture has cooled to about 70° F. The skins of the oranges and lemons are well rubbed with the four remaining pounds of sugar, so as to form an oleo-saccharum, and this is added to the fermenting mixture forty-eight hours after it has begun to work. When fermentation ceases, the wine is racked into a new cask, the two bottles of grape wine are added, and the product is allowed to clarify.

Cowslip Wine.—The blossoms of the common cowslip, or paigle, communicate to neutral home-made vinous liquids a bouquet reminding of that of muscatel or elderflower. For the rest, these blossoms possess no ingredients which would make their employment advantageous to vinification. The basis of a cowslip wine of which considerable quantities are produced at Leicester, are sugar and lemon-juice; and the product is made slightly effervescent, so as to be an agreeable, and, as we are informed, only slightly alcoholic drink.

Wine from Mixed Fruit.—It is stated by Booth that there are many gentlemen who prefer wines made from mixed fruit to those of the simple kind; the mixture may be made up of some or all of the fruit that ripen at the same season, and in variable proportion. It is probable that such wine is made on account of its economic advantage. A useful recipe for making a wine of this kind is communicated in the eleventh volume of the 'Correspondence of the Bath and West of England Agricultural Society,' by a correspondent of the name of Matthews.

Ginger Wine and Ginger Beer.—These products are made of the same ingredients, but differ in this, that the former is more completely fermented for the purpose of preservation, whereas the latter is made for immediate use, and bottled in such a state as to acquire in the course of a few days such a degree of fermentation as will make it very frothy when it is poured out. Moreover, ginger wine is generally much more alcoholic than ginger-beer. And it is one of the great advantages of genuine and well-made ginger-beer, that by its spice and effervescence it is highly refreshing, while by its low alcoholicity it is an agreeable stimulant without being intoxicating. With such ginger-beer should not be confounded the aërated drink called gingerade, which differs from ginger-beer in this, that, not being fermented, it contains no alcohol. A strong ginger-beer is made by boiling with every gallon of water 2 lbs. of loaf sugar and 1 ounce of bruised ginger, 1 ounce of cream of tartar, and one small lemon, sliced. To the cooled mixture some yeast is added, and the whole is set aside for fermentation. When the tumultuous fermentation is over, the liquid is bottled. Ginger-beer thus made is, when properly fermented, of considerable alcoholic strength, equal at least to strongest Scotch ale. A ginger-beer for ordinary use in hot weather should be much weaker; and for this purpose the initial mixture should contain only such a quantity of sugar as can be fermented in the bottle without any previous fermentation in the wood. This amount of sugar is about 2 to 3 per cent. of the mixture; when properly fermented this will give about 1 per cent. of alcohol, and a free effervescence of carbonic acid, and will therefore yield a beverage which can be used by young and old of both sexes, even in hot weather, without hesitation.

Mead, or Wine from Honey.—The English name mead is derived from the Saxon medo or medu, and is therefore identical with the Greek name methu, signifying originally, probably, a strong vinous liquor; but used by Homer exclusively for wine. When wine and beer, and in later centuries, distilled spirits, had to be sweetened, this was effected with honey, and then the word meth came to be applied to all drinks into the preparation of which honey entered as a factor. The Welsh signified by metheglin, a liquor compounded of honey and wine, the same which the Germans called weinmeth; biermeth was made of beer and honey; essigmeth (oxymel) of vinegar and honey; wassermeth (hydromel), or simply meth, of pure water and honey, so that meth shared the fate of "lucus," in this, that as the latter was called so "a non lucendo," the former lost its meaning of strong intoxicating liquid, and acquired that of sweet non-alcoholic drink. At one time the word may have been used ambiguously, but this abuse was abandoned when, in consequence of the expansion of the art of brewing beer from barley, men learned the art of fermenting honey-water by means of the yeast obtained in the fermentation of beer. After that, meth or mead was almost exclusively employed to signify an alcoholic drink made from honey and water by fermentation. In King Alfred's translation of 'Orosius,' recording the travels of Ohter and Wolfstan, the latter is made to speak thus of the Eastern Country, which is supposed to mean the shores of the Baltic, and the banks of the Vistula. "This Eastern Country was very large, and contained many cities, each of which had its king. Great plenty of honey and fish were there. The king and the richest men drank mare's milk; but the poor and the servants drank mead. There was much wine; but there was no ale brewed among the Eastern people, for they had mead in abundance."

These people, therefore, probably imported their wine, no doubt by sea, from France, Spain, and the Levant. In England, honey-water was seldom fermented without yeast, because, as it was boiled and scummed, the yeast-germs naturally contained in it were destroyed, and could be renewed but slowly from the air, or suddenly by addition of yeast from beer. When honey is simply dissolved in water, of a heat between 80° and 90° Fahrenheit, it mostly enters into fermentation in ten or twelve hours. Into the mixture of honey-water intended to be made into mead, cream of tartar is mostly given; the French also add elder-flowers; but this seems to complicate the fine flavour of the honey. Most prescriptions for the making of mead which we have perused indicate so much honey that, after the most complete fermentation possible, a strongly sweet thick liquid must remain. Macquer's prescription leads to a honey syrup so concentrated that it will support a fresh egg on its surface without allowing it to sink to more than half its bulk. Another French recipe prescribed to infuse six gallons of boiling water on eight or ten ounces of elder-flowers ; to the infusion 2 lbs. of cream of tartar are to be given ; afterwards 40 lbs. of purified honey are to be dissolved in it, and the wort thus obtained is to be started with 4 lbs. or 5 lbs. of good fresh yeast. Even where less honey is recommended, the mead obtained is to be strongly sweetened with cane sugar. We have no doubt that, independently of the fact that honey is a relatively dear material for the production of an alcoholic beverage, mead has become disused on account of the excessive sweetness which used to be imparted to it. Mead to be an agreeable beverage should not contain more than 25 lbs. of honey in 100 lbs. of the wort to be fermented ; the presence of excess of cream of tartar is of less consequence, except as waste, inasmuch as it does not remain in solution in the wine ; 1 lb. of cream of tartar upon 25 lbs. of honey would be sufficient.

Wine from Malt.—The extract of malt, termed wort, has an agreeable sweet taste, with only little of the peculiar barley flavour. A wort still more resembling a pure sugar solution can be produced by transforming a solution of pure starch into the peculiar barley, or malt sugar, which has received the name of maltose. Both common wort and this solution of maltose are easily fermented, either by evolution of yeast from aerial germs, or by the addition of yeast in quantity, as in the manufacture of beer. Maltose has an exquisitely sweet taste ; it has the same composition as cane-sugar ; but unlike this latter, is fermentescible by yeast directly, while cane-sugar is not so fermentescible, but requires the prolonged influence of much yeast, aided by acid, in order to become interverted, as it is called, *i.e.* to be split up into the two fermentescible sugars termed dextrose and levulose. Maltose worts may be acidified with citric acid to the extent of ½ per cent., or with cream of tartar to the extent of 1 per cent. The wine obtained is so pure in flavour that any desired artificial bouquet may be easily imparted to it.

Booth describes a species of liqueur wine made from malt, which was sometimes to be seen at the tables of the Scotch ale-brewers. A pale wort of a very high gravity was attenuated by fermentation to half its specific gravity; at this period it was cleansed, and a gallon of good French brandy was added to every ten gallons of the fermented liquor. The spirits became perfectly incorporated with the wine within a year. It was usually drunk without any further addition or flavourings. We abstain from giving the complicated prescription for malt-wine published at the beginning of the present century by Dr. A. Hunter, of York. As it requires, while fermenting, to be daily roused with a stick during a month, we fear that few, if any, are likely to make up the prescription.

Birch and Plane Wine.—The sap of the birch (*Betula alba*), and of the plane-tree (*Acer pseudo-platanus*), have frequently served for the production of wine in this country, and do serve for that purpose abroad. Lightfoot, in his 'Flora Scotica,' gives detailed instructions for the production of birch-wine.

In the beginning of March, while the sap is rising, and before the leaves shoot out, bore holes in the bodies of the larger trees, and put tubes therein, made of eldersticks, with the pith taken out; and then put any vessels under to receive the liquor. If the tree be large, you may tap it in four or five places at a time, without hurting it; and thus from several trees you may gain several gallons of juice in a day. To every gallon of liquor 4 lbs. of sugar are to be added, and the mixture is to be allowed to ferment. Lightfoot advises to boil the liquor before and after the addition of the sugar, and to skim off all froth. This seems unnecessary, and is perhaps intended only to retain more sugar in the wine than would remain without the boiling. The resultant wine is agreeable.

The manufacture of the juice of the plane-tree is conducted in the same way, and the wine is said to be equally good. The American maple (*Acer saccharinum*), is a tree of the same genus. It is tapped in a similar manner as the birch, and the juice is so rich in sugar that none need be added to it if it is intended to ferment it; it even serves to produce crystallised sugar like that from the cane.

Sugar-cane, *Beet-root*, *and Parsnip Wine.*—Liquids prepared by fermentation from these plants have a coarse taste, and are, if drinkable at all, not attractive.

BEER.

Beer is an alcoholic beverage made from sprouted barley or malt, hops, yeast, and water. In the manufacture of some varieties of beer, sugar from various sources is also used; such sugar may be cane-sugar or starch-sugar, the latter produced either by the influence of acid (invert sugar), or of ferment (diastase maltose). In the manufacture of other varieties of beer, grains other than barley (*e.g.* wheat), are used; but in Europe this is rarely the case.

The quantity of beer produced in Europe has greatly increased during the last thirty years, owing not only to the increase in the well-being of the population, but also to the diminution or want of increase in the production of wine. The quantities of beer produced in 1873 in several European countries were: Great Britain, 50 millions hectolitres; Germany, 38½ millions; Austria, 12½ millions; Belgium, 9⅓ millions; France, 7 millions; Netherlands, 1⅓ millions; Russia, 1¼ millions. It will be observed that the production of wine in France, together with that of beer, amounts about to the same number of hectolitres as the production of beer in Great Britain.

The consumption of beer per head of population per year, has been stated to be about as follows: Russia, 13 litres; France, 19·5 litres; North America, 26 litres; Austria-Hungary, 34·5 litres; Prussia, 39·5 litres; Baden, 56 litres; Saxony, 60·5 litres; Würtemburg, 154 litres; England, 200 litres; Bavaria, 219 litres.

Beer, under the name of wine made from grain, *e.g.* barley-wine, has been known to many nations since the earliest times. But it was probably then not made with hops, the use of which has become general only since the Middle Ages. Tacitus (Germ. c. 23), describes the barley-drink of the Germans as similar to spoiled wine. Diodorus (I, 14, 15, 34), has a better opinion of barley-drink, and does not think it much inferior to wine in flavour. According to this author, mankind received the barley-drink zythus, as well as the vine, from Osiris; and zythus, he adds, is a substitute for wine to those who cannot afford to buy wine. The Emperor Julian, however, did not think highly of the barley-drink of either Germany or Gaul, for in an epigram he describes it as smelling, not of the god Dionysos, but of the he-goat, which used to be sacrificed to that god. Beer is, nowadays, characterised and receives its full value by hops (cf. G. Thudichum, 'Traube and Wein in der Kulturgeschichte,' 1881). To which event in the history of beer the legend of Gambrinus, King of the Netherlands, owes its origin is difficult to ascertain (cf. Gruner, 'De confectione zythus sive cerevisiæ veteris, Jenæ 1805; also Journ. compl. des Sc. méd. 13, 253). The beers of various nations pass under the name of chica, saki, uytzet (Genth.); the later Latins termed it cerevisia, from the goddess Ceres, whence the early French cervoise. According to Merat and Delens (Dict., art. Aile), the English ale, or hel, was a beer made without hops; but the word has become synonymous with beer. Some kinds of beer are flavoured with bitter and aromatic substances other than hops; but they have no very wide area of consumption; thus the so-called spruce-beer is made with the branches of the spruce-fir (*Pinus sylvestris*, L.). The Canadian pine-beer made by the early French settlers was called sapinette (from *sapin*, pine, being here *Abies alba, rubra*, and *nigra*, L.). Cook caused such spruce-beer to be prepared with a pine of New Zealand, and gave it to his sailors. Posset seems to have signified both whey and a mixture of whey and ale without hops; also, perhaps, mixtures of curd and whey, or sour milk with ale, which were eaten cold in summer, and mixtures of sweet milk with ale, eggs, spices, &c., which were drunk hot in cold weather.

Barley.—Several species of this cereal are cultivated in two principal forms, as winter and summer barley; it ripens up to 71° north latitude, and on mountains up to 1200 m. high; the winter crop requires from 270 to 300 days for vegetation, the summer crop 100 days. The latter is most suitable for beer. The chemical analysis of barley corn has yielded mean: water, 13·78; nitrogenous matter, 11·16; fat, 2·12; sugar, 1·56; dextrine, 1·70; starch, 62·25; cellulose, 4·80; ash, 2·63. Barley is transformed into *malt* by the process of germination. It is first steeped or soaked in water; the saturation takes place in warm water, or in summer time, in from 1½ to 2 days; in cold water, and during winter time, in from 5 to 6 days; during this process the barley increases in weight by from 30 to 60 per cent., and in volume about 25 per cent.; about 1 per cent. of the constituents of the barley pass into the soaking water and are lost. The swelled barley is allowed to germinate at a low temperature, while lying in heaps; the germination shows itself by the appearance, first of the rootlet (radicula); secondly, of the leaflet or feather (plumula), the beginning of the stalk and leaves, or haulm. This process requires from six to twelve days, and is completed, as regards the preparation of malt, when the leaflet has attained the length of about three-quarters of the length of the grain. The changes which occur in the barley during this process are, in the first place, a considerable increase of the soluble nitrogenous matters; the additions are ferments, of which diastase is the most important one, as by its power starch is transformed into sugar in the most convenient manner; other ferments are peptonising like the gastric juice; but, like the asparagin formed at the same time, they are of less importance for the production of beer. Of the starch contained in the barley, a quantity is used up for the production of power, including heat; another portion of starch is transformed into dextrine; while a third portion is metamorphosed into maltose (the sugar peculiar to malt, and producible from any cereal starch by the diastase, particularly of malt). Altogether, the losses which barley experiences during its transformation into malt amount to about 14·7 per cent. of its weight; of these, 1·0 per cent. goes in solution in the soaking water; 10·2 per cent. pass away as gaseous products of the germinating process, or become dextrine and sugar, while 3·5 per cent. are made up by the radicles. In the ordinary process for making beer, the malt is not used in its fresh or green state; but is dried, and the shrivelled rootlets are removed mechanically. These latter are used as food for cattle.

The malt is roughly ground and mixed with warm water, so that the heat of the mixture, termed mash, is from 60° to 65° C. The liquid part, termed wort, is boiled or otherwise treated until it has the desired degree of concentration. Every per cent. of sugar yields about a half per cent. of alcohol by fermentation; a wort, therefore, which is intended to yield beer with 4 per cent. of alcohol and 5 per cent. of extractives, must contain $2 \times 4 + 5 = 13$ per cent. of solids in solution.

During the process of mashing the starch in the malt is almost entirely transformed into the peculiar sugar termed maltose, or barley sugar; this body, long mistaken for dextrose or grape sugar, was shown by Dubrunfaut to be peculiar, to rotate the ray of polarised light three times as much as dextrose, and on the other hand to decompose only about two-thirds of the amount of alkaline copper solution which is reduced by dextrose. The chemical formula of malt sugar is probably like that of cane sugar $C_{12} H_{22} O_{11}$.

Diastase is contained in malt in quantities varying between

0·1 and 0·2 per cent. Its power over starch is destroyed when it is exposed to a temperature above 75° C. The dextrine formed by the side of maltose is a kind of soluble starch, which derives its name from its dextro-rotatory influence upon polarised light, and is not capable of being fermented by yeast; and by long-continued influence of diastase it can pass into maltose. In the manufacture of beer it remains in the beer, because the action of diastase is cut short by the boiling of the wort with the hops; but in the manufacture of spirit the diastase is allowed to continue its action during the alcoholic fermentation, so that most dextrine is transformed into sugar and alcohol.

When the action of the diastase in the mash is completed, the wort is separated from the exhausted malt by filtration. The malt may again be treated with water, and the product added to the first wort, or it may be kept and treated separately for the production of small beer. The clear wort is now boiled with hops.

Hops are female non-impregnated compound flowers (catkins) of the hop plant (*Humulus lupulus*, L.), which belongs to the family of Urticaceæ. The hop plant is probably indigenous to many parts of Europe and Asia. In early days of beer production wild hops only were used, as is the practice in Styria at the present day; but it has been largely cultivated during nearly a thousand years, and at the present time the hops of Bohemia, Bavaria, Baden, Würtemburg, Alsatia, England (Kent and Surrey), and America are staple articles of a large trade. In Europe 53,000,000 kilogrammes of hops are produced annually on an average; in good years the production may rise to near 80,000,000 kilogrammes. The active ingredients of hops are the mixture of substances termed lupulin, which is deposited in minute yellow adhesive globules underneath the bracts of the flower tops, and amounts to from 20 per cent. to 30 per cent. of the dry hops. This lupulin contains hop resin (50 per cent. to 80 per cent.) and hop bitters, or bitter acid of hops, which imparts to beer its bitter taste. It further contains hop oil, a mixture of volatile oils, boiling between 140° and 300° C, and supposed to contain alcohols and hydro-carbons, which are not yet accurately known. This hop oil imparts to beer a peculiar aromatic flavour. Lupulin further contains tannic acid = 1·18 per cent. of the hops, wax, nitrogenised and saccharoid matters, which are of minor influence upon the composition of beer. Besides the 30 per cent. lupulin, hops contain about 15 per cent. of other nitrogenised matters, 16 per cent. of cellulose, 6 per cent. of ash, from 2 per cent. to 3 per cent. of sand, and the rest is made up by moisture. This refers to hops dried in the air, or in drying kilns at about 40°. To preserve hops from mould and other changes they are sulphured, *i.e.* impregnated with sulphurous acid gas.

The clear wort obtained, as above described, is boiled with hops in such quantity that for ordinary beer the wort from 100 parts of malt receives from 1½ to 2 parts of hops, while for lager beer and the stronger ales the wort receives from 2 to 3 parts. Of the ingredients of the hops about 30 per cent. pass into the wort, consisting of 10 to 14 per cent. hop-resin, 3 to 5 per cent. extractives free from nitrogen, 4 to 6 per cent. nitrogenised, and 3 to 5 per cent. mineral matters. The hopped wort is now filtered from the exhausted hops; it contains from 8 to 15 per cent. of matters in solution, of which sugar of malt (maltose) and dextrine are the largest in quantity; the proportions of these matters to each other vary greatly according to the intentions of the brewer, or according to the greater or lesser success of the mashing operations; it has been found that the relation of maltose to dextrine may vary between 1 : 0·43 and 1 : 7·17. The filtered hopped wort is cooled as quickly as possible, in case it is intended for upward or high fermentation to from 12° to 18° C., in case it is intended for downward or low fermentation to from 3° to 8°.

The wort thus cooled is placed in the fermentation vats, and to every 100 litres of from 10 to 15 per cent. strength 0·5 to 0·6 litres of good thick beer yeast are added. The high fermentation is completed in from four to eight days, the low fermentation lasts much longer. While the fermentation proceeds the rise of temperature is counteracted by floating coolers filled with ice. The process of fermentation splits maltose first into dextrose sugar, and this latter into alcohol and carbonic acid. A part of the dissolved nitrogenised matter is precipitated, and a quantity of new yeast is formed, while the old yeast dies off. The fermentation process further produces glycerine, succinic acid, small quantities of acetic and lactic acid, and some ethers. Before the fermentation is complete, the beer is transferred into barrels, and clarified by various means; one of the most common processes is to maintain a weak secondary fermentation in the barrels, and allow the froth to escape from the bung-hole; this secondary fermentation is aided by placing wood shavings into the barrels, and adding small quantities of strongly fermenting wort from time to time.

Beer becomes stronger or weaker according to whether more or less malt or other saccharine matter is used in its production. Beer which is to be transported from the place of its production to long distances, or to be exported to other countries by land or sea, must contain more alcohol and extractives than beer to be consumed in the locality of its manufacture. The colour of beer is mainly produced by extractives formed in the malt; of these less is found in malt dried at 30° to 40°, more in malt dried at higher temperatures. Very dark beer, *e.g.* porter, is made with a portion of roasted malt, or with burnt sugar. Most varieties, even of the best beer, are partly coloured and flavoured by special preparations, which increase its attractive aspect and flavour or bouquet.

It is supposed that hops are sometimes supplanted, entirely or in part, in the manufacture of beer, by absynth (herb), menyanthes (leaves), quassia (wood), gentian (root), and some others. But these adulterations are rare, and if practised persistently would no doubt be discovered, and the liquids produced by their aid would be declined by the public.

Much more than by intentional adulteration is beer endangered by the development of unwelcome ferments, which multiply by the side of yeast. Most troublesome in this respect is the lactic acid ferment, which may appear already in the mash ; it becomes dangerous in wort before vinous fermentation if the former is not cooled down quick or low enough, and the yeast added is impure, or not sufficiently active, so as to crowd out by a rapid development of the yeast fungus other organised ferments. Beer then becomes sour, and of bad taste ; it is turbid by suspended ferment and precipitated matter. The less dangerous ferment is the acetous, which requires the presence of alcohol for its development, while the lactic ferment acts not upon alcohol, but upon sugar and dextrine. Other ferments are those which produce viscosity and scud and decoloration of the beer. These ferments and the means of avoiding their evil effects have been described by M. Pasteur. He has more particularly shown how to produce pure yeast.

Yeast is the uniform mass of microscopic fungi (*Saccharomyces cerevisiæ*), which have the power to transform sugar into alcohol and carbonic acid. Compressed yeast contains from 75 to 83 per cent. of water. Low fermentation yeast, considered as free from water, contains albumen 36 per cent., gluten-casein 9 per cent., pepton 2 per cent., fat 5 per cent., extractives 4 per cent., cellulose 37 per cent., and mineral ingredients 7 per cent. The fermentation is part of the growing and life action of the yeast ; in the beginning it requires a little oxygen, but its main action takes place without any participation of the oxygen of the air, and is not interrupted by a pressure rising to 17 atmospheres. One hundred parts of extract of malt, considered as dry, will yield by fermentation 48·4 alcohol and glycerine, &c., 46·3 carbonic acid, and 5·3 yeast.

The water to be used in brewing should be pure, clear, and not too hard ; it should not contain much organic matter, as this has a tendency to aid the development of mildew on the steeped barley, and of lactic acid ferment in the mash. A very hard water diminishes the production of maltose ; a water containing gypsum aids the wort in becoming clear. The presence of some chloride of sodium, or common salt, is not hurtful, but may not exceed a certain limit, which is fixed by certain restrictions concerning beer which are enforced by authority.

Beer is stimulating and intoxicating by means of its alcohol; it is refreshing by its carbonic acid; it has a peculiar sedative influence upon the nerves by means of its lupulin—this effect is very like that of opium; the hop oil gives it its aroma. The extractives make it somewhat nutritive, and give it a roundness of taste termed body. The taste is vinous, sweetish, and bitter at the same time. The alcohol varies between 3 and 5 per cent., the extractives between 5 and 8 per cent., sugar may approach 1 per cent., dextrine and gum vary between 2 and 5 per cent., carbonic acid and glycerine are mostly present in equal proportions, namely, 0·22 per cent., the lactic acid varies between 0·1 and 0·3 per cent., the ash between 0·2 and 0·27 per cent. When to any beer an excess of ammonia is added a precipitate of phosphate of magnesia and ammonia ensues. The specific gravity of beer varies between 1·0142 and 1·0237.

DISTILLED SPIRITS.

Distilled spirits receive various names, according to the materials from which they are derived. The reasons for which they are distilled are mainly that the liquors from which they are obtained are not drinkable, or not agreeable in their natural state. Spirits are also compendious essences, which can be easily transported and made into a beverage by mere mixing with water.

The number of establishments for the production of spirit in the world amounts probably to half a million. In the German Empire there are 40,000 distilleries, which produce more than 4,000,000 hectolitres of spirit of 80 per cent. of strength annually, and use in this production about 25,000,000 hectolitres of potatoes, 5,000,000 hectolitres of corn, and more than 1,000,000 hectolitres of beet-root molasses. In France the distilleries of eau-de-vie produce annually 600,000 hectolitres from wine alone, of which 180,000 hectolitres are Cognac brandy so-called, made in the Charente, while the remainder, 420,000 hectolitres, are so-called trois-six, made in the South of France. Some brandy is produced from murk, and some from yeast. A number of spirits are produced from sweet fruit, cherries, plums, &c., and from syrup obtained from the beet-root or the sugar cane. The large bulk of spirit consumed by the labouring classes in the shape of whisky and gin is produced from barley, rye, rice, maize, and other materials containing starch, amongst them foremost the potato, which, as we have seen, furnishes in Germany the material for the production of at least four-fifths of all the spirits distilled there. In England and Belgium rye is mainly used for the production of whisky and gin, with some malt, to effect the conversion of the rye starch into fermentescible sugar. This conversion is effected by the mashing process described under beer.

In most cases the agent for the transformation of the starch into sugar is diastase, in some, however, sulphuric acid is used. Sugar so produced does, however, not give a spirit of good taste, though by rectification and charcoal pure alcohol can be produced from it. The potatoes are steamed and crushed previous to being mashed.

The fermented liquids are introduced into stills and the spirit is driven out by heat, and condensed in an apparatus called a cooler, or, from its common shape, a worm. In the still there remains a mixture of liquid and solid matter, termed "wash," which is used as food for animals, mainly cattle and pigs. Such wash from rye contains about 93·48 per cent. water, 1·4 per cent. nitrogenised substances, 0·22 per cent. fat, 4·05 non-nitrogenised matters, 0·52 cellulose, and 0·33 per cent. ash. The wash from potatoes contains more cellulose (cork), 0·92 per cent. (from the peels); less non-nitrogenised matter, 2·17 per cent., the other matters in quantities similar to those from rye wash. The wash from beet-molasses is remarkable in this, that it contains 12·04 per cent. nitrogenised, and 4·56 per cent. non-nitrogenised matter, no fat, and 1·54 per cent. of ash.

The residues from distillation have mostly an awful smell, and even the residues from wines are by no means well flavoured; indeed the latter, in France, have given rise to contentions as nuisances, when they were discharged into water-courses.

The distillates, on the other hand, contain besides the ethylic alcohol common to them all, other volatile matters, which differ according to the material, and impart to the distillate so peculiar a smell and taste that its origin can thereby be accurately recognised.

Spirit distilled from a grape-mash, or from wine, smells of wine or œnanthic ether, and is termed brandy; spirit distilled from a malt or grain mash smells of grain, and is whisky; spirit distilled from a sugar-cane mash, or from molasses, smells like dilute butylic ether, and is termed rum; from potatoes, smelling of fusel, potato-spirit; from cherries, smelling of bitter almonds, cherry water (Kirschenwasser), maraschino; from rice, smelling like Russian leather, arrac; from apple wine, smelling like quinces, the spirit is termed malac. In all cases the quality of the distillate is absolutely dependent upon the qualities of the materials which are used in the production of the mash. The mercantile value depends on the peculiar flavouring ingredients, and this is much higher than that of the mere ethylic alcohol.

Rectification consists in redistillation, with the addition of certain chemical solvents, chiefly of an alkaline nature, which serve to retain some or all the objectionable matters in the bottom of the still, and to prevent them from passing over with the new, or second, or rectified product.

There are varieties of brandy, whisky, or rum which may be improved by slight rectification without loss of their distinctive characters. Something disagreeable has been taken out of them, and they are still what they were before, not of first-class quality, but better for the process to which they have been submitted, and still marketable. Again, there are certain varieties which are so nasty, or so deeply tainted from the faults of the raw material, that the taint can only be removed by a degree and amount of rectification which removes the distinctive characters also; and then we no longer have rectified brandy, whisky or rum, &c., but only rectified spirit, from which everything distinctive of brandy or whisky or rum has been removed. From potato spirit the fusel oil is removed by filtration through animal or vegetable charcoal. The coal acts most successfully, when the spirit is of proof strength; and the contact is continued for several days (Döbereiner). The first spirit which passes in the process of rectification contains matters of lower boiling point than alcohol, *e.g.* aldehyde; then passes the bulk of the alcohol, and afterwards matters which have a higher boiling point than alcohol, namely propyl-isobutyl and amyl-alcohol. Before the latter begins to pass over the distillation is mostly interrupted. The residues, containing the heavier alcohols and acids, if it is desired to obtain them, are distilled separately in particular stills. A mode in which an agreeable flavour can be imparted to silent spirit, which has stood over charcoal, is the following:—Certain proportionate quantities of acetic and sulphuric acid are added, and the mixture is again distilled. Small quantities of acetic and other ethers are formed, and the rectified product has the agreeable flavour of these new compounds.

When spirit is highly rectified it becomes gradually more concentrated, until nearly absolute alcohol, or spirit of from 90 to 95 per cent. strength is obtained. First distillates generally have the composition of brandy originally so-called, that is to say, they consist of a mixture of nearly equal parts by weight of alcohol and water.

A variety of spirits were examined, and found to have the following amounts of alcohol:—

	Alcohol Volume Per Cent.	Weight Per Cent.	
Russian Dobry Wutky . .	62·0	54·2	
Scotch whisky	50·3	42·8	H. Grouven.
Irish do.	49·9	42·3	„
English do.	49·4	41·9	„
Gin (Genever)	47·8	40·3	„
German schnaps, common .	45·0	37·9	„
American whisky.. . . .	60·0	52·2	„
Rum	49·7	42·2	„
„	51·4	43·7	Koenig.
Cognac.	55·0	47·3	„
do.	69·5	61·7	„
Arrac	60·5	52·7	„

Wine Brandies of the South of France.—Large quantities of brandy, or eau-de-vie, are distilled from wine, and some from murk over which red wine has fermented, in the South of France, the ancient province of Languedoc, more particularly in the department of the Hérault, bordering upon the Mediterranean. The brandy is called of good taste (*de bon goût*), when the wine from which it has been made was sound. When the wine was spoiled in any way the resulting spirit is ranked with and termed spirit of murk, or of bad taste (*de mauvais goût*).

All these brandies pass in trade under names which are derived from their strength. We must premise a few observations on that subject. A certain quality is termed "Proof of Holland." This is given by Rendu ('Vins du Languedoc,' i. 71) as of 52 vol. per cent. strength; but Payen ('Chimie industrielle,' 3rd ed. p. 712) gives Proof of Holland at 58·7, and Proof of London at 58 vol. per cent. British (or Sikes's) proof spirit at 15°5 contains 57·06 vol. per cent., or 49·24 weight per cent. of absolute alcohol. The designations of spirits of various strengths used in the Languedoc and other parts of France are derived as follows:—Common eau-de-vie is accepted as the standard, and supposed to show an alcoholic strength of 19° of Cartier's instrument at 12°5 temperature. It then contains a little less than 50 vol. per cent. of absolute alcohol. Trois-six is a spirit, of which three volumes added to three volumes of water were supposed to give six volumes of eau-de-vie of 19° Cartier. This trois-six is the common wine-alcohol of commerce, marks 33° on the scale of Cartier, and contains, consequently, 84·4 vol. per cent. of absolute alcohol. Trois-cinq is a spirit of which three volumes added to two volumes of water were supposed to give five volumes of eau-de-vie at 19° Cartier; while trois-sept is a spirit of which three volumes added to four volumes of water were supposed to give seven volumes of standard eau-de-vie. It is evident that by the introduction of the accurate chemical methods of ascertaining the strength of spirits these names no longer cover accurate definitions. But whenever they are used in French works, or in the following without the definition of the exact strength in vol. per cent., or degrees Cartier, we may assume that by 3/7 is meant a spirit of 94 vol. per cent.; by 3/6 a spirit of about 84 vol. per cent.; by 3/5 a spirit of about 78 vol. per cent.; by "Proof of Holland" and "Proof of London," a spirit about equal to British proof according to Sikes's tables; by eau-de-vie double de Cognac, a spirit of 52·5 vol. per cent.; by eau-de-vie as commonly sold in retail, a spirit of 49·1 vol. per cent.; and by common feeble eau-de-vie, a spirit of 45·5 vol. per cent.

The trois-six of murk, or of bad taste, is from 25 to 50 per cent. less valuable than that of good taste. The latter is the most important product of the still both as regards quantity and quality. It is obtained by means of a still which, from its inventor, is called De Rosne's. As the wines of the plain, which are used for distillation, contain from 7 to 11 vol. per cent. of 3/6 of 84°, an apparatus which can produce four pièces per day, and consume 336 hectolitres of feeble wine of the plain, containing 7 per cent. of 3/6, will, when consuming wines containing more alcohol, consume a lesser quantity. The average strength of the wine distilled is 11 and 12 per cent. of three-six when the year is good, so that a manufactory which produces four pièces of three-six in twenty-four hours, will consume from 230 to 240 hectolitres per day. Such a manufactory therefore discharges every day more than 200 hectolitres of residue or wash.

The strength of spirit in the Hérault is frequently ascertained with the aid of the alcoholometer of Bories. This is a very ancient instrument, and manufacturers and producers of the Languedoc are as reluctant to give it up as the Germans are with regard to that of Tralles, or the English with regard to that of Sikes, and the inhabitants of the Charente with regard to that of Tessa.

There are in the Hérault four markets for spirits distilled from wine and murk; Béziers (on Fridays); Pézenas (on Saturdays); Cette (on Wednesdays); and Lunel (on Mondays). To one or other of these markets the producer or distiller generally takes his brandy, accompanied by a written warranty of its alcoholic strength. The inspector of the market tests the spirit himself, and if he finds the warranty correct, admits, if he finds it incorrect, returns the spirit. Each separate barrel, termed pièce, is thus tested. The limpidity of the spirit must be perfect; it must be colourless and of good taste, free from strange or bad taste.

The 3/5 and 3/6, and Proof of Holland, are employed to strengthen wines—as the French say, *viner les vins*—which have not sufficient alcohol of their own (technically termed "body") and are intended to be exported. All varieties of distillates are used for making, by dilution with water, the better class of eau-de-vie of Montpelier, which is drunk as such, or diluted with water. The best qualities of spirit are made, as in the Charente, from white wines just fermented, made generally from the grape termed "good quality of Terret Bourret." Good qualities are also produced from wines from the Picpoule. New red wines, provided they have not been allowed to ferment with the stalks, also give eau-de-vie of great softness.

The average annual production of 3/6 in the four departments—the Eastern Pyrénées, the Hérault, the Gard, and the Aude—is estimated at 500,000 hectolitres. It is produced either by manufacturers who make a distinct occupation of it, or by farmers who have a still attached to their farm arrangements. These farmer distillers are more numerous in the circle of Béziers than in that of Montpelier, but on the whole the larger quantity of the wine is distilled by the professional distillers. This is by no means to the advantage of the product, as the 3/6 distilled immediately after fermentation is (as in the case of Cognac) always the best.

The murk is distilled by persons who use the residue either as food for sheep or as manure; 13,000 kilos. of murk yield about 600 litres of 3/6 of bad taste.

The distilled spirits of the South of France are either consumed in the country, or exported, and consumed by most nations of the earth as eau-de-vie or brandy, or in the shape of many liqueurs.

Brandies of the Department of the Charente and Cognac.—Near the little town of Ruffec, the hill country, as far as the eye can reach, is covered with vines, mainly white varieties, the folle blanche, boilot, blanc doux, colombas, sauvignon, and St. Pierre. Of these varieties the first-named one gives the sweetest and best-flavoured spirit, the characterising ingredient of the eau-de-vie Cognac. The wine of the folle blanche is not agreeable to drink, although it is rich in alcohol. Wine made from black grapes does not yield a spirit of the same soft and bouqueted properties as that obtained from white wine. The varieties of vines cultivated for red wine are named balsac, maroquin and dégoûtant. The latter is a peculiarly characterised plant; it affects the shape of a tree, its leaves are felted, and its grapes black and shining like coal.

In the Charente the wines are distilled immediately after the fermentation is over. Distillation therefore is carried on during the whole winter. Almost every other vineyard proprietor possesses a still. Those, however, who do not possess a still, sell their products to the larger distillers, or get it distilled by the migrating distillers, who go about from village to village and distil the spirit out of the wine of any comer. By the time spring arrives the whole of the wine is mostly distilled. The spirit obtained is for the most part colourless, and of the strength called "four degrees of Tessa," equal to from 59 to 60 volumes per cent. of absolute alcohol, or a trifle stronger than British proof spirit. Its strength is mostly ascertained by the alcoholometer of Tessa, a somewhat antiquated and irregular instrument, known and used only in the Cognac district. It is supposed that each of its degrees above four is equal to three volumes per cent. of alcohol, so that "five of Tessa" would be about 63 volumes per cent., and so on. Calculating the value of the lower degrees at that rate, the zero point of Tessa would be about 47 to 48 volumes per cent. of absolute alcohol. We may surmise it to coincide with the strength of eau-de-vie as formerly sold in commerce, namely 49·1 volumes per cent. New cognac, like new whisky, has a disagreeable, burning and rough taste, without any flavour, and is, in fact, undrinkable. It is kept in barriques of 200 litres for a period of from one to four years. During that time it ameliorates, becomes sweet and tasty, and extracts from the wood the light-brown, amber, or yellowish colour which it has when sold in trade. Very old and fine brandy develops a flavour reminding strongly of vanilla ; it is, like rum, quite free from even the suspicion of fusel oil or amylic alcohol. The quantity of brandy produced in the Charente amounts to 180,000 hectolitres, being the produce of the distillation of 1,400,000 hectolitres of wine, which together with 300,000 hectolitres sold as wine and drunk in the country, make up the 1,700,000 hectolitres of wine which grow annually on the 112,648 hectares of vineyards in this department. It is estimated that one bottle of cognac brandy of a strength of several degrees over-proof is obtained from six to seven bottles of wine in good years. In bad years eight to ten bottles of wine are required to give a bottle of Cognac. The value of wine in this part of France is very small, no more than from 8 to 10 francs per 200 litres being paid for white, and 18 to 20 francs for red wine. Yet wine continues to be produced, no doubt because climate and soil do not admit of any other crops. The little humus there is rests everywhere upon a limestone, which crops up so as to cover the land with fragments. The only cultivation which this soil receives is a hoeing in spring. The vines are cut in spring, and beyond these no further operations are undertaken either upon the soil or the vines; the rest is left to the sun.

Addition of Spirit to Wines.—To consumers of sherries, ports, Spanish red, South French, and a variety of other wines, the consideration of the origin of distilled spirit should be as interesting as that of the original wine itself. For sherries and ports and Catalans receive nearly half their alcohol in the shape of Berlin potato-spirit, while South French receives several per cent. in the shape of trois-six; and Champagnes, Burgundies, Clarets, and other wines of central France receive a portion of their alcohol in the shape of Cognac brandy. Of Cognac brandy, of course only the tasteless or slightly tasting sorts are used for mixing with the wines indicated.

When we say "Berlin potato-spirit" we do not mean thereby to do more than indicate the origin and place of manufacture or sale of the spirit in question. We do not intend to convey that this spirit is not on the whole very pure alcohol, or very pure silent spirit, so called, and mostly as free from fusel-oil as a spirit need be. Indeed it is, or can be made, so pure, that it bears being mixed with most other varieties of alcohol of pronounced flavour, without introducing into them any new or extraneous flavour. It is for this reason that it is preferred for mixing with wines containing much saccharine and extractive matter, like port and Spanish red.

On the other hand the pure alcohol from grain or potato cannot be drunk by itself, without having received some addition in the shape of flavouring matter. For this purpose it is, like whisky, placed into wine casks, particularly sherry casks, and allowed to extract the wine and flavour which has been sucked up by the wood. Or it is flavoured with certain kinds of ether artificially produced, particularly œnanthic ether, which gives it some resemblance to Cognac brandy, and in that shape is sold as British brandy. The word "brandy" in England is mostly intended to signify "Cognac brandy;" whisky and gin, though actually being brandies, i.e., burnt or distilled waters, or spirits, not being called brandy.

Whisky.—Whisky is a spirit which is distilled either from fermented malt, or a fermented mixture of malt and unmalted corn, the corn being rye, barley or oats, in a so-called pot-still, which brings over together with the spirit a variety of flavouring and other ingredients from the grain. If the grain were damaged, mouldy, or ill-flavoured, the spirit thus made from it would be either undrinkable or inferior. Hence to obtain good whisky it is necessary to use only the very best malt and grain which can be obtained.

Silent spirit is made in what are called "patent" stills, from any vegetable matter which will yield alcohol by fermentation; and the patent still, when properly and carefully managed, brings over alcohol and water only, leaving all flavouring matter behind. Hence by its aid pure spirits can be obtained even from damaged materials, and the use of perfect materials confers no advantage on the product. But it is contended by the whisky distillers that such spirits are not by any means whisky, and, being destitute of flavouring ingredients, are undrinkable.

Whisky, therefore, has an original flavour, but contains further ingredients, *e.g.* volatile oils and vegetable acids, which by time, *i.e.* so-called maturation by keeping, are transformed into substances of more agreeable smell and taste, substances which, although they do not seem to have been isolated chemically, have, owing to the manner of their formation, been termed ethers. They are easily discoverable by their smell and taste, and it is also said, by their power to produce exhilaration, which is exercised over and above the similar effect of the alcohol which holds them in solution. The ethers are extremely volatile and unstable; they belong to what may be called the fusel-oil family, and, in some varieties of spirit, fusel oil is among the substances in the form of which they first appear, and out of which they are formed by time.

The presence of grain ethers is the condition of the genuineness of whisky.

Silent spirit, on the other hand, undergoes no change by keeping, and must be flavoured to become drinkable. For that purpose it is either made smoky, to become like Scotch, or it is mixed with Irish pot-whisky, to become like Irish whisky. (Cf. 'Truths about Whisky,' London, 1878.)

The product of the patent still derives its name from the fact that it is mere alcohol and water, "having no distinctive qualities, telling no tales to nose or palate of the source from which it was obtained, and hence, in the almost poetic language of the trade, is commonly called silent spirit." ('Truths about Whisky,' p. 32.) The owner of a patent still, instead of being confined, like a whisky distiller, to the use of the best materials, is able to make his spirit from any, even spoiled and waste materials, and with little reference to any other quality than cheapness. The worst of the spirit thus produced is fit only for methylation, preparatory to being used for trade purposes exclusive of consumption as a beverage. When intended for a beverage it must be rectified and flavoured. It thus serves as a basis for the implanting of artificial flavours, which may be those of sham whisky, sham brandy, or sham rum.

Whisky is explained to be a corruption of the Irish and Erse word "usquebaugh," water of life, the French eau-de-vie.

Strength of Burnt Spirits.—The finest Dublin whisky, when made, is reduced to a uniform strength of 25 per cent. over proof, and is stored in casks of considerable size; its full maturity and excellence cannot be reckoned upon under an age of from three to five years. The grain constituents of perfectly new whisky are not palatable in the estimation of people in general; but after about a year the whisky may be said to be drinkable, after about two years to be good, and after about three years to be as good as anything with which the average consumer is likely to become acquainted.

Arac (arak, arack, arrack) is the name of the spirit made from rice. The same name with a slight terminal variation is applied, as *araka*, to the alcoholic product of the distillation of koumiss, used by the Tartars; as *araki*, applied in Egypt to an alcoholic liquid prepared by fermenting dates; as *araki*, applied in various other parts of Africa to fermented palm-tree sap.

Liqueurs.—The first class of liquids of this kind have been called liqueur-wines, and are wines made from fruit without subjecting it to fermentation. Booth terms them appropriately preserves diluted with spirit. They form agreeable and nutritive stimulants, and are made and used by all nations. In the 13th and 14th centuries they were much used under the name of piments or pigments, from the spices with which, as well as honey and wine or brandy, they used to be prepared. A standard wine piment of the time of Richard II., bore the name of hippocras, another that of clarry. Of these so-called medicated liquors the only kinds still in use are wermuth or vermouth, which is manufactured in Hungary, Italy, and France, and much used in Mahommedan countries; "bishop" is prepared by extracting one or more toasted Seville oranges by a certain amount of Burgundy or other red wine, and sweetening the whole with sugar; when Rhine wine is used for this infusion, the product receives the name of cardinal, and when Tokay is employed it is termed pope. These mixtures are perhaps mainly made to improve wines which are not so pleasant when drunk in their unmixed state.

These fruit-juice liqueurs have the advantage that they can be made perfect in a few days: they can be made more or less alcoholic, in technical phrase "generous."

Cherry liqueur is one of the most fragrant drams of this class. It is particularly well made in Scandinavia, with the aid of the northern or Vistula cherry (Kärsebeer of the Danes). The cherries are bruised together with their stones, and heated over a slow fire so that about a third of their weight is evaporated in the shape of water. To the pulp from twelve pounds of cherries, weighing after the concentration eight pounds, add four pounds of good red wine and two pounds of proof spirit or brandy. Leave the mixture in a closed vessel until clear, and then decant and bottle.

The concentration by heat may be avoided, if to every gallon of cherry-pulp four and a-half pounds of white sugar are added. To the mixture half its volume of spirit should be added.

In a similar manner liqueur wine may be made from white cherries, mixed fruit, and from apricots and peaches. They can be fined with isinglass or milk.

Liqueur wines made from grape-must without fermentation are produced in many parts of the south of Europe. The ripe grapes are generally dried to some extent in the sun, and then pressed. The specific gravity of such must may vary between 13° and 22° Baumé. It is immediately mixed with one-fifth of its volume of alcohol of 40° Cartier, and the mixture is put into the sun to amalgamate. The Spaniards call such liqueur "dulce," and value it according to its age. They drink a little glass of it the first thing early in the morning, and call the practice "tomar la mañana," taking the morning. The so-called muscat of Rivesalte, Frontignan and Lunel, in the department of the Hérault, are made in the same manner. Such wines have also been made with considerable success in Australia. Some of the wines of the Cyprus Commandery, and Cape Constantia, are also unfermented liqueur-wines—juice of the grape preserved by alcohol

True liqueurs are solutions of sugar in alcohol to which a flavouring ingredient has been added, also colouring matter sometimes. A number of such liqueurs are known by all the world, and will probably survive many changes of things hereafter. Thus noyeau is a liqueur in which the crushed almonds of stone fruit have left their prussic acid flavour. Curaçao derives its flavour and colour from the Seville or bitter orange. Anisette is flavoured by aniseed, and is much used in the south to flavour a drink of cold water in summer time. There is the absinthe liqueur, of which the erratic conduct of some French youths has been supposed to be a consequence. There are numbers of compound liqueurs of which the recipes and monopoly of manufacture are claimed by religious brother- and sister-hoods, *e.g.* Benedictine-bitter, Chartreuse, &c. There are liqueurs made with peppermint, others with carraway-seeds, which latter is particularly esteemed in the north of Germany. A most elegant liqueur is termed parfait d'amour, which unites in itself all the refinement of noyeau and maraschino de Zara. These aromatic liqueurs are by the French termed ratafias, and are in France taken after dinner in small quantities. This word is supposed by some to be derived from the Malay tâfîa, signifying a distilled spirit prepared from sugar-cane; in Italian the form taffia for ratafia is not unfrequently employed. According to others the word is derived from the latin formula "res rata fiat," *i.e.* the matter approved or resolved shall be done, and the liqueur drunk on such an occasion received the title derived from the final formula. In other countries, however, the taking of liqueurs of a very compound nature, at frequent intervals independently of meals, has become habitual, and in the United States of America, *e.g.*, the names of liqueurs, which have mostly a taste uncongenial to European palates, are legion. They are mostly mixtures of so many vegetable extracts that they have the character of the most tasty drugs which could be mixed together from the medicine loft of an ancient Dutch droogery.

Liqueurs are frequently offered at a price which amounts to five or six times the value of their ingredients. At some places of restauration a little glass of liqueur, containing two thimblefuls, is marked one shilling on the list of prices. Such values diminish the otherwise deserved popularity of these confections.

THE ÆSTHETICAL USE OF WINE

AND ITS

INFLUENCE UPON HEALTH.

BY

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President of the West London Medico-Chirurgical Society, etc.

"Pour forth, Muses, to me, the cheerfully sonorous voices,
From Helikonian lips of song the melodious showers,
For to whom-ever spends drink the source effervescent with music,
Joyfully listens to words of happiness sung to the lyre."

IN adopting this hexametric invocation of the epic poet Nestor, of Laranda in Lykia, of the time of the emperor Severus, I desire at once to define the standpoint from which I intend to treat the subject of the æsthetical use of wine and its influence upon health. To my mind æsthesia is correct feeling, such as enables us to have the natural desires, the true physiological senses of pleasure and displeasure, and also the power of their correct gratification, by which the whole of organic life exists and is perpetuated. In many minds this feeling exists in its most perfect form as a natural gift apparently, but is no doubt the result of atavistic education, or of the collective influence of the good and happy lives of their forefathers through many ages. In other minds, however, who have not had similar advantages, this feeling is subdued, clouded, or even overcome by coarser motives, and of their possessors it may be said that they are victims of two contending desires, of which one only is æsthetic, while the other arises from ignorance of true pleasure, or from a delusion of the mind regarding the sources and nature of true pleasure. This condition has a complete remedy in education, the application of the mind to the study of things and ideas. Such study leads to science in its widest sense, as a corrector and regulator of feeling. In this connection science includes poetry; for poetry is really the manifestation by highly gifted individuals of the fullest knowledge of that store of thought and feeling which we call the human heart, and the expression of that thought and feeling in forms so beautiful and true that they excite permanent pleasure and settled assent. Aesthesia is therefore, practically, a compound faculty, of natural organisation, of inherited structure, aided by science as a substance and refined by poetry as a form.

In order to understand aesthesia thoroughly, we may consider its negation or exaggeration. The term anaesthesia is no longer available for purposes of general definition, as it is exclusively applied to a state of physical insensibility, produced by medical art for special purposes, namely, for enabling sufferers from mechanical injuries or painful diseases to undergo operations necessary for their recovery, without that suffering of pain and shock, which, in times gone by was so great an addition to the original calamity. We must therefore be satisfied with describing the absence of the true aesthetical feeling by a longer negative than the convenient alpha privativum of the Greek language. But its opposite, namely an exaggerated sensibility to impressions, we may still describe as hyperaesthesia, and with the aid of these definitions we may now come closer to our subject than we could have done without them.

Alcohol is essentially an anaesthetic. It is taken in many forms for counteracting mere bodily pain, and does so counteract it. But it has collateral effects which make it undesirable for the production of higher degrees of anaesthesia. Physicians, therefore, take derivates of alcohol, more or less closely related to it, in a chemical sense, but all directly derived from it, such as ether, and chloroform, to produce a quick and perfect insensibility. But these pharmaceutical preparations are not adjuvants of that euphoria which is valued in common life. Ether is dangerously inflammable, chloroform sickening; neither are agreeable in any form to a natural taste. They have in no case the effect of natural alcohol, such as is present in wine, of influencing the physical heart, and the imagination, so as to remove the actual sense of pain, the algesia, arising from physical fatigue, or from mental depression.

We have indeed a very powerful antidote to the hyperaesthesia produced by the friction of life in that remarkable compound termed beer. This drink contains relatively little alcohol, less indeed than other forms of alcoholic drinks, of which it is, therefore, generally the weakest, so called. But it contains a powerful anaesthetic in the form of the extract of hops, or lupulin, a principle which in Europe takes the same place as that which opium takes among eastern nations. Hops, like the poppy, stimulate at first the nervous energies of various departments of the system, but in larger doses they act as a sedative, and dull anomalous as well as normal sensibilities. Beer is, therefore, by no means an alcoholic beverage merely, and on that account admits of no direct comparison with wine or diluted spirits.

Alcoholic drinks, amongst them foremost wine, have effects which have caused them to be used and praised by all nations and generations of which we have any knowledge. They can be used with results which are the reverse of aesthetical; and it is to discountenance such abuse, injurious to health, and detrimental to pleasure, that all sanitarians should raise their voice. Of all alcoholic drinks, however, true wine, such as we shall define it, offers the least opportunity or inducement to abuse. Natural wine may make drunk, but it never produces delirium tremens, it never produces those permanent lesions of the tissues which are the consequences of excess in the use of spirits and of beer. Whenever such effects are added as the results of wine, they will be found to be due to wine plus spirit added thereto, particularly to those fiery mixtures which under the names of sherry and port have done so much to obscure the real and beneficial qualities of wine.

Happily, after many centuries of fiscal misgovernment, which has perverted the natural taste and habits of the people of these islands, we have been allowed to return to a state of liberty as regards the choice of our wines, and the effect of this liberty has been most marvellous. The brandied wines, which were formerly almost the only ones which could be obtained or were drunk in Society, have been recognised to be incompatible with the more refined manners of our social gatherings, and, are so much neglected by the wealthy classes that the customs revenue from them has decreased by £300,000 a year. The natural wines have increased in favour, though, owing to unfavourable years, not to the same amount as the others have diminished. There are, however, indications to show that the intention of the legislature as manifested in 1858 is being realised, and it is my intention to aid now and in the future in this realisation, as I have done in the past.

But let us look for a moment at the origin of wine in nature, its history and preparation. This will enable us better to appreciate its importance to Society, and the danger of its counterfeits. I quote some passages from the Handbook on Alcoholic Drinks, which I was honoured with the commission to write for this Health Exhibition, and which I hope will soon be available to the public.

The vine grows naturally in the temperate parts of Western Asia, the south of Europe, Algeria and Morocco. In Armenia, and to the south of the Caucasus and the Caspian Sea, it exhibits its quality as a creeper, and rises up high trees, bearing fruit without being either cut or otherwise tended. It grows vigorously in ancient Bactriana, in Affghanistan and Badackshan, and in Cashmir. I have studied it in the Algaida, a forest situated on the south bank of the Guadalquivir, to the east of San Lucar de Barrameda. This forest consists mainly of sea-pines (*Pinus* *maritima*), but contains also groups of the silvery elm. Almost its entire border, and many small and large open spaces in its interior, are lined with the wild vines first described by Clemente. I found vines covering the whole of large fir-trees, silver elms, oleander bushes, fig-trees, and, together with sarsaparilla in blossom and brambles, creeping up and covering shrubs of lentiscus. These garañonas, as the Spaniards term the wild vines, are really indigenous wild plants, and not stray children of the vineyard; for all the flowers which I observed had the *stamina recurvata*, which are the characteristic feature of the female type of the *diœcic* wild vine, and no erect stamina. I observed myself, in 1871, the place described by Clemente, where "the vines form impenetrable thickets, magnificent banqueting halls, most graceful pavilions, grottoes, covered walks, winding foot-paths, labyrinths, walls, arches, pillars, and a thousand original and indescribable caprices." The wild grapes here are black, acidulous, but good to eat. The growth of the plant is so vigorous that a one-year's shoot, which I pulled from a tree, measured fifty feet in length.

That the vine lived in Europe in the tertiary period is proved by the evidence of fossils. That it was present in pre-historic times is shown by the occurrence of preserved parts of the plant in various situations. Thus vine seeds have been found in the remains of the lake dwellings of Castione, near Parma, under conditions which show that they belong to the bronze age, at least 9000 years before our time; other lake dwellings, such as those at Varese, in the province of Como, and at Wangen in Switzerland, exhibit similar proofs. Near Montpellier, vine leaves were found in tufas, which, like those of Meyrargue, in the Provence, are pre-historic, but post-tertiary.

A. de Candolle is of opinion that the idea of producing grape-juice and allowing it to ferment might have originated with different nations, particularly in Western Asia, where the vine abounded, and grew well. It is unquestionable that the Semites, as well as the Aryans, knew wine long before historic periods, and were in a position to introduce it into all the countries to which they migrated, including Egypt, India, and Europe. They could do this the easier as they found the vine wild in several of the countries in which they arrived. As regards Egypt, we have documentary evidence that the cultivation of the vine and the making of wine were practised nearly six thousand years ago, namely under Phtah-Hotep, who lived at Memphis four thousand years before our era. The progress of the cultivation of the vine by Phœnicians, Greeks, and Romans, is well known. A. de Candolle says that towards the east of Asia it seems to have advanced so slowly, that the Chinese do not seem to have cultivated the vine before A.D. 122, although several varieties of wild vines are known to occur in their northern provinces. This is, however, at variance with the statement of Welles Williams, according to whom the first cultivation of the vine in China is ascribed to Foh-hi, a ruler estimated to have lived about three thousand years before the Christian era. It is further recorded that about 1120 B.C. wine was considered in the celestial empire to be dangerous to the state.

The Accadian or Chaldaean epic poem, which describes the adventures of Nimrod, brings him to Hasisatra—the Noah of the Israelites. The latter in the course of the account which he gives to Nimrod of his salvation from the flood, also gives details of the manner in which he provisioned his ship, the ark. Six thousand men carried provisions in six thousand baskets; he took on board also wine, much wine, aye rivers of wine. This emphasis, which I quote by memory from the translation of George Smith of the cuneiform inscribed tablets from the library of Assurbanipal at Nimrod, now in the British Museum, shows us that wine was known and highly valued under such depressing circumstances as the prospect of an aquatic voyage for which Hasisatra prepared, and which he endured.

It is not necessary for our present purpose to investigate the particular steps in the progress of the human intelligence, by which wine, such as we know it now, was discovered

The shepherds of the Algaida gather the wild grapes in earthenware pots, and bury them in the ground under leaves and brushwood, and later on drink the fermented juice at their leisure. From such an original proceeding to the confection of Burgundy or of Champagne there are many stages, to describe which would lead us too far. We will therefore pass at once to a description of wine such as can be given by abbreviated science.

Wine is the fermented, purified, and ripened juice of the grape; as such it contains alcohol, acids, salts, extractives, and those principles which give to it its particular colour on the one hand, and its particular flavour, smell, or bouquet on the other. While some of the ingredients can be accurately described and isolated, others are accessible to a definition by the sense of smell only. The conventional value of wine is determined less by its principal ingredients than by the prominence of the specific character termed bouquet, and the absence of certain faults. Dietetically, most wines are of equal value, provided they are the products of a favourable season, are pure, and free from the faults produced by parasitic fungi.

The principal alcohol in wine is alcohol strictly so called, or spirit of wine, the chemical composition of which is expressed by the formula C_2H_6O. In rare cases there is some butylic alcohol, $C_4H_{10}O$, and in others some amylic alcohol, $C_5H_{12}O$, so-called fusel oil, present. The quantity of alcohol present in wine can be estimated by distillation, and ascertaining the amount of spirit in the distillate by the determination of its specific gravity, or by ascertaining the specific gravity of the wine, then driving away all spirit from it, and having again brought it to its original bulk by the addition of water, ascertaining its specific gravity without the spirit. Other methods are less accurate. The quantity of alcohol present in natural wines from the grape varies between 6 and 12 per cent. Unsound wines may contain some aldehyde, C_2H_4O, produced from alcohol by the loss of hydrogen.

The acids present in wine are those naturally present in the grape, namely tartaric, malic and tannic; and those produced during fermentation, namely acetic, formic, succinic, and carbonic. In addition to these there are nearly always traces of the more complicated fatty acids, such as propionic, butyric, and œnanthic acid present. Tartaric acid, $C_4H_6O_6$, occurs in must as acid potassium salt, or so-called tartar, and is in part precipitated during fermentation, as it is less soluble in spirit than in water. During the ripening of wine, tartaric acid forms with alcohol tartaric ether. The tartaric acid most commonly found in wine turns the plane of polarised light to the right, and is therefore called dextro-tartaric acid. Some wines, however, *e.g.*, Italian, contain also tartaric acid, which polarises to the left, levo-tartaric acid, always, however, combined with the dextro-tartaric acid, forming what is known in science as racemic acid. All three acids have one and the same chemical composition expressed by the formula $C_4H_6O_6$. Sherries contain no tartaric acid, as it is removed from the must of Jerez grapes by gypsum or plaster of Paris.

Malic acid, $C_4H_6O_5$, is not only present in grape-must, but in the juices of many varieties of fruit, which we shall have to consider—apples, cherries, plums, currants, and the red berries of the mountain ash.

Tannic acid is present in most varieties of wine, and is derived from the husks and kernels mainly; more rarely contained in the juice of the grape. Red wines contain more of it than white wines, because they are always fermented with the husks and seeds.

Succinic acid, $C_4H_6O_4$, in wine is one of the results of the fermentation of grape-sugar, which, in that process yields about half a per cent. of its weight of that acid. When the formulæ of succinic, malic, and tartaric acid are compared, it will be perceived that they all contain the same number of atoms of carbon and hydrogen, but not of oxygen, of which latter element succinic acid contains four, malic acid five, tartaric acid six atoms.

Acetic acid, $C_2H_4O_2$, occurs in wine and other fermented liquids, principally as the result of the oxydation under the influence of the air, of some alcohol. When the entire amount of alcohol in a fermented liquid is transformed into acetic acid, vinegar results. Vinegar from wine preserves some of the flavour of wine, and those accustomed to its use are therefore not inclined to exchange it for the more common vinegar made from fermented malt, or from acetic acid obtained by the fiery decomposition of wood. In good natural wine the amount of acetic acid does not exceed 1·78 per thousand, but is ordinarily only about half a pro mille; in spoiled wine its amount may rise to 3·63 per thousand.

The œnanthic acid, to the ethylic ether of which most wines are supposed to be indebted for their characteristic smell, has the formula $C_{14}H_{26}O_3$, and does, therefore, probably not belong to the same series of acids as acetic, propionic, and butyric acid.

In good, sound wines the total amount of free acid varies between 0·3 and 0·7 per cent; wines with more than the latter amount of free acid taste excessively sour, and are not easily digested.

The ethers in wine are aceto-ethylic, which contributes much to the general flavour of the wine; aceto-propylic, butylic, amylic, caproylic; further butyro-ethylic, caprylo-ethylic, capro-ethylic, and pelargo-ethylic, and the tartaric ethers. The characteristic smell of the œnanthic ether distinguishes all kinds of wine from every other fermented liquid. The flavour or bouquet, however, by which wines from different vines and vineyards are distinguishable from each other, is produced by substances which are already present in the grapes, and the effect of which is only heightened by fermentation. The volatile ethers in wine mostly surmount the fixed ethers in quantity. The alcohol obtained by the decomposition of all the ethers is rarely more than 0·06 per cent of the wine.

Wines may contain more or less of sugar of one kind or another. Must contains a mixture of sugars, of which one polarises to the right, and is therefore termed dextrose, while the other polarises to the left, and is in consequence termed levulose. If wine contains cane-sugar, it has been added, *e.g.*, to champagne. Even added cane-sugar is, under the influence of the natural acidity of the wine, gradually transformed into the mixture of dextrose and levulose, this mixture also goes by the name of invert-sugar. Some wines, *e.g.*, Sauternes and old sweet Rhine wines, contain also a peculiar sugar, occurring in flesh and brain, namely, inosite. All sugars in must and wine have the chemical composition expressed by the formula $C_6H_{12}O_6$, but differ in properties. They are, therefore, not identical, but, as it is termed, isomeric with each other.

Another sweet-tasting substance occurring in wine and all other fermented liquids is glycerine, $C_3H_8O_3$, originally known as one of the constituents of animal and vegetable fats. During fermentation it is formed from sugar; 100 parts of cane-sugar, or 105·26 parts of grape-sugar, yield on an average 3·69 parts of glycerine, or one-fourteenth part of the alcohol produced by the same fermentation.

The colouring matters of wines are either natural constituents of the grape, or produced in must and wine during and after fermentation. Of the latter kind are most yellow and amber colours of natural so-called white wine. They are not rarely the result of the oxydation of astringent or tannic acids. But the red colouring matters are mostly contained in the husks, and dissolved only by the concurrence of the alcohol formed during fermentation and the acid naturally contained in it. The grapes from which some of the best red wines, *e.g.*, Burgundy or Médoc wines are made, yield an almost perfectly colourless juice if pressed before fermentation. But some rarer vines, and those yielding inferior wine, have, like the black currant, a coloured juice. Some of the red colouring matters contain iron as an essential chemical ingredient, and are therefore supposed to make the wines in which they are contained particularly wholesome.

Wine contains traces of ammonia, present in all vegetable juices; also albuminous matters, which are supposed to make the wine liable to undergo decomposition more readily. Wine also contains some substances, which remain when it is evaporated to dryness, and are termed extractives. They have an agreeable smell and taste, and contribute to the smell and taste of wine in the same manner as the extractives of meat contribute to the smell and taste of meat and broth. Wine further contains a certain amount of inorganic or mineral ingredients, pot-ash soda, lime, magnesia, and phosphoric, sulphuric and hydrochloric acid in combination with the former. Sherries contain a large excess of sulphate of potassium, due to the treatment of the must with plaster of Paris.

Wine may be aesthetical wherever grown or made, provided only that it be free from faults of manufacture and the destructive fermentations called diseases. These latter fermentations are the main cause, while better methods remain unpractised, of the addition of spirit to the wines of southern climates. All former ages have abhorred strong wines, and the ancients mixed some of theirs with water. In the last century yet natural wine was esteemed, spirited wine denounced in this country.

I quote, after the late Dr. Druitt, some passages from Armstrong's 'Art of Health,' written about a hundred and fifty years ago, which are supposed to show how much Burgundy and other natural wines were esteemed at that time. When speaking of wholesome wine, he praises

> "The gay, serene, good-natured Burgundy,
> Or the fresh fragrant vintage of the Rhine."

He further describes Burgundy as the drink for gentle-men, and Port as an abomination :—

> "The man to well-bred Burgundy brought up,
> Will start the smack of Methuen in the cup."

The last line refers to the Port wine imported into England under the Methuen treaty made with Portugal in 1703 whereby the wines of the latter country were favoured by a low import duty, whereas the trade in French wines was impeded by an import tax amounting to more than double of that imposed upon Peninsular wines.

Armstrong already reprobates the mixing of wine with brandy, which seems to have been at his time, if not a new, at least a newly-revived practice. In describing a man's sensations on awakening after having drunk Port wine the evening before, he says :—

> "You curse the sluggish Port, you curse the wretch,
> The felon, with unnatural mixture first
> Who dared to violate the virgin wine."

We can easily learn the aesthetical uses of wine from the poets of all ages, beginning with him, however, who has most endeared himself to thinking men.

In his ode to Septimius (Od. II. 6). Horace alludes to Tarentine wine, growing on the hill Aulon, near Tarentum.

> "There Jove accords a lengthened spring,
> And winter's wanting winter's sting,
> And sunny Aulon's broad incline,
> Such mettle put into the wine,
> Its clusters need not envy those,
> Which fiery Falernum grows."

The Romans affected handsome or important slaves to pour out their wine for them. Horace asks Iccius (Od I. 29) if it be true that he grudges the Arabs their wealth, and is actually forging fetters for the hitherto invincible Sabaean monarchs, and those terrible Medians ? To which of the royal damsels does he intend to throw the handkerchief, having first cut down her princely betrothed in single combat? Or what young "oiled and curled" Oriental prince is for the future to pour out his wine for him? Iccius (says Theodore Martin) like many another Raleigh, went out to gather wool and came back shorn.

In his Ode to Pompejus Varus (Od. II. 7), who had been a fellow-student with Horace at Athens, and had fought with him at Philippi under Pompey, the poet describes more fully the use which he and his friends made of wine on joyous occasions, such as was the return of Varus (Martin, 136).

"Then pay to Jove the feasts that are his fee,
And stretch at ease these war-worn limbs of thine,
Beneath my laurels' shade; nor spare the wine,
Which I have treasured through long years for thee.

"Pour till it touch the shining goblet's rim,
Care-drowning Massic; let rich ointments flow,
From amplest conchs! No measure we shall know.
What! shall we wreaths of oozy parsley trim,

"Or simple myrtle? Whom will Venus send
To rule our revel? Wild my draughts shall be,
As Thracian Bacchanals! For 'tis sweet to me
To lose my wits, when I regain my friend."

Even when praising measured enjoyment of the fortunes of life, he does not forget wine, as in his Ode to Dellius (Od. II. 3).

"Where the tall spreading pine
And white-leaved poplar grows,"

splendid description of a southern forest! the mixture of the sea-pine, and the alamo of the Spaniards,—

"And, mingling their broad boughs in leafy twine,
A grateful shadow throw,
Where down its broken bed the wimpling stream,
Writhes on its sinuous way with many a quivering gleam.

"There wine, there perfumes bring,
Bring garlands of the rose,
Fair and too short-lived daughter of the spring,
While youth's bright current flows
Within thy veins, ere yet has come the hour,
When the dread Sisters Three shall clutch thee in their power."

The poet also depicts a state of melancholy, when

"neither marbles from the Phrygian mine,
Nor star-bright robes of purple and of pall,
Nor the Falernian vine,
Nor costliest balsams, fetched from farthest Ind,
Can soothe the restless mind."

In his Ode against false prognostications (Od. I. 11) he warns the reader not "to wrest a false assurance from Chaldaean horoscope," but gives the positive advice: (Martin, 151):

"Be wise, your spirit firing
With cups of tempered wine,
And hopes afar aspiring,
In compass brief confine.
Use all life's powers;
The envious hours
Fly as we talk; then live to-day:
Nor fondly to to-morrow trust more than you must or may."

In the Ode to Sestius (Od. I. 4), the gloom of Orcus is made the back ground, on which to depict life, all fresh, joyous, luxuriant and lovely! Be happy "drink in at every pore the spirit of the season," while the roses are fresh within your hair, and the wine-cup flashes ruby in your hand (Martin) for—

"Thee soon shall night enshroud, and the Manes' phantom crowd,
And the starveling hours unbeautiful of Pluto shut thee in;
And thou shalt not banish care by the ruddy wine-cup there,
Nor woo the gentle Lycidas, whom all are mad to win."

The statesman fatigued with the cares of his office, Maecenas, he addresses thus (Od. IV. 9):

"Thou dost devise with sleepless zeal,
What course may best the state beseem,
And fearful for the city's weal,
Weighst anxiously each hostile scheme,
That may be hatching far away,
In Scythia, India, or Cathay."
(Martin, 158.)

But he urges him to escape from town for a few days:

"Scion of Tuscan Kings, in store
I've laid a cask of mellow wine,
That never has been broached before.
I've roses too, for wreaths to twine,
And Nubian nut, that for thy hair
An oil shall yield, of fragrance rare."

Martin relates that Maecenas was of a melancholy temperament, and liable to great depression of spirits. On his first appearance in the theatre after one of those dangerous attacks of fever to which he was liable, he was received with vehement cheers, and to mark the event the

Poet laid up in his cellar a jar of Sabine wine, and some years afterwards he invites Maecenas to come and partake of it (Od. I. 20). From this we learn incidentally that it was not all '*grand vin*' (as the French term the best quality), what Poets did drink at Rome (Martin, 161).

> "Our common Sabine wine shall be
> The only drink I'll give to thee,
> In modest goblets, too;
> 'Twas stored in crock of Grecian delf,
> Dear Knight Mæcenas, by myself,
> That very day when through
> The theatre thy plaudits rang.
> Old Caecuban, the very best,
> And juice in vats Calenian pressed,
> You drink at home, I know:
> My cup no choice Falernian fills,
> Nor unto them do Formiae's hills
> Impart a tempered glow."

Julianus of Egypt had, some short time before the Emperor Theodosius the Great, composed many graceful poems, of which only fragments have been preserved. One, entitled 'The Swallowed Eros,' I translate from the Greek Anthology of my father, Dr. George Thudichum. Vol. viii. p. 1066.

> "When lately twining garlands,
> From freshly gathered roses,
> I found a lovely Eros;
> I took him by his winglets,
> And dipped him in my wine-cup,
> And drank him down entire.
> Now ever since that moment,
> He scrabbles in my inside."

The fragment thus leaves the poet in a not uncommon dilemma, and suggests caution in similar emergencies. At all events poetic souls should think of an antidote to such intoxication, before they expose their hearts to the risks of similar unhappiness. Perhaps Zerlina could help them, who in her aria 'Batti! Batti!' also avows the scrabbling of Eros, but says that she can cure it:

> "I know a remedy,
> Tender and sure."

This aria, with Mozartian music, seems to me a perfect cure in itself. However, Egypt no less than Spain prizes wine, and even the Moslems, to whom wine is forbidden by the book of Mahomet, drink Champagne, as not subject to the interdict. The Shah of Persia, however, when in this country was a complete abstainer, or at least entirely disdained brandy and soda-water. The proper use of wine suggests ideas ; some admit that the ideas are only more rapidly evolved with the aid of wine, and not increased in number or scope; as it is practically expressed, a wine drinker thinks quicker, but not better, with the aid of wine. The quicker flow of ideas facilitates their communication, and thus wine aids in animating conversation. It is also believed by authors of many ages, that the effect of wine is antagonistic to hypocrisy and untruthfulness, and that under its influence men lay aside their mental masks, and show their actual features, an effect which the Latins described in the saying, " In vino veritas ! "

As we are internationally assembled—although the representatives of foreign nations may be conspicuous by their absence—it is perhaps not inappropriate for me to allude to some other praises of the aesthetic uses of wine, which have been propounded in different tongues.

There are those beautiful verses, breathing Horatian inspiration, Latin, statuesque, humorous :

> " Mihi est propositum in taberna mori,
> Vinum sit appositum morientis ori,
> Ut dicant cum venerint angelorum chori,
> Deus sit propitius huic potatori."

Here the very angels are to intercede for the deceased oenophilist.

Another breathes the tender melancholy of a solitary man—a poet, forsooth—who has got, as Artemus Ward would term it, " into the sere and yeller leaf," and does not like it. He feels with the Chorus in Sophocles' Oedipus in Kolonos :

> " When manhood has left him, alone he stands and powerless,
> Every disgrace he must suffer."

This is his monologue, appropriate to be sung on a moonlit evening, with flauto obbligato.

"Lauriger Horatius, quam dixisti verum,
Fugit Euro citius tempus edax rerum.
Ubi sunt nunc pocula, dulciora melle,
Rixae pax et oscula rubentis puellae.
Crescit uva molliter et puella crescit,
Sed poeta turpiter sitiens canescit.
Quid juvat eternitas nominis, amare
Nisi terrae filias licet et potare."

The Greek poets, epic and lyric, are the great examples of enthusiasm for good wine. Thus sang Homer nearly 3,000 years ago, in the ninth book of the Odyssey, describing the beneficence of Maron, the minister of Apollo: remember of Apollo, our special patron, the healing God.

"He fetched me gifts of various excellence,
Seven talents of fine gold; a book all framed
Of massy silver; but his gift most famed
Was twelve great vessels, filled with such rich wine,
As was incorruptible and divine.
He kept it as his jewel, which none knew
But he himself, his wife, and he that drew.
It was so strong, that never any filled
A cup, when that was but by drops instilled,
And drunk it off, but 'twas before allayed
With twenty parts in water; yet so swayed
The spirit of that little, that the whole
A sacred odour breathed about the bowl;
Had you the odour smelled and scent it cast,
It would have vexed you to forbear the taste;
But then, the taste gained, the spirit it brought,
To dare things high, set up on end my thought."

This is quoted by Mr. T. G. Shaw, in his beautiful work on wine, from the translation of the Odyssey by George Chapman, 1609. It was this wine which prepared Polyphemos for the loss of his eye, and thus helped to liberate Odysseus from the grasp of the fabulous cannibal.

The lyric poetry of Anacreon is to Greek literature what that of Horace is to Roman. Thus in the nineteenth Ode he sings:

Ἡ γῆ μέλαινα πίνει,
Πίνει δὲ δένδρε' αὐτήν.

Πίνει θάλασσ' ἀναύρους,
'Ο δ' ἥλιος θάλασσαν,
Τὸν δ' ἥλιον σελήνη.
Τί μοι μαχεσθ', ἑταιροι
Καυτῷ θέλοντι πίνειν;

The ancients knew no temperance or total abstinence societies, and practised no rivalry as to the wines of different countries. But the modern, or so-called cultured nations, have altered that. Thus our French neighbours, of whom Julian the Apostate said yet that they were poor in vines, and that their beer smelt of the he-goat and not of Bacchus, now are quite convinced that their wines are superior to any other in the world. Champagne comes in for the highest praise from the pen of Amaury de Cazanove, who however exhibits his limited taste by denouncing Bordeaux as a wine for old and decrepit people.

"Que le vieillard cherche un reste de vie,
Dans le Bordeaux qui réchauffe les sens,
Pour charmer les banquets la jeunesse n'envie
Que le Champagne aux flots resplendissants."

This was, no doubt, before champagne became dry, and extra dry, and brut, harsh, sour, and dosed with cognac brandy; before it assumed that quality which a diplomatist disliked, and of which he believed that others disliked it also, no matter what they professed: he believed that the man who said that he liked dry champagne would say anything. However, the champagne of good years, with its natural sweetness and gentle mousse, is one of the finest inventions of the French genius. A wit said that there were only three human inventions worthy of the ingenuity of man: foil-fencing, the Jesuits, and champagne. However M. de Cazanove cannot conclude his canzonette without a hit at the English:

"Vous, froids Anglais, qui vantez notre France,
Et ses enfants au rire toujours prêts,
Avez-vous soif d'amour, de gaîté, d'espérance?
Buvez, buvez! et vous rirez après!"

We omit the refrain, as the circumstances are no longer fitting it. But we accept the advice, for we know it to be correct from experience.

> "Et vous verrez les brouillards de votre onde,
> Fuir dans les cieux en nuage vermeil!"

The Italians of our days have also their national pets. Thus Redi, in his poem "Bacco in Toscana," proclaims Montepulciano to be king of all wines!

> "Bella Arianna con bianca mano,
> Versa la Manna di Montepulciano;
> Col mane il tonfano e porgilo a me.
> Questo liquore, che sdrucciola al core,
> O come l'ugola e baciami, e mordemi!
> O come in lacrime gli occhi disciogliemi! . . . .
> Montepulciano d'ogni vino è il re!"

We hope the Italians will not allow themselves to deviate from the path of progress which they have entered upon, and revert to liqueur wines We have in this Exhibition a number of samples of Italian wines which may go far to counteract the results of former Exhibitions.

The Americans also have a pet wine, which in their opinion beats Champagne, namely Catawba wine. Of this Longfellow sings:

> "Very good in its way.
> Is the Verzenay,
> Or the Sillery soft and creamy;
> But Catawba wine
> Has a taste divine,
> More dulcet, delicious, and dreamy.
>
> "There grows no wine,
> By the haunted Rhine,
> By Danube or Guadalquivir,
> Nor an island or cape,
> That bears such a grape,
> As grows by the beautiful river.
>
> "Drugged is their juice,
> For foreign use,
> When shipped over the reeling Atlantic,
> To rack our brains,
> With the fever pains,
> That have driven the old world frantic."

Here is one for M. de Cazanove, and for the rest of European wine-bards.

However, in my humble opinion, good Catawba is an excellent, marvellously-flavoured beverage. I can enjoy it without thinking all other wines Borgia tinctures or Devil's elixirs.

English literature is rich in allusion to the virtues of wine, and the English people have always been excellent customers of wine-growing lands. Indeed it may be said that the vineyards of Jerez, the Alto Douro, and of Madeira are mainly Britannia's vineyards; while the French vineyards furnish a considerable share of English consumption.

The Germans have perhaps the most varied lyric poetry in praise of wine, probably because their poems are mostly set to music, and are sung by young and old on joyous occasions.

Thus there is the celebrated song,

> "Bekränzt mit Laub den lieben vollen Becher,
> Und trinkt in fröhlich leer!" etc. etc.

The song is full of humour, but a little old-fashioned in cadence and melody. It denounces not indeed foreign wines, but other German Hills, which do not, like those of the Rhine, produce wine, or produce bad wine.

There is the Thuringian three-men wine, so called because, if any one wants to drink it he must be held by a second man, and a third must force it down his throat.

There is Silesian, to which the Devil was treated, but he said that to go on with it was only possible to a born Silesian.

But the end of the *Rheinweinlied* concerns us here, as it expresses the proposition we are here to discuss:

> "So trinkt ihn denn, und lasst uns alle Wege
> Uns freun und fröhlich sein!
> Und wüssten wir wo jemand traurig läge,
> Wir gäben ihm den Wein."

Ay! Wine is a cure for melancholy! and if there were more good wine in the world there would be less melancholy in it.

Among German songs may yet be mentioned:

"Im kühle Keller sitz' ich hier,"

for a bass voice solo.

Lessing's poem of the bibber who cheated Death by telling him he intended to become a doctor and go halves with him as regards his patients, ending in this joyous strophe:

"Ewig soll ich also leben,
Ewig! denn beim Saft der Reben,
Ewig soll mich Lieb und Wein,
Ewig Wein und Lieb erfreun."

Who does not think of Luther's:

"Wer nicht liebt Wein, Weib, Gesang,
Der bleibt ein Narr sein Leben lang?"

and lastly of Göthe's Chorus:

"Sollst uns nicht nach Weine lechzen.
Frisch das volle Glas heran;
Denn das Aechzen und das Krächzen,
Hast du längst schon abgethan."

All factors which promote happiness, promote health. And as wine promotes happiness it promotes health. But it does so on the condition that it be aesthetically used, *i.e.*, in accordance with the dictates of feeling, reason, and science.

MR. A. J. R. TRENDELL moved a vote of thanks to Dr. Thudichum for his able and interesting lecture, which was carried unanimously.

PUBLIC HEALTH LABORATORY WORK.

BY

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PART I.—BIOLOGICAL LABORATORY.

BY

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WITH

CATALOGUE OF THE EXHIBITS IN THE LABORATORY.

PUBLIC HEALTH
LABORATORY WORK.

I.

It has of late been shown that in a considerable number of infectious and contagious diseases, minute living bodies are present of various shapes and characteristics, which have in some instances been shown to be the cause of the disease. These bodies belong to the lowest class of plant life and are termed Schizomycetes, because at first they were only supposed to multiply by division or fission, as it is technically called. The most common names for this class are, however, Bacteria or Micro-organisms. There are four well-marked groups of bacteria, divided according to differences in form. These are (1) Bacteria proper, small oval or slightly elongated bodies; (2) Bacilli or rod-shaped bodies; (3) Micrococci or round bodies; and (4) Spirochætæ or spiral bodies.

Many of these micro-organisms can move actively in fluids, their progression in most instances being probably due to the presence of a lash or cilium at one or both ends. This has been demonstrated to exist in the bacteria and in some forms of Spirilla (belonging to the fourth class). Movement also is present in some of the bacilli, but the majority of those associated with disease are motionless. In most cases moving bacteria have a motionless stage. The spontaneous movements of these bodies are sometimes difficult to distinguish from the well-known molecular motion of minute particles suspended in fluid. The former is, however, as a rule, well marked, the organisms changing their place either with a swift darting or slow undulating movement; while the latter is a dancing, or in the case of rods an oscillating motion without change of position.

The mode of growth is in most cases by division. A rod elongates and soon divides transversely to its long axis, giving the appearance of two rods joined together by their ends; these rods separate, and we have thus two individuals. In the case of the micrococci the division may take place

Fig. 1.

1. MICROCOCCI AND STREPTOCOCCI; 2. BACTERIA; 3. BACILLI; 4. SPIRILLA.

not merely transversely but longitudinally, and thus we may have pairs of micrococci or triplets, or fours, or groups; or it may take place in one direction only, giving rise to long chains. In the last case the organism is called a chain micrococcus or streptococcus. The rapidity of growth of bacteria depends greatly on the temperature and on the nature of the soil; but it has been calculated with regard to one or two forms grown on suitable soil at the ordinary summer temperature of this country, that they double their numbers at the least once in an hour, so that every individual produces 8,388,408 in 24 hours.

Not only does growth occur by fission, but it also takes place, more especially in the bacilli, by the formation of spores, (see figs. 1, 3). These appear in the rods as bright refracting, round or oval bodies, the rod after a time disappearing and liberating the spores.

These spores are of great importance, as they are extremely resistant to the action of heat and chemical agents. They may retain their vitality for years in the dry state, and grow again into the fully developed organism if placed in suitable circumstances.

Ever since the discovery of these organisms till within the last few years there have been constant and often violent discussions as to their origin, some asserting that they were always derived from a parent, others stating that they arose *de novo* in organic fluids from aggregation of organic molecules, which became vivified as the result of various physical causes—the theory of spontaneous generation Abiogenesis or Heterogenesis. The latter theory has been gradually disproved step by step till it is now no longer upheld, and there can be no doubt that whenever micro-organisms develop they have been derived from one which has come from the air, water, or surrounding objects. The fallacy arose from the fact that, when an organic fluid such as infusion of meat, was placed in a flask, boiled and the flask hermetically sealed, in a certain number of instances the fluid became turbid from the development in it of these minute bodies. As boiling a fluid for a few minutes was supposed to be destructive of all existing life, a positive result was held to be proof of the origin of these bodies *de novo*. Sometimes the fluid was boiled after the flask was sealed and the temperature was raised above 212° Fahr., and yet in a number of instances development occurred. The fallacy in these experiments is two-fold ; in the first place the upper parts of the vessel were not sterilised previous to the introduction of the fluid, and in the second place nothing was at that time known of the existence of spores. The introduction of the method of first heating the flask for some hours at a temperature of at least 300° F. after the orifice had been plugged with cotton wool, taking care in the introduction of the impure fluid that it does not touch the upper part of the vessel, and then boiling the fluid for ten or fifteen minutes, was followed by a very great diminution in the number of instances in which development afterwards occurred in the fluid. And when it was shown by Tyndall that, if the fluid, instead of being boiled only once for a long time, were boiled on several successive days for a few minutes at a time, no instances of development occurred, the last blow was struck at the theory of spontaneous generation, and it may now be finally dismissed from consideration. Tyndall made the brilliant deduction from his observation that some of these bodies must form very resistant spores, and his object in boiling the fluids more than once was to give time for the spores not killed on the first occasion to develop into mature organisms, when they are readily killed by the second or subsequent boilings. This deduction, made before the spores in these organisms had been observed, has now been amply confirmed by microscopical observation. At the present time it is perfectly easy to maintain any organic material pure for an indefinite time if the vessel in which it is placed be sterilised at a high temperature for some hours after being plugged with cotton wool, if care is taken to introduce the fluid to the bottom of the vessel, and if the fluid be afterwards heated for an hour for two or three days in succession to a temperature even a good deal below the boiling point of water.

These organisms and their spores are found almost everywhere in nature in enormous numbers. They float in the air: in large numbers in the air of factories, towns, and inhabited rooms, in woods and forests; in smaller numbers in the air in the open country; still fewer at high altitudes; and in the air on the glaciers in Switzerland, for example, they are almost if not entirely absent. They are constantly present in water; the more stagnant the water is, the more numerous they are; they pass through the ordinary filters, and are, therefore, numerous in drinking water. The surface of the animal body is covered with them, and in the mouth and parts of the alimentary canal they flourish in great luxuriance. All dust contains them, and the soil is the special habitat of many forms of the greatest importance in the plan of nature.

These organisms play a very important rôle in nature, and without them vegetation and with it animal life would greatly diminish if not entirely cease to exist. They are the mechanism by which dead vegetables and animals are decomposed and rendered suitable food for future generations of plants. The higher plants derive their carbon almost entirely from the carbonic acid of the air, and their nitrogen in part from the ammonia of the air and soil, and in part from nitrites and nitrates in the soil. By the combined action of the chlorophyll and the sunlight the carbon is extracted from the carbonic acid and used to form the complex organic substances of which the walls and contents of the cells of plants are composed. In the same way, also, the nitrogen must probably be in its elemental form before it can be utilised. The higher plants cannot take up complex chemical substances and utilise them as food; these must first be reduced to their simple forms. Hence, there must be some mechanism for reducing these compounds to their simple forms, otherwise the higher plants would perish for want of suitable food. Part of this destructive work is done by animals. They can take up these complex substances and utilise them as food, and, as a part of their vital action, they reduce a portion of them to carbonic acid, water, and other simple forms, in the lungs and throughout the body. But the reduction of these substances by animals is very imperfect and quite insufficient for the purpose, while, further, the dead animal body must be itself converted into these simple elements, otherwise a large amount of energy and nutritive material would be constantly lost. This gap is filled up by the lowest forms of plant life—the miscroscopic fungi, but more especially the bacteria; their existence is therefore essential for the maintenance of all life.

It must not, however, be supposed that every bacterium is capable of taking up a complex organic substance and splitting it into its elementary constituents. All take up oxygen either from the air or from the substances in which they grow, and probably all produce more or less carbonic acid, but some are only able to carry on the destructive process to a certain stage, and when their work is done other forms come to their aid and complete the change. Among these partial changes in organic substances, as the result of the growth of micro-organisms, we have the great class of fermentations which result in the production of some of the essential elements of food and many of the so-called luxuries.

There is one class of micro-organisms which gives evidence to the naked eye of the change they occasion in the material in which they grow. These are micro-organisms which produce various pigments. There are now a large number of pigment-producing organisms known. Among the torulæ there are some which produce pigments of various colours. The best known of these is one which forms a pink substance (Rosahefe). This substance only becomes pink at the surface in contact with oxygen; at the deeper parts of the growth, the material formed is colourless, but rapidly becomes red when exposed to the action of the air. In none of these cases is the micro-organism itself coloured, but it is the material produced by and surrounding it that has the property of absorbing certain portions of the spectrum. Other forms of torula produce other colours; for example a yellow torula is very common. Among the subdivision *bacterium* of the Schizomycetes there are a few which produce pigments. Chief of these is one which causes the greenish-blue colour which is sometimes seen in pus; also one which produces the so-called yellow milk, and one which gives rise to a brown colour. It is necessary to mention here that it is not only in pus or in milk that these respective colours are produced. Pigment micro-organisms always produce the same colour on whatever soil they grow, provided that the soil possesses the necessary chemical substances. And the same pigment is always produced by the same organism. An organism cannot at one time produce a red, at another a blue, at another a yellow substance; it always produces the same colour, or where the soil is unsuitable, but where it is still capable of growth, no colour at all. There are very few *bacilli* which cause the formation of pigments, but of these the best known is the bacillus of blue milk. These bacilli can be cultivated apart from milk, and when introduced into a glass of milk which is becoming sour, but has not yet coagulated, they produce this blue change. A red pigment is also produced by a bacillus—*Bacillus ruber*. By far the largest number of these pigment-producing organisms belong, however, to the class of *micrococci*. These grow with great readiness on boiled potatoes, and also on various gelatinised organic infusions. One of the best known is *Micrococcus prodigiosus*, which gives rise to a beautiful blood-red colour. Among other colours produced are a yellow (*Micrococcus luteus*); an orange-yellow (*Micrococcus aurantiacus*); violet, green, &c. These pigment organisms are very important for experiments on the specificity of these minute bodies, and also, as will be seen later, for testing the power of various agents in destroying the vitality of these lower forms of life.

The changes produced by the other micro-organisms associated with fermentation are not so evident to the naked eye as those we have just been considering, but nevertheless it is possible to render these changes visible in some cases. For example, when most forms of bacilli grow in an organic fluid rendered solid by the addition of gelatine, this solid material becomes fluid as the result of the action of these bacilli on the gelatine. The fluidity of the gelatine is at once a test of the presence of bacilli, and an evidence of the extensive chemical alterations they produce in the soil in which they grow. I may mention a beautiful example of a chemical change rendered visible to the naked eye which occurred to me lately. A yellow torula was being cultivated on a gelatinised meat-infusion which contained a minute quantity of blood-colouring matter. In the preparation of the material, the blood-colouring matter had been converted into methæmoglobin, a substance convertible into oxyhæmoglobin by the action of oxidising and reducing agents. On one occasion, in re-inoculating this yellow torula, a bacterium became mixed with it; the cultivation was impure. After these two organisms had grown on the gelatine for a few days, it was found that the material beneath the yellow patch, and extending far beyond the growth of organisms, had assumed a delicate pink colour, which on spectroscopic examination was found to be due to the presence of oxyhæmoglobin. Re-inoculations of this bacterium on similar soil was always followed by the same result, the bacterium evidently producing a gaseous reducing agent which passed a certain distance into the gelatine, and converted the methæmoglobin into oxyhæmoglobin. That the growth of bacteria is followed by changes in the soil in which they grow is also easily ascertainable by chemical analysis, and among the most important of these changes are the various fermentations which occur in organic substances.

The most extensive fermentation caused by micro-organisms is the conversion of glucose and maltose into alcohol, carbonic acid and other substances. This is brought about by the growth of the *Torula cerevisiæ* in solutions containing these substances. Other torulæ and also some fungi are capable of causing the conversion of sugar into alcohol, but their effect is insignificant as compared with that of the organism employed for the purpose—the *Torula cerevisiæ* or yeast plant. The torulæ are small microscopical cells, round or oval, with cell wall, granular protoplasm, and sometimes vacuoles. They grow by budding, and in some cases by the formation of spores. They grow with great rapidity in suitable sugary solutions if exposed to the air. When there is plenty of free oxygen present they do not cause much fermentation of the fluid ; but if the supply of oxygen is insufficient, they grow less luxuriantly, but produce a much greater change in the constitution of the fluid. In these circumstances they are supposed to take oxygen from some of the compounds in the material in which they grow—probably from the sugar which splits up chiefly into alcohol and carbonic acid, a small quantity of glycerine and other substances being also formed.

Many other fermentations are caused by the Schizomycetes. Thus the souring of milk is due to the growth of a small bacterium, the *Bacterium lactis* (Lister) in it. This organism can be cultivated pure in solutions other than milk, and when again inoculated into milk, the latter becomes sour and coagulates from the formation of lactic acid from the milk sugar. The butyric acid fermentation has been shown to be due to a bacillus, which only grows in the absence of oxygen, and indeed is killed by it. When cultivated in various fluids, even in Pasteur's solution, it causes the butyric fermentation. This organism is of use in the preparation, especially the ripening of Swiss cheese. It grows and causes the butyric fermentation during the first twenty-four hours, while the cheese is still under the press, and the fermentation is accompanied by the evolution of large quantities of gas. The slower development of this gas which occurs later explains the formation of cavities in the cheese. The chemical change consists in the partial transformation of the milk sugar into butyric acid. Sugar at times undergoes a viscous fermentation. This is the transformation of sugar into gum, mannite, and carbonic acid, and results in the formation of a viscid ropy fluid. This fermentation is due to micro-organisms, said to belong to the class of micrococci. Putrefaction is a fermentation accompanied by the development of a foul smell, but is a much more complex process than the other fermentations, and is probably caused by several organisms producing a succession of fermentations. This fermentation is a very important one, as during its course products may be formed which are intensely poisonous to animals, and introduced into the circulation may cause symptoms resembling those due to various alkaloids. The acetic fermentation is due to a small bacterium which converts alcohol into acetic acid. The growth of this bacterium only occurs when suitable nitrogenous and other nutritive substances are present and when the fluid does not contain more than ten per cent. of alcohol.

Other fermentations are associated with bacteria, and though not yet thoroughly worked out are undoubtedly due to them. The old idea that organic substances underwent fermentation and decomposition owing to the action of the air or other causes independent of the growth of these bodies, has been shown to be erroneous, for the most diverse organic materials may be kept for an indefinite time with suitable precautions without the occurrence of any change in them. Thus, milk may be taken from the cow with certain precautions, received into a sterilised flask, protected from the dust by a cotton wool cap, and kept for an indefinite time without undergoing any change and without the development of any organism. In the same way blood or portions of the organs from a healthy animal just killed may be placed, under similar arrangements, in vessels, and kept indefinitely, without decomposing. These experiments show not only that organic substances do not undergo fermentations if micro-organisms are absent, not only that bacteria do not originate spontaneously (i.e. without a parent) in organic substances, but also that bacteria are not present in the blood or tissues of a healthy living animal. This is a point of great importance.

Many of these micro-organisms will only grow on particular soils, while the great majority will grow on any albuminous substance. The necessary substances are water, carbonaceous and nitrogenous organic substances, and various organic salts, especially phosphates and salts of potash. One of the most important points with regard to the soil is the reaction, most bacteria requiring a neutral or slightly alkaline substance. This is, however, not invariably the case, as for the bacterium which causes the acetic fermentation, for example, an acid soil is requisite. Again, bacteria as a rule grow best in the presence of plenty of oxygen; but there are some which will not grow unless oxygen is almost or entirely absent. Some of those which cause fermentation do so most vigorously in the presence of free oxygen, others act best when there is no oxygen, where, therefore, they must take their oxygen from the substances in which they grow. The temperature is also a point of great importance, a medium temperature of 60° to 80° F. being best for most forms. The best temperature is, however, different for different forms, some, for example the bacillus of tubercle, only growing at the average body temperature.

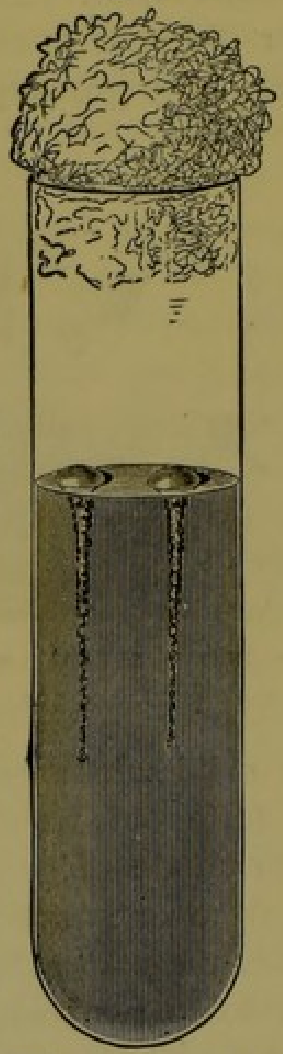
Fig. 2.

SURFACE OF COAGULATED BLOOD SERUM ON WHICH THE BACILLI ARE GROWING. × 100.

When growing on solid substances, such as gelatinised meat-infusion many forms of bacteria show distinctive characteristics in their mode of grouping, &c., and thus may be distinguished from one another, though this would be hardly possible under the microscope. Thus the *Bacillus anthracis* grows in a loose network, the rods not being closely applied to each other; the bacillus of tubercle grows in dense masses of parallel rods, which soon become more or less S shaped (see fig. 2); the bacillus of septicæmia in mice forms an extremely delicate cloud; the micrococcus of pneumonia forms pin-shaped colonies at the point of inoculation (see fig. 3), and so on. Thus by the naked eye one can pick out many organisms by their mode of growth or solid substrata.

Not only are these microscopic plants essential in nature, by causing fermentation and decomposition of the substances in which they grow, but some forms can also prove injurious to vegetable and animal life. Those which injuriously affect plants belong almost solely to the class of fungi, while of those which are hurtful to animals only one or two are fungi, the great majority being various forms of bacteria.

Fig. 3.



APPEARANCE OF CULTIVATION OF THE MICROCOCCI OF PNEUMONIA (FRIEDLAENDER) ON GELATINE. (NATURAL SIZE.)

These bacteria may be hurtful by the production of poisonous substances which belong to the class of alkaloids, and are rapidly fatal to life in a sufficient dose. If a quantity of putrid blood be injected into a number of mice, for example, a certain number may die only after a day or two or may not die at all ; but where the quantity injected is large the animals may die in a very short time (a few hours), as the result of the absorption of the poisonous substances resulting from the growth of the micro-organisms in the putrefying blood. Some observers state that they have been able to extract from this putrefying blood an alkaloid substance, which, injected into animals, produces the same poisonous effects as the original putrid blood. This septic intoxication is of great importance in surgery, for in wounds to which micro-organisms are freely admitted these substances are produced, and if absorbed in moderate quantities give rise to fever, or, if in larger quantities, and rapidly, to death.

This condition of septic intoxication must be carefully distinguished from the action of other forms of micro-organisms which are parasitic on the animal body, and, growing in the blood or tissues, give rise to a large number of diseases grouped together under the term "Infective Diseases." Of these there are two groups, those in which the infection occurs from a wound or open surface—Traumatic Infective Diseases—and those in which no wound is necessary and where the pathogenic organisms are supposed to be able to enter the body through uninjured surfaces. Of these the traumatic infective diseases have been most completely worked out, and have been shown in a larger number of instances to be due to the action of specific micro-organisms. Some of these pathogenic organisms are not only parasitic on the living body but can also grow outside the body on dead organic substances, being ever ready, however, to become parasitic on a living body when an opportunity offers. One of the best examples of this is the bacillus of anthrax, which in the living body does not form spores. It can, however, grow on dead vegetables such as peas, especially when lime is present, and form spores, producing the disease again when taken into a living body. Other pathogenic organisms are, however, apparently incapable of growing outside the body though they retain their vitality for a considerable time in the dry state, and can grow when they again enter a living body. One of the best examples of this is the bacillus of tubercle, which, though it can be artificially cultivated outside the body under special conditions, can seldom if ever meet with these necessary conditions in nature.

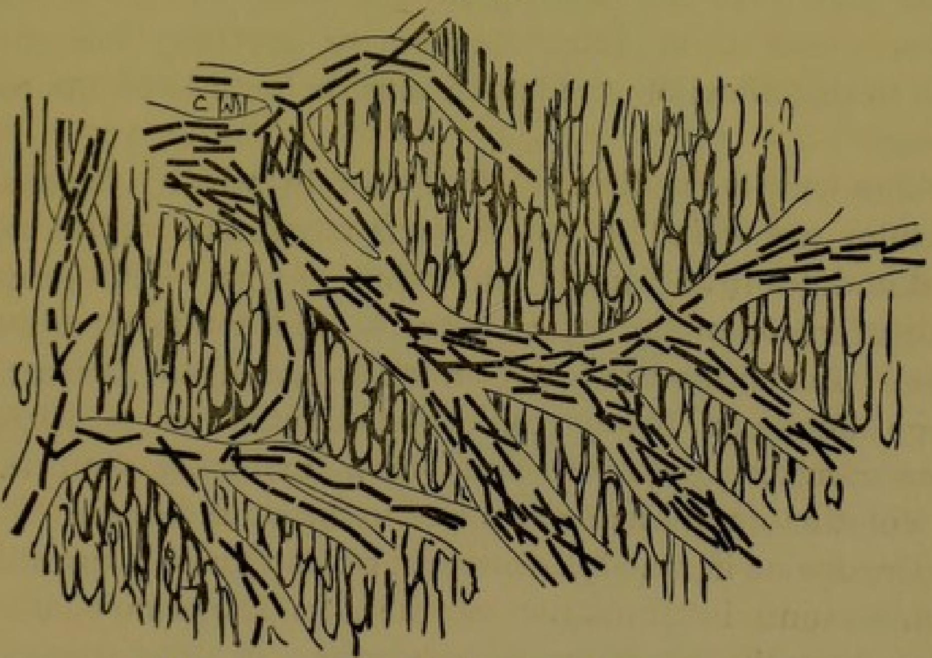
The following are the chief steps required for the proof that a given organism is the cause of a disease. Firstly, an organism of a definite form and with definite characteristics must always be found in the blood or in the affected parts of the animal body. The blood or the affected parts containing these organisms, when inoculated into another animal of the same species, must produce the same disease. Treatment of the blood or affected parts in such a manner as to destroy the micro-organisms present in them must also destroy their power of causing disease in another animal. When the diseased parts are inoculated on suitable soil outside the body the micro-organisms grow, and can be indefinitely propagated on similar soil.* When in this manner the organisms have been separated from the remains of the animal substances in which they were imbedded, their inoculation on a suitable animal must again produce the disease, the same organisms being also found in the diseased parts. This sort of proof has now been furnished for a considerable number of diseases.

The best known example of a disease due to micro-organisms in which the above proof has been furnished is that of anthrax or splenic apoplexy. This disease affects all mammalia, including man, and birds are also liable to be attacked by it. It may commence by the formation of a pustule of a carbuncular nature, but usually, especially when the disease is rapid in its course and the animal is particularly liable to it, no pustule is observed. Sometimes animals are suddenly struck down while apparently well, but generally the temperature becomes high, they stagger, bleed from the nose, mouth, &c., and rapidly die.

* The cultivation of some pathogenic organisms, for example of leprosy, and relapsing fever, has not yet been successful, but it is necessary for the absolute proof that they are the causes of these diseases.

In man the carbuncular form is not uncommon, and patients so affected may recover; when, however, the disease becomes generalised death almost always results. In the blood of animals affected with this disease one constantly finds rod-shaped organisms belonging to the class of bacilli. These bacilli are long and thick and are among the largest of the pathogenic bacteria. Not only are the bacilli present in enormous numbers in blood drawn from the body, but if after death portions of the organs are hardened in alcohol, cut into very thin sections, and stained with some of the aniline dyes, all the smallest blood-vessels

Fig. 4.



ANTHRAX BACILLI IN THE CAPILLARIES. × 700.

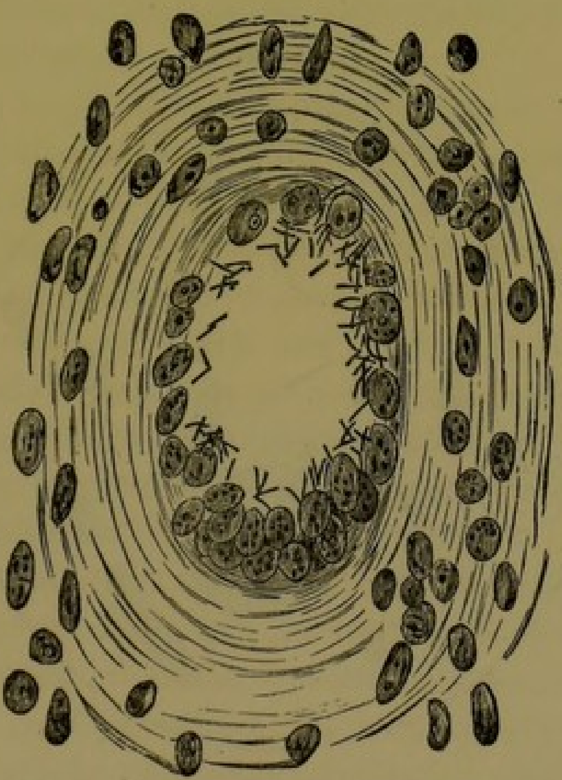
throughout the body will be seen to be full of these organisms (see fig. 4). The smallest quantity of blood containing these organisms rubbed into a scratch in another animal causes its death in a very short time, the same appearances being found. If this blood is exposed to a high temperature or treated with substances which destroy the vitality of these bacilli it no longer produces any effect when inoculated. If a previously heated wire is dipped into the infective blood and then introduced into a sterilised infusion, or stroked over a gelatinised nutritive material, or over a purified potato, care being taken to prevent the entrance of extraneous organisms during and after the experiment, growth of the bacilli occurs in the fluid or on the surface of the solid substance, in the latter case forming the loose net-work mentioned before. From the first material a second may be inoculated, and then a third, and so on indefinitely till all trace of the original blood is lost except these bacilli. If now an animal be infected with the minutest quantity of these cultivated bacilli the same disease and fatal result follow as when the infective blood was employed. Heat or substances which kill the bacilli render the material harmless when inoculated. These facts show that the bacilli were the cause of the original disease, and as no other bacteria or anything else gives rise to this affection, the bacilli must be held to be the only cause.

Glanders is a disease of horses in which ulcers and nodules are found in the mucous membrane of the nose and nodules in the lungs and other organs. This disease also affects man and other animals, and is almost always fatal. In the diseased parts minute bacilli are present in large numbers. They can be cultivated on gelatinised meat-infusion, potatoes and other materials, and their inoculation on animals gives rise to the same disease.

Erysipelas in man is a disease in which there is a spreading redness and inflammation of the skin, sometimes accompanied by the formation of abscesses. At the spreading margin large numbers of minute micrococci are found in the lymphatic vessels of the skin. These can be cultivated on potatoes, gelatinised meat-infusions, &c., forming whitish masses spreading over the cultivating material. The inoculation of these micrococci as also of erysipelatous pus on the ear of rabbits causes extensive redness, which generally passes off without producing any ill effects, and is followed by peeling of the skin in the same manner as occurs in man. Advanced cancerous and other diseases in man, in an unsuitable condition for operation have been benefited by an attack of erysipelas, and the use of these cultivated micrococci has been as effectual in causing erysipelas and as beneficial to the patient as the use of erysipelatous pus.

Tubercular diseases assume a variety of forms in man of which the chief are phthisis and acute tuberculosis. In rodents we find only acute tuberculosis. In cattle and other animals there are various peculiarities, but the essential characters of the disease are the same. The inoculation of sputum from a case of phthisis, of portions of phthisical

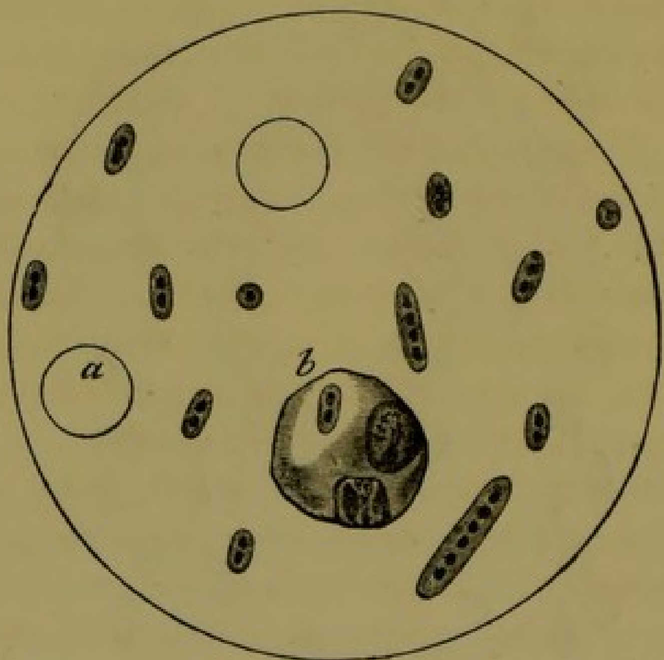
Fig. 5.



GIANT CELL FROM A TUBERCLE CONTAINING TUBERCLE BACILLI. × 700.

lungs, of tubercle of cattle, &c., into rodents gives rise to acute tuberculosis. In the same way inhalation of tubercular material gives rise to acute tuberculosis in rodents. The inoculation of other materials, provided they are not tubercular, does not cause the disease. The disease, therefore, is infective and specific. Examination of tubercular materials, sputum, phthisical lungs, acute tuberculosis, &c., shows the constant presence of a peculiar form of bacillus (see fig. 5), differing in certain chemical characteristics from most of the other known bacteria. The destruction of these bacilli removes the infective property of tubercular substances. The bacilli can be cultivated on solidified blood serum kept at the temperature of the animal body, and forms the peculiar S-shaped growths previously mentioned. These cultivated bacilli can be indefinitely propagated in successive generations in any number of tubes containing blood serum. The inoculation of these bacilli on animals causes acute tuberculosis, identical in every respect with the disease caused by inoculation of tubercular materials. They are,

Fig. 6.



MICROCOCCUS OF PNEUMONIA. × 800.

therefore, the cause of tubercular diseases, though it is probable that a variety of conditions, such as special predisposition, are necessary before they can grow in the living body.

In the affected parts of the lung in pneumonia in man are found micrococci which have the peculiarity of being surrounded by a capsule (see fig. 6). They may be single, in pairs, or chains. They are also present in the fluid in the pleural cavity and in the sputum. They may be cultivated on potatoes or gelatinised meat-infusion, &c. If the point of a sterilised needle be dipped into the pleural fluid, or passed into the diseased lung, and afterwards pushed into gelatinised meat-infusion, a whitish growth appears along the track of the needle, and at the surface this growth assumes the appearance, in relation to that occurring along the track, of the head of a pin. These pin-shaped growths are peculiar to the micrococci obtained from some cases of pneumonia. These micrococci can be grown through an indefinite succession of generations. Their injection into mice is followed by pneumonia, and inhalation by mice of these cultivations also causes pneumonia in a considerable proportion of the animals.

Septicæmia in mice is a rapid disease, resulting in the death of the animal in one to two days, and has been shown to be due to the growth of a minute bacillus in the blood. These bacilli are found in large numbers in the blood and in the blood-vessels throughout the body. They can be cultivated in tubes, and the inoculation of the cultivated bacilli produces the disease. Inoculated on rabbits they only produce a local affection. A peculiarity of this disease is, that while it readily affects tame mice and house mice it does not attack field mice.

For rabbits and other animals a considerable number of pathogenic bacteria have been found, and complete proof has been furnished that the bacteria are the only cause of the disease. Among others may be mentioned various septicæmic diseases in rabbits and mice, chicken cholera, pneumoenteritis in pigs, &c.

Besides the bacteria one or two fungi have been found which are capable of living in the body and causing the death of the host. Among these are two species of mucor and *Aspergillus fumigatus.* In man there is also a fatal disease termed actinomycosis, which is evidently due to a fungus living in the tissues. In man there are various skin diseases, as ring-worm, favus, &c., also due to fungi growing in the cutaneous structures.

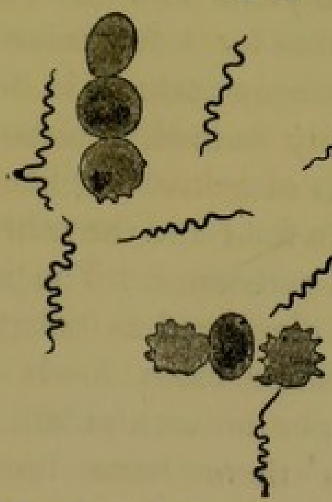
In other diseases in man the proof is not so complete as in the diseases of which I have been speaking above, because animals have not yet been found which are liable to the disease. Fortunately, however, for the advance of medical knowledge, so many diseases of the same type have been shown to be due to bacteria as the result of experiments on animals, that in these cases the constant presence in the diseased parts of organisms, showing definite morphological characteristics and differences from other bacteria in their mode of growth on cultivating media, leads us by analogy to assume, practically with certainty, that they are the virus of the disease. In typhoid fever minute short thick bacilli are found in the ulcers in the wall of the intestine, in the mesenteric glands, and forming plugs in the vessels of the spleen and liver, and sometimes in the lungs. These bacilli can be cultivated, and their mode of growth presents special characteristics. In cholera a bacillus is present in large numbers in the walls of the intestine, somewhat resembling in appearance the bacillus of glanders, and capable of cultivation on suitable soil outside the body. In ague, during the shivering stage, bacilli of peculiar and distinctive appearance have been found in large numbers in the blood. In diphtheria a bacillus is often found at the part where the disease progresses; it can be cultivated, and the result of experiments on animals points very strongly to the view that it is the cause of diphtheria in man; but as yet no animal has been found in which the disease can be produced with all the characteristics of the affection in man.

There are also some diseases in which definite organisms have been found in constant association with the morbid process, but these organisms have not yet been successfully cultivated. Thus in relapsing fever (see fig. 7), spirilla appear in the blood at the commencement and even before the commencement of the febrile attack, and increase rapidly in numbers till defervescence occurs. In leprosy enormous numbers of bacilli are found in the nodules, these bacilli being marked out from other forms of bacteria as well by their appearance as by definite chemical characteristics.

These parasitic diseases are not confined to the higher animals, but they also affect those much lower in the scale of organisation. Thus the fungous disease of salmon and other fish is due to the growth of a fungus (*saprolegnia*) on the surface of the body; flies often die from the growth of a fungus (*Empusa muscæ*) in their bodies; and *pebrine* and *flacherie*, so destructive to the silkworm industry, are due to micrococci.

The demonstration of these bodies by means of the microscope is not always an easy matter, and when they

Fig. 7.



SPIRILLA FROM RELAPSING FEVER. × 700.

are present in tissues they can only be properly seen when they are stained. In the case of fluids one can by placing a drop under the microscope and using a sufficiently high power, generally see the bacteria and observe their movements, &c.; but when they are lying among other structures this is very difficult, and as a rule impossible. In the case of bacteria in fluids, also, it is always best to stain them. This is done by allowing the fluid to dry on the surface of a thin piece of glass (cover glass), and afterwards fixing the organisms to the glass by heating it, by passing it three or four times through a gas flame; the glass is then placed in the staining fluid for a sufficient length of time, it is afterwards washed in water, dried and mounted in canada balsam. The materials used for this purpose are the basic aniline dyes, such as magenta, gentian violet, &c. In the case of tissues, fine sections are made, generally by means of a microtome, and stained in one of the above solutions. If now they are washed in dilute acetic acid, alcohol and oil of cloves successively, the colour disappears from the tissue, and only the bacteria and the nuclei of cells are left coloured. The processes employed are very various and not suitable for discussion in the present handbook. I may, however, mention one solution which is useful for almost all forms of bacteria. Take of a 1 to 10,000 solution of caustic potash in water—100 parts; add of a saturated alcoholic solution of methylene blue 30 parts, shake and filter; after staining in this for a few minutes the section may be washed, if very deeply stained, in dilute acetic acid ($\frac{1}{2}$ p. c.); if not very deeply stained, in water only.

There are two methods of cultivating bacteria, the one in which they are grown in a fluid and the other in which they are grown on some solid substance. The latter method is the one now generally employed as being the most free from error, though in some cases fluids are still useful. The most common danger in manipulating fluids is that bacteria may fall into them from the air, hands or instruments employed, and, growing by the side of those intentionally introduced, the two become mixed together, and the experiment is thus almost hopelessly ruined. If on the other hand a solid medium is employed, and bacteria accidentally gain access to the vessel during the manipulation, they grow at the point where they fell and do not necessarily mix with and spoil the organisms inoculated. Any impurity can thus be seen, and a fresh inoculation can be made before the organisms experimented with become contaminated by those which entered accidentally.

Fluid cultivating materials are usually infusions of animal or vegetable substances. These are in most cases neutralised, filtered, and introduced by a siphon into flasks which have been purified by heating them at a temperature of 300° F. for two or three hours after their necks have been plugged by cotton wool. The fluid is then boiled two or three times at intervals of twenty-four hours, so that all the bacteria contained in it are destroyed, and the fluid remains pure so long as it is kept in the plugged flask. The best flasks for this purpose have a neck at the side, through which the fluid can be poured into smaller vessels. This neck is wide where it joins the bottle and narrow at the end. After fluid has been poured through it and the bottle is again placed upright a drop remains in the end so that no air enters the flask which has not been filtered through the cotton wool over the mouth of the flask. From this flask the fluid is poured into smaller flasks or tubes, which have in like manner been purified by heat, and are covered with caps of cotton wool after filling them. The fluid may be again sterilised by boiling, and then the flasks or tubes are kept for some days at the temperature of the human body. If the fluid still remains clear after a few days it may be looked upon as pure and used for experiments. The cotton wool cap being lifted momentarily, with precautions against the entrance of dust, the material to be tested, blood, pus, &c., is rapidly introduced, the cap again applied, and the flask placed in an incubator at 90° to 100° F. The material may be introduced by means of a syringe purified by heat, by platinum wire which has been heated, by sucking up a little in a capillary tube and dropping it in, &c. If growth occurs the fluid generally becomes turbid in a few days, the turbidity being due to the enormous numbers of bacteria present.

Solid-cultivating materials are boiled potatoes, coagulated blood serum, various infusions rendered solid by the addition of gelatine or agar-agar, &c. Potatoes are cleaned with a dilute solution of bichloride of mercury, steamed till they are cooked, divided with a heated knife, and placed on a dish under a glass cover with wet blotting paper around to keep them from drying up. Potatoes are very good soil for a large number of bacteria, and it is much easier to carry on pure cultivations on them than in fluids. The disadvantage is that they are opaque, and that therefore the mode of growth of the organism experimented with cannot be observed under the microscope. This difficulty is obviated by the use of infusions, rendered solid by the addition of gelatine or agar-agar. The latter is in some cases an advantage, because it remains solid at the temperature of the body, at which gelatine is fluid. These gelatinised infusions are kept in pure tubes or flasks plugged with cotton wool, or they are melted and poured out on heated glass plates which are kept in a moist chamber and protected from the dust. The best composition for a cultivating material is an infusion of meat to which is added 3 per cent. pepton, $\frac{1}{2}$ per cent. common salt, and 5 to 10 per cent. gelatine, the whole being carefully neutralised. Most of the common forms of bacteria will grow on this, though modifications must be made in some instances. If this material is poured out on a glass plate and allowed to solidify, it may be inoculated with the bacteria under investigation, and their mode of growth observed. This is done by dipping the end of a fine platinum wire, which has been heated and allowed to cool, into the material containing the bacteria, and then rapidly drawing lines on the gelatine with it. Along various parts of the track of the needle bacteria remain, and if the pabulum is suitable and the temperature and other conditions correct, they grow in the form of colonies at these points. If any adventitious organism has fallen on the gelatine during the exposure it develops where it fell, and can easily be recognised as an impurity, while further cultivation may be made from the needle track before this adventitious colony has grown so large as to become mixed with those inoculated. At the same time, the gelatine being clear the growth may be observed under even comparatively high powers of the microscope, and may be photographed. As I have already stated, different organisms differ greatly in the form and mode of growth of the colonies which they form on a solid substratum, and in this way organisms, hardly distinguishable under the microscope, may be readily separated from each other.

In other cases the pabulum employed is coagulated blood serum, and some organisms, such as the bacillus of tubercle, grow only sparingly and slowly on any other soil. The advantage of the serum is that it can be kept at the temperature of the human body without becoming fluid, and also that very few organisms liquify it while gelatine is liquified by almost all forms of bacilli.

The best cultivating material for microscopic fungi is a bread infusion, made by rubbing down bread, mixing it with water to a thick consistence, and sterilising it by heat.

I have already mentioned that when cultivations in fluids become impure, i.e. when other bacteria besides those intentionally introduced gain access to the fluid, and grow in it, the cultivation is lost, as it is a matter of great difficulty to separate the various forms from each other; at least, it was a matter of great difficulty till Koch introduced his method of cultivating on solid substrata. Before the solid method was employed the separation was made by what is termed the fractional method. Experiments were in this way successfully made by Sir Joseph Lister on the bacteria of the lactic fermentation of milk. He first estimated the number of bacteria of all kinds present in a given quantity of the fluid, for example in one drop. He then diluted this drop with boiled distilled water till every drop of the mixture thus obtained only contained one bacterium, supposing the organisms to be equally distributed throughout the liquid. To each of a large number of flasks containing sterilised milk or other cultivating material a drop of this diluted bacteric liquid was added. In a certain number of flasks nothing grew; but, in a certain number pure cultivations of the *Bacterium lactis* were obtained. This method, though very ingenious, is, however, very laborious and uncertain in its results, and is now given up in favour of the methods introduced by Dr. Koch. A sterilised, gelatinised infusion is liquefied, poured out on a sterilised plate of glass and allowed to solidify. A fine platinum wire sterilised by heat is now dipped into the fluid containing the bacteria, and then drawn rapidly across the surface of the gelatine. In this way bacteria are sown along the track of the wire, and if a sufficiently small quantity be taken up on the point of a needle, and if the experiment be skilfully performed, it will be found that in parts of the track nothing grows, while at various points small colonies appear. It will be found on examination that some of these colonies consist of only one kind of bacteria, and pure cultivations can then be made from them. The following is another method. A minute quantity of the bacteric fluid is introduced into a tube containing the gelatinised material which has been liquefied at the body temperature. The fluid gelatine is now well shaken up so as to distribute the bacteria throughout the mass ; it is then allowed to solidify. In this way bacteria are caught at various points in the solid gelatine, and grow there to form colonies. On examination it will be found that many of these colonies are pure cultivations. It is more convenient, instead of retaining the gelatine in the tube, to pour it on a sterilised glass plate while it is still fluid, as in this way there is readier access to the colonies after their development for examination and further cultivation. These glass plates are kept in vessels to protect them from the dust, moistened blotting paper being present to prevent drying of the gelatine.

It is on this last principle that Koch's method of examining water is based. A measured quantity of the water to be examined is well mixed with a measured quantity of liquefied sterilised gelatine material, and this is poured out on a sterilised glass plate, and kept moist and protected from dust as in the previous instance. At various points in the gelatine organisms develop and their number can be counted, while, as previously mentioned, the class to which they belong may be determined by their method of growth even without having recourse to the microscope. In case of difficulty, any particular colony can be examined under the microscope, and if necessary inoculated into a suitable animal. This method of examination has been carried out for a long time under Dr. Koch's direction in the Sanitary Institute at Berlin, and in the report of any specimen of water sent to him for examination, not only is the chemical analysis given, but also the number and kind of micro-organisms present are mentioned.

Soil is examined in the same manner. The soil to be investigated is crushed with precautions against the entrance of organisms other than those originally present and in the soil. It is then scattered over the surface of gelatine, spread on plates, as in the foregoing method, and the number and kind of the organisms which develop is in this way determined. Already valuable results have been obtained in this way. For instance, in a hospital at Amberg, an epidemic of pneumonia broke out, and a large number of patients died. Dr. Emmerich examined the soil under the floor of the ward, and found there large numbers of the peculiar micrococci, which seem to be the cause of that disease; these are not present in the same situation in healthy wards. He was in this way enabled to determine the cause of the outbreak.

By the use of the gelatine method air can also be very conveniently and accurately examined. Plates covered with a layer of sterilised gelatine may be exposed in various situations for various lengths of time, and the number and character of the organisms which fall on them may be readily determined (see fig. 8). Air may also be analysed quantitatively by the same method. Into long tubes, the walls of which, more especially the lower wall, are covered with a layer of sterilised gelatine, a known quantity of air may be aspirated and the dust allowed to settle. Development occurs at various points, and the number and kind of the organisms present in a given quantity of air may be determined. Very interesting results obtained by this method are given by Dr. Hesse in the second volume of the "Mittheilungen des Gesundheitsamtes in Berlin," and the accompanying woodcut is copied from one of his plates. Another method is employed by Dr. Miquel of the

Mont Souris observatory in Paris. He introduces a definite quantity of the air from certain localities into a large number of flasks containing sterilised infusions, and counts the number of flasks in which development occurs and the kind of organism in each flask. This method is, however, not so exact as the other, and there are many objections to it; for example: in Hesse's experiments it was found that the organisms in his tubes develop at different dates. Now, if two organisms of different rapidity of growth gain access to the same flask of meat-infusion, the one which grows first may entirely prevent the development of the second, while in many cases two organisms may

Fig. 8.

RESULT OF EXPOSURE OF A LAYER OF GELATINISED MEAT-INFUSION TO AIR. DEVELOPMENT OF VARIOUS FUNGI AND BACTERIA AT DIFFERENT PLACES ON THE GELATINE. (NATURAL SIZE.)

resemble each other very closely in microscopical appearance but differ in the appearance of their growth on a solid substratum.

One of the most important functions of these laboratories is to determine the best means of destroying the bacteria associated with disease, i.e. to determine the best methods of disinfection. Only in some of the infective diseases has the cause been as yet made out, and the bacteria already proved to be the cause of disease differ much in their resistance to various disinfecting means. The most resistant of all are, however, the spores of some bacilli, more especially of bacillus anthracis, and of a short thick bacillus found in earth. If, therefore, substances and methods are tested as to their power of destroying these most resistant bodies, it is practically certain that they will be efficient as disinfecting means in all cases. This matter has been worked out very carefully by Dr. Koch, by the aid of his new method of cultivation. It is not merely of importance to determine what will destroy these bodies, but also what will impede or prevent their growth ; and it has been found that it is much easier to hinder the growth of bacteria than to destroy them. The method adopted by Koch was to soak sterilised threads in spore-bearing cultivations of anthrax bacilli and also in cultivations of non-spore-bearing and less resistant forms, such as micrococcus prodigiosus, and also to use dried earth, which always contains the thick bacillus with the very resistant spores. Among chemical substances able to destroy these spores with great rapidity he found that bichloride of mercury was the most potent. Mixed with the cultivating material in the proportion of 1 to 300,000, the bacillus anthracis was unable to grow. Spores of anthrax dried on threads and placed in a solution of 1—20,000 for ten minutes were incapable of development, but a weaker solution than this was uncertain. Solutions of 1 to 5,000, or stronger, destroy all spores with certainty in a few minutes ; indeed, it was found that to wet the spores with a spray of this solution and then allow them to dry sufficed for their destruction. A large number of other substances acted in the same manner, though not in such dilute solutions.

Of the various other disinfectants employed, only the following were able to *kill* the spores of the anthrax bacillus in less than 24 hours.

Chlorine water.
Bromine (1 per cent. in water).
Iodine water.
Permanganate of potash (5 per cent. in water).
Osmic-acid (5 per cent. in water).

The following acted slowly or imperfectly on the vitality of the spores.

Ether (incomplete destruction after eight days, complete destruction of life after thirty).

Aceton (incomplete after five days).

Iodine, 1 per cent. in alcohol (incomplete after one day).

Sulphuric acid, 1 per cent. in water (incomplete after ten days).

Sulphate of copper, 5 per cent. in water (incomplete after five days).

Boracic acid, saturated watery solution (incomplete after six days).

Hydrochloric acid, 2 per cent. in water (complete on the tenth day).

Arsenious acid, 1 per thousand in water (complete after ten days).

Sulphurous acid (incomplete after five days).

Sulphide of ammonium (complete after five days).

Formic acid 1·12 s. g. (complete on the fourth day).

Quinine, 2 per cent. in water ($\frac{3}{8}$) and alcohol ($\frac{5}{8}$) (incomplete after one day).

Quinine, 1 per cent. in water with hydrochloric acid (complete on the tenth day).

Turpentine oil (incomplete on the first day, complete after five days).

Chloride of lime, 5 per cent. in water (incomplete on the first and second day, complete after five days).

Chloride of iron, 5 per cent. in water (incomplete on the second day, complete after six days.

Carbolic acid in 5 per cent. watery solution killed all the spores between the first and second day. In 5 per cent. oily or alcoholic solution it produced no effect on spores, and bacilli without spores which are killed by the watery solution in a few seconds were not destroyed by the oily and alcoholic solutions till the sixth day. The question has been raised whether the evaporation of carbolic acid at the ordinary temperature would be sufficient to disinfect the air, but this must be answered in the negative. Spores of the earth bacillus placed in a vessel with carbolic acid and exposed to the vapour of carbolic acid for 45 days, developed as readily as before the experiment was commenced. On the other hand, if the vapour of carbolic acid is heated, although precautions are taken that no more is given off than at the ordinary temperature, the action becomes very rapid, so that carbolic acid vapour at a temperature of 167° F. almost completely destroys the spores of the earth bacillus in two hours, though this temperature of itself does not in the least impair the vitality of the spores.

Sulphurous acid is another disinfectant which is much used, but which turns out to be overrated. Dry micrococci are killed by a 1 per cent. vapour per volume in 20 minutes ; if moist, in two minutes. Therefore, for a disease due to micrococci it is sufficient, but it is quite different when it is tested on spores. Spores of anthrax, earth and hay bacilli, exposed for 96 hours to a vapour of sulphurous acid, at first of the strength of 6·13 vol. per cent. and after 96 hours of the strength of 3·3 per cent., were quite unaffected.

Such are examples of the results obtained by this method, and they show that though the ordinary disinfectants in use are sufficient when the virus is a bacterium which is not spore-bearing, yet where spores have to be dealt with they are insufficient. In the case of those diseases in which the cause has not yet been worked out, it is safest to treat them as if the virus possessed the resisting power of the most resistant spores, though it may turn out later that it does not do so.

In disinfecting fluids other factors come into play. Thus, one disinfectant may form compounds with substances in the fluids and lose its properties, while another which is in reality weaker may not do so, and thus be more effectual. Thus, in recent experiments on the destruction of the tubercle bacillus in phthisical sputum, Schill and Fischer found that corrosive sublimate solution (1—500 in water) added to an equal quantity of sputum failed to destroy the tubercle bacillus even after 24 hours' action, while carbolic acid (5 per cent.) added in the same proportions to sputum disinfected it thoroughly in 24 hours. And yet, acting on dry spores of bacillus anthracis the sublimate solution is much more effectual than the carbolic acid. In the case of sputum the difference probably depends on the different chemical affinities of the two substances, the sublimate either losing its antiseptic properties by entering into new combinations, or being unable to penetrate and act on the masses of secretion which contain the bacilli.

Among other methods of disinfection, the most popular are disinfection with hot air and with steam. Dr. Koch's results show that disinfection of clothing, bedding, and large masses of material is impossible with hot air. One experiment will show where the fallacy lies. It is known that spores can resist dry high temperatures for a long time, but that two or three hours' exposure to a temperature of about 300° F. will effectually destroy them. At this temperature clothes are destroyed ; they become brown and useless. But, independently of this fact, Koch made the interesting discovery, that when a roll of clothes is put into a baking apparatus, though the clothes may become brown at the outside, the temperature in the interior of the mass is very low, and quite useless for disinfecting purposes. Thus, a piece of linen, about 40 inches long, was rolled up tightly, and 32 complete turns were in this way made, giving 64 layers from one side to the other. A maximum thermometer was placed in the middle of the roll, and between every fourth turn from within outwards. Beside each thermometer were placed spores of bacillus anthracis, of earth bacillus, and micrococcus prodigiosus, a non-spore-bearing organism very readily killed. The whole was placed in the disinfecting oven. The experiment began at 2 o'clock p.m., and lasted for four hours. The temperature of the air in the interior of the oven was taken at different times and was as follows :

At 2 p.m.	227° F.
„ 2.20 „	284° F.
„ 3 „	293° F.
„ 4 „	298° F.
„ 4.30 „	298° F.
„ 5 „	302° F.
„ 5.30 „	298° F.
„ 6 „	298° F.

When taken out at 6 p.m., the following were the readings of the maximum thermometers:

In the middle of the roll	94° F.
4 turns from the middle	109° F.
8 „ „	126° F.
12 „ „	152° F.
16 „ „	165° F.
20 „ „	175° F.
28 „ „	212° F.

If the roll was moist the result was still less favourable. A similar roll, which had been moistened, was placed in the oven at the same time, and the thermometers in it stood as follows:

In the middle			114·5° F.
4 turns from the middle			129° F.
8	"	"	131° F.
12	"	"	142° F.
16	"	"	152·5° F.
20	"	"	159° F.
24	"	"	165° F.
28	"	"	166° F.

Of the organisms enclosed, micrococcus prodigiosus within the central 18 turns (it was not placed further out) was unaffected, and the bacillus spores which were placed outside the 24th turn also grew. Spores of these bacilli lying free in the oven were destroyed. It is thus evident that dry heat is useless as a method of disinfecting bedding and masses of clothing.

It was also found that there was the same difficulty with steam, even though it were much superheated. The temperature in the central parts of large masses of cloth was very much below that of the steam outside, and much too low to be effectual as a disinfecting agent. If, however, the steam, instead of being shut up in a closed vessel, was allowed to flow through the vessel, there being thus a constant current of steam, at 212° F., the result was very different. In a comparatively short time even large masses were thoroughly heated throughout, and the steam at this temperature acted like boiling water, and completely destroyed the spores in the interior of the masses. Further, the steam injured the various woollen and other fabrics much less than the hot air, and it is evident that where heat is to be employed as a disinfecting agent, it must be employed in the form of a current of steam at 212° F. constantly passing over the material for about three hours.

In connection with this subject it must also be mentioned, that recent experiments have shown that it is possible to diminish the virulence of certain of these pathogenic micro-organisms, and when this is done it is found that in some cases the inoculation of the attenuated virus protects the animal against the effects of the virulent form. Pasteur found, with regard to the organism of fowl cholera, that if it is cultivated in a thin layer of fluid for some months it loses its virulence, and may be inoculated into fowls without causing death, these fowls being now protected against attacks from the virulent organism. Toussaint found that by heating blood containing bacillus anthracis to 134·6° F., and adding carbolic acid, the organism diminished in virulence, and its inoculation protected animals more or less from the virulent form. Chauveau found that by heating for 15 minutes at 125·6° F., or for 20 minutes at 122° F., a sufficient attenuation was obtained. Pasteur cultivated these bacilli at 107·6° F., and thus gradually diminished the virulence of the organism. Koch has worked out the degrees of attenuation which are most suitable for the purpose of affording protection. It has also been found by Pasteur that a virus may be attenuated not only by cultivation in flasks, but by inoculating animals belonging to different species. In certain cases, the blood of these animals, when inoculated into animals of the species in which the disease naturally occurs, causes a mild form of the disease and protects the animal from the more virulent attack.

From this short sketch the great importance of the work done in a laboratory of this kind will be evident, and it is remarkable that in this country there is no public laboratory devoted to these researches. The functions of the bacteriological laboratory in connection with hygiene may be summarised as follows :

1. The investigation of the causes of infective diseases in man and animals, the cultivation of the micro-organisms causing them where they are due to micro-organisms, and the study of the life history of these organisms. In connection with this part of the subject we have the various methods of staining and cultivating organisms, and also of

photographing them. It is also of importance that other organisms, not specially connected with disease but nevertheless of great importance in nature, such as those associated with fermentations and food, should be studied. In this connection also the parasitic diseases of plants deserve special notice.

2. The investigation of air, water and soil, for the presence of micro-organisms, also the determination of the kinds found, and their relations to disease.

3. The discovery of the different methods of destroying these organisms, or of making them useful instead of hurtful. Here we have to do with experiments on disinfectants, and also with the valuable experiments on the attenuation of virus, and the conversion of hurtful organisms into useful vaccine materials.

CATALOGUE OF EXHIBITS

IN THE

BIOLOGICAL LABORATORY.

Microscopes and microscopical apparatus exhibited by Messrs.
C. Baker, 244 High Holborn, W.C.
R. & J. Beck, 68 Cornhill, E.C.
C. Coppock, 100 New Bond Street, W.
Powell and Lealand, 170 Euston Road.
J. Swift & Son, 81 Tottenham Court Road.
Carl Zeiss, Jena.

All these makers kindly allow their instruments to be shown in use.

Staining materials exhibited by Messrs. R. & J. Beck and Dr. G. Grübler, 17 Dufour Strasse, Leipzig.

Microtomes by Messrs. Swift & Son, R. & J. Beck, and A. Frazer, 7 Lothian Road, Edinburgh.

Apparatus for bacteriological research, by Dr. Hermann Rohrbeck, 100 Friedrich Strasse.

Diagrams of parasitic diseases of plants, by Worthington Smith, Esq.

Most of the bacteria, as well as the maps of infective diseases and the vaccination statistics have been obtained from Dr. Koch's laboratory in Berlin.

The glass apparatus used in the laboratory is supplied by Mr. E. Cetti, 36 Brooke Street, Holborn, E.C.

The staining reagents used in the laboratory are supplied by Dr. Georg Grübler, 17 Dufour Strasse, Leipzig. Agent in England, Mr. C. Baker, High Holborn, W.C.

Demonstrations are given every Thursday at 4 P.M.

1. *Apparatus used in the Cultivation of Bacteria.*

Flasks of various kinds, test tubes, glass slides, glass dishes, platinum needles, glass cells, microscopic slides.

Two forms of hot stage, exhibited by T. P. Hawksley, Oxford Street.

The flasks and test-tubes are plugged with cotton-wool, placed in a hot air chamber at the temperature of 300° Fah. for three hours. In this way all micro-organisms in their interior and in the cotton-wool are destroyed and a sterilised cultivating material may be kept in them without risk of contamination.

Glass slides, &c., are placed in a beaker plugged with cotton wool and subjected to the above temperature for three hours.

Dishes, &c., may be disinfected by washing in a 1 per 1000 watery solution of bichloride of mercury. This may then be got rid of if necessary by rinsing in boiled water or washing with alcohol.

Platinum needles are simply heated to redness in the gas flame.

2. *Cultivating Materials.*

(*a*) Boiled potatoes. Old potatoes are thoroughly washed with water and then with the bichloride of mercury solution (1 per 1000), and steamed for half-an-hour. They are cut with a large previously-heated knife (the hand in which they are held being previously dipped in the bichloride of mercury solution), and placed in a glass dish with cover purified as above described. A piece of moist filter paper is placed in the glass dish to prevent drying of the potato.

(*b*) Meat infusion. One pound of meat is chopped up and infused with 37 ounces of water for two or three hours, or is placed in the water in an ice safe for 24 hours. In the latter case the meat is pressed after 24 hours to get rid of all the fluid. The fluid obtained in either of these ways is then boiled and filtered. If desirable it may be neutralized, or peptone or other ingredients may be added to it before filtration. The clear fluid is then introduced by siphon into a sterilised flask, steamed for fifteen to twenty minutes on two or three successive days, and set aside for use.

(*c*) Gelatinised meat infusion.

Constituents :—

Lean meat, 1 lb.

Gelatine (5 to 10 p. c.) $1\frac{1}{2}$ to 3 ounces.

Peptone (1 to 3 p. c.) $2\frac{1}{2}$ to $7\frac{1}{2}$ drachms.

Common salt (·1 p. c.) 15 grains.

Water about 37 ounces.

(Instead of gelatine, Japanese isinglass (1 to 2 p. c.) may be used).

A meat infusion is obtained as described in (*b*), only half the quantity of water, however (16½ ounces), being used.

The gelatine is soaked in the other half of the water until it is thoroughly saturated; it is then added, with the water which is not absorbed, to the extract of meat. The whole is now boiled for some minutes to complete the solution. The peptone and salt are then added and dissolved. The mixture, which is acid, is neutralised by the addition of carbonate of soda or neutral phosphate of potash.

The solution, now very turbid, may be rendered clearer by beating up with it the whites and shells of two or three eggs and then boiling briskly. The egg albumen, coagulated by the heat, rises to the surface and carries with it the solid particles.

A perfectly limpid solution is now obtained by filtering the fluid in a water-bath.

The material is then introduced into the sterilised test-tubes or flasks, and steamed on three successive days for a quarter to half-an-hour on each occasion. When it cools we have a perfectly clear cultivating material, solid and remaining solid below 80° F.

(*d*) Milk. The milk (skimmed milk is best) is introduced by siphon into sterilised flasks and steamed for fifteen to thirty minutes on three successive days.

(*e*) Bread. One part of bread and two parts of water introduced into a sterilised flask and steamed for fifteen to thirty minutes on three successive days.

(*f*) Solidified blood serum.

Serum free from blood corpuscles is collected, introduced into sterilised tubes, and kept in a water-bath at 58° C. (136·4 F.) for an hour on six successive days. The tubes are then laid obliquely in a water-bath, and the temperature kept at 65° C. (149° F.) till they solidify.

The necessary apparatus is exhibited.

3. *Cultivations of Micro-organisms.*

These are growing in the various materials mentioned above. The potatoes are inoculated by dipping the heated platinum needle into a pure cultivation of the micro-organisms and stroking it over the potato. The tubes are inoculated by dipping the heated needle into a pure cultivation and pushing it into the fresh gelatinised material, the tube being held obliquely to prevent dust falling in. The serum is inoculated by rubbing the needle carrying the bacteria over the surface.

In looking at the cultivations in gelatine, observe the production of colour, liquefaction of the gelatine, the mode of growth along the needle track and the growth on the surface.

(*a*) Pigment producing organisms. None of these are hurtful to animals.

Torula producing a black colour, cells oval, black colour only formed in contact with air, forms black colour on potato; obtained from air.

Torula producing pink colour, cells almost round, red colour only formed in contact with air, grows on potatoes; obtained from air.

Micrococcus Indicus.—A large micrococcus, producing scarlet colour, grows on potatoes and the gelatinised material, liquefies the gelatine. Obtained by Dr. Koch in Egypt from the air.

Micrococcus Prodigiosus.—A large micrococcus producing blood red colour, size $\frac{1}{2}$ to 1 μ in diameter. Grows on potatoes, bread, the gelatinised material, &c., liquefies the gelatine. Very common in the air in certain localities.

Bacillus producing a violet colour, liquefies gelatine, violet colour formed in contact with air; obtained from water.

Bacillus causing fluorescence of the material in which it grows, does not liquefy gelatine.

Bacillus of green pus produces green colour and liquefies gelatine, also causes fluorescence. Obtained from wounds, and there causes the green colour sometimes seen in the discharges.

Bacillus of blue pus produces blue colour in contact with air, and liquefies the gelatine. Obtained from wounds, where it makes the discharge of a blue colour.

Sarcina producing yellow colour, growing in the gelatinised meat infusion.

Closely allied to the above, but not producing colour are

Sarcina Ventriculi found in the vomit in many cases of cancer of the stomach. Grows in whitish colonies.

(*b*) Organisms which are found in milk.

Torula cerevisiæ, the cause of the alcoholic fermentation.

Bacillus of blue milk.—A bacillus (size 2·5 to 3·5 μ in length) which is occasionally found in milk and produces a blue colour. The bacillus grows on potatoes and causes a dark blue colour

In gelatine the colour is greenish blue and the gelatine remains solid, the growth spreads out from the needle track forming a tree-like growth.

Milk inoculated with the above bacillus showing blue colour.

Bacterium lactis.—A minute bacillus (1·5 to 3 μ in length), the cause of the lactic fermentation of milk. In the gelatinised medium forms a delicate whitish growth along the needle track, grows slightly on the surface.

Milk sterilised and inoculated with the bacterium lactis showing the pure lactic fermentation.

Bacillus of butyric fermentation.—Size, 3 to 10 μ in length, below 1 μ in breadth. Grows in the gelatinised material, liquefies it and forms a scum on the surface. Produces the butyric fermentation.

Milk sterilised and inoculated with the butyric bacillus showing the pure butyric fermentation.

Micrococcus frequently found in milk. Grows in gelatine in form of delicate colonies, the gelatine remains solid. Produces no apparent change in milk.

Milk inoculated with the above micrococcus apparently unchanged.

Oidium lactis, a fungus found often in milk. Growing in bread infusion.

Milk inoculated with oidium lactis apparently unchanged.

(*c*) Organisms associated with diseases in man.

Bacillus of tubercle.—Found in all tubercular affections in man and animals; it may be cultivated on the coagulated blood serum at the temperature of the human body; it grows slowly and forms whitish irregular crusts on the surface. The specimen shown is the 21st cultivation from the lung of a patient who had died of phthisis

Bacillus of glanders.—Found in all cases of glanders; may be cultivated on blood serum or potatoes kept at the temperature of the body; on blood serum forms small round moist semi-transparent colonies. It grows very slowly on the gelatinised material at the ordinary temperature, forming a whitish mass.

Micrococcus of acute osteomyelitis.—Always found in pus from acute osteomyelitis; forms orange yellow colonies on potatoes, liquefies gelatine, and forms orange yellow deposit; produces acute osteomyelitis in rabbits when injected into the veins if bones have previously sustained any injury.

Bacillus of enteric fever.—Always found in typhoid ulcers, mesenteric glands, frequently in spleen and liver as plugs in blood-vessels, grows slowly in the gelatinised material, forming somewhat brownish almost homogeneous growth along the track of the needle. Grows slightly on surface.

Micrococcus of pneumonia.—Found in most cases of acute lobar pneumonia, grows rapidly in the gelatinised material, forming whitish growth along the track of the needle, and a rounded mass on the surface, the whole resembling a nail.

Micrococcus of erysipelas.—Present in all cases of erysipelas in man in lymphatic vessels at spreading margin of redness; may be cultivated on gelatinised meat infusion, potatoes or blood serum; grows slowly in gelatine, forming delicate colonies along the track of the needle.

Bacillus Anthracis.—Size, 5 to 20 μ in length; 1 to 1·25 m. in breadth; may be cultivated on a variety of substances, grows in the gelatine in the form of a loose network, and soon liquefies it.

Attenuated bacilli of Anthrax.—By growing these bacilli between 42° and 43° C. (107·6° to 109·4° F.) they gradually lose their virulence, till by and by they will not kill any animal. When partially attenuated they may act like vaccine in not only not killing the animal into which they are inoculated but in protecting it from the virulent disease. The specimen exhibited will not kill any animal.

Also microscopical specimens of the bacillus of leprosy, the spirilla of relapsing fever and the *cholera* bacillus.

(*d*) Organisms fatal to lower animals but not affecting man.

Bacillus of mouse septicæmia.—Very small, ·8 to 1 μ in length; frequently present in decomposing fluids, grows in the gelatinised material, forming a delicate haziness around the needle track.

Bacterium of rabbit septicæmia.—A small oval organism (1·4 μ in length, ·7 μ in breadth) growing in the gelatinised material as a delicate brownish growth along the needle track. Probably the same as Davaine's septicæmia; very fatal to rabbits when inoculated, death occurring within 24 hours.

Fowl Cholera.—Small bacteria closely resembling in appearance and mode of growth the rabbit scepticæmia, kills fowls in 17 to 20 hours.

Micrococcus tetragenus.—A micrococcus with the cocci arranged in groups of 4; frequently found in phthisical sputum; when unstained it closely resembles sarcina; grows in the gelatinised material, forming large flattened milk-white colonies along the needle track, and on the surface gives rise to an irregular plate. When inoculated into guinea pigs and mice, the animals die in 2 to 10 days, the organisms being present in large numbers in the blood.

Also microscopical specimens of the bacillus of malignant œdema in guinea pigs (*vibrion septique, Pasteur*), and the bacillus of foul brood in bees.

(*e*) Fungi.

Tinea or Favus Galli.—Forms crusts on the comb and wattle of fowls which may spread over the breast and back, belongs apparently to the class of torula; grows on the gelatinised material as a thin whitish growth; pure cultivations mixed with vaseline or glycerine, and rubbed on the combs of healthy fowls produce the disease.

Aspergillus flavescens.

Aspergillus fumigatus.—Growing on bread infusion. Both these organisms, when injected in sufficient quantity into the veins of rabbits, cause the death of the animals by growing in the capillary blood-vessels.

Aspergillus niger.

Aspergillus albus.—Also growing on bread infusion. Neither of these can live in the animal body.

Mucor, described by Lichtheim, kills rabbits when injected into the veins.

Mucor not pathogenic.

4. *Staining Materials and Methods.*

Bacteria are most satisfactorily examined after being stained. In the case of fluids a drop is placed between two cover-glasses, the glasses are squeezed together so as to get a thin layer, and then they are slipped apart and set up to dry. When dry they are heated to make the layer adhere to the glass, either by passing the cover-glass thrice through the gas flame, or by keeping them at from 100° to 120° C. for an hour.

Ehrlich's method is to place a lamp under one end of a brass plate and to allow the plate to stand till it has got thoroughly warm; then ascertain the part of the plate where water boils, place a cover-glass at that place, and one a little nearer to the flame and leave them an hour. They are then stained by floating them on the surface of the methylene blue solution mentioned in the text or in a methyl violet or other solution.

The methyl violet or fuchsin solution is made by adding a saturated alcoholic solution to distilled water till a sufficiently deep colour is obtained. The cover-glasses are floated on these solutions for about ten minutes, then washed in water and afterwards in a ½ to 1 p. c. solution of acetic acid, dried and mounted in Canada balsam. They may also be stained brown for photography in a saturated watery solution of vesuvin.

For tubercle bacilli a different solution is employed. Add to 100 parts of a saturated watery solution of aniline, 11 parts of a saturated alcoholic solution of fuchsin, filter and use as above. At the ordinary temperature the material must stain for 12 to 24 hours, at the body temperature for 2 to 3 hours, at a temperature near the boiling point for a few minutes. Afterwards immerse for a few seconds in diluted nitric acid (1 part of strong nitric acid to 2 parts of water). Wash in water and stain in a solution of methylene blue (100 parts of water, 20 parts of saturated alcoholic solution of methylene blue) for about an hour, wash in water, dry, and mount in Canada balsam. The tubercle bacilli remain red, all other bacteria (except leprosy bacilli) and the nuclei of the cells become blue.

For bacteria in tissues harden in alcohol for two or three weeks, then take a small piece, place in water for two or three hours, then in a strong solution of gum, freeze and make sections with microtome. Stain in the alkaline methylene blue solution or in solutions of the other stains, wash in water, dilute acetic acid, alcohol, oil of cloves or cedar, and mount in Canada balsam. For tubercle bacilli use the stain mentioned above, afterwards wash in water, alcohol, oil of bergamot or cloves, and mount in Canada balsam.

Gram's method of staining bacteria is very simple and beautiful. Take 100 parts of saturated watery solution of aniline, add 11 parts of saturated alcoholic solution of gentian violet. After cutting the sections place them in absolute alcohol, then in the above solution for two or three minutes (tubercle for some hours), then immerse in solution of iodine and iodide of potassium (1 part of iodine, 2 parts of iodide of potassium, 300 parts of water) till they are decolorized (a few minutes as a rule), then place in absolute alcohol, for a second or two in a saturated watery solution of vesuvin or Bismark brown, again in absolute alcohol, oil of cloves, and mount in Canada balsam. The bacteria appear dark blue, the tissue brown. Successful staining is only a matter of experience.

5. *Demonstration of Bacteria.*

For this good microscopes with condensers are required. More important even than powerful lenses is correct illumination of the specimen.

Various bacteria are shown under the microscope on Thursday afternoons.

A *microphotographic apparatus* is also exhibited.

Also a number of *microphotographs* taken by Dr. Koch of erysipelas, anthrax, relapsing fever, mouse septicæmia, rabbit septicæmia, pyæmia in rabbits, ulcerative endocarditis, acute osteomyelitis, &c.

6. *Examination of Air, Water and Soil for Bacteria.*

Various experiments are shown. The methods are referred to in the text.

The glass plates for the water cultivations are sterilised in an iron box shown. They are laid in glass dishes prepared as above described for potatoes, and the apparatus placed on a level plate of glass on a levelling stand. The plates of glass may be marked out in squares to facilitate the numeration of the bacteria. The cultivation is left for three or four days to develop and is then taken out, placed on a black ground, and the number of colonies of bacteria counted and their kinds ascertained under a low power of the microscope.

The tubes used in Hesse's air experiments are sterilised in the steaming apparatus after being filled with the gelatinised material Apparatus for growing bacteria in various gases is also shown.

Also Pasteur's experiment to disprove spontaneous generation.

7. *Method of testing the Power of Disinfecting Agents in destroying Bacteria.*

Apparatus and experiments are shown.

The power of killing (1) spores and (2) mature actively growing organisms must be tested.

The organisms generally used are spores of anthrax bacilli, and for non-spore-bearing organisms, micrococcus prodigiosus.

Sterilised cotton threads are soaked in the cultivations of the organism to be tested, and are then rapidly dried in a desiccating chamber. When spores are used the threads may be kept for weeks or months in a dry state, without the vitality of the spores being impaired. In the case of non-spore-bearing organisms, the threads must be used within two or three days after drying. The prepared threads are placed for varying periods of time in the solution to be tested or subjected to the temperature, &c. They are then removed, and in the case of immersion in chemical solutions, washed in boiled distilled water, to get rid of the antiseptic, and planted on the solid gelatinised material spread out on a glass plate and kept protected from dust. The occurrence of growth is then observed. In the case of the pigment-producing organisms, the production of the proper colour shows that the organisms have not been killed. In the case of anthrax, the method of growth is typical and easily recognised. If there is any doubt a mouse may be inoculated with the cultivation.

8. *Parasitic Diseases of Plants.*

A large number of *diagrams* are exhibited by Worthington Smith, Esq., illustrating diseases of potatoes, clover, turnips, corn, &c.

C. B. Plowright, Esq., exhibits various dried specimens of ergot, canker of apple-trees, diseases of corn, &c.

Also two plants showing the effect of parasitic fungi.

1. A plant of barberry which last year had no æcidium upon it, was on the 22nd of May last infected with germinating spores of Puccinia graminis on wheat straw. On May 30th spermogonia first began to indicate their appearance by the production of yellow spots. Three days later they became well developed, and have now (July) been succeeded by the æcidium berberidis. The straw with the Puccinia upon it used in this culture is tied up in a little bundle and placed in the same pot.

2. A well grown plant of poa trivialis infected on the 9th of May with æcidiospores from ocidium on ranunculus repens. On May 20th the infected leaves began to show sickly yellow spots. On May 22nd the perfect uredospores were developed. On June 3rd abundant development of the uredo with some teleutospores of uromyces poæ beginning to develop.

9. *Maps showing the Death-rate of Children in Germany.*

Tables showing the relative prevalence of infective diseases in various towns. These are not a complete series, but have been lent by Dr. Struck, of the Kaiserlich. Gesundheits Amt in Berlin, to show the method of registration employed.

Dr. Struck also lends tables showing the effect of the introduction of compulsory vaccination in Germany on smallpox. There was no compulsory vaccination in Germany except in the army till 1874. The German law now compels vaccination in childhood and revaccination at 12 years of age. A third vaccination is compulsory in the army.

Part II.—HYGIENIC LABORATORY.

BY

W. H. CORFIELD, M.A., M.D., F.R.C.P.,

AND

CHARLES E. CASSAL, F.I.C., F.C.S.

PUBLIC HEALTH

LABORATORY WORK.

II.

THE work of a hygienic laboratory chiefly consists in the chemical and microscopical examination, and in the general study, of all those natural and artificial substances which, on account of the uses made of them, have some bearing on the Public Health.

Such work therefore includes the examination of drinking waters, of air and of soils ; of foods and drinks of every description ; of the various substances used in the construction and decoration of houses, such as wall-papers and paints ; and of the materials used for clothing, especially as regards the dyes which are applied to them. The comparison and valuation for sanitary purposes of filtering materials and disinfectants, and the examination of drugs and patent medicines also form part of the ordinary work of a model hygienic laboratory.

New methods of chemical analysis are constantly being devised, and the value of these has necessarily to be ascertained, and while there is a wide field for original work in the invention of new processes, the hygienist has also great opportunities for research in the study of the causes of pollution of water and air, the nature and degree of such pollution under different circumstances, and with different polluting agents, and the extent to which the methods at his disposal will enable him to detect and estimate these pollutions and the adulterations and impurities existing in the substances used as food.

The passing of the Public Health Act and of the Sale of Food and Drugs Acts has been attended by a very large decrease of adulteration and has greatly diminished the sale of inferior food, and of substances unfit for food, more especially in the metropolis and in the larger provincial towns. The work of the public analysts appointed under the provisions of the "Sale of Food and Drugs Act," is to a great extent hygienic, inasmuch as the samples submitted to them have to be examined not only with the view of determining whether they are of the "nature and quality demanded," but of ascertaining the presence or absence of substances injurious to health.

Many local authorities, however, have unfortunately not made full use of the powers possessed by them under these Acts, and on the other hand it has very frequently been extremely difficult to obtain a satisfactory punishment for a proved offence, even in the Metropolis. It is obviously very desirable that in all cases where an adulteration which actually is, or which may be under certain circumstances, dangerous to health, has been proved to exist in any article, a very severe punishment should be inflicted; for example, in the case of milk, an article on which infants and young children so largely depend for their nourishment.

It is not possible in a work of this kind to enter into a full account of the details of laboratory work, but a general idea can be given, and with this object it will be convenient to describe briefly some of the processes and apparatus made use of in hygienic investigations.

AIR.

The chief constituents of atmospheric air are:—oxygen, nitrogen, and carbonic acid; the first two in large quantity, the last in very small quantity. In 10,000 parts by volume of air, there are:

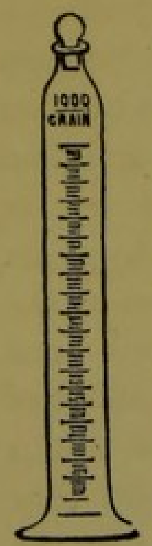
7,900 Nitrogen.
2,096 Oxygen.
4 Carbonic Acid.

The amount of carbonic acid varies slightly in the pure air of places differently situated.

A number of substances are continually passing into the atmosphere,—gases, vapours and solid material particles. In all close and ill-ventilated places the air has become more or less charged with the products of combustion and of respiration—carbonic acid, water vapour, and foul "organic" matter—and it becomes therefore necessary to estimate the extent to which this pollution has taken place. The quantity of carbonic acid present may be taken as the measure of the degree of pollution of air. It has been shown that the diminution of oxygen and the increase of carbonic acid in the air of inhabited places are so slight as to be of very little importance in themselves, and that the dangerous pollution of such atmospheres is due to the presence of foul organic matter. Nevertheless, as the increase of carbonic acid is proportional to the degree of such foul organic pollution, and as the amount of carbonic acid is easily and very accurately determined by the process about to be described, the quantity present is taken as a measure of the degree of pollution.

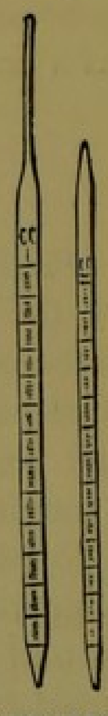
Estimation of Carbonic Acid in Air.

Pettenkofer's Process:—In this process, advantage is taken of the fact that carbonic acid unites with lime to form carbonate of lime, which is insoluble in water. Lime water is prepared by pouring pure distilled water over pure lime, and pouring off the clear solution from the sediment; and a rough method of estimating the quantity of carbonic acid is to place ½ oz. of this clear lime water into a 10½ oz. stoppered bottle containing the air to be tested, shaking it up and leaving it to stand. If the lime-water becomes turbid (from the formation of carbonate of lime), the air contains more than 6 parts of carbonic acid per 10,000 parts of air by volume. It has been shown that if the carbonic acid of an enclosed space exceeds that of the outer air by more than 2 parts per 10,000, the ventilation of that space is insufficient, the fouling matter in the air being then in sufficient quantity to render the air perceptibly impure to the senses.

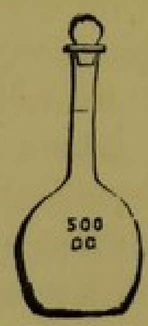

MEASURING GLASS.

The collection of a known volume of air for subsequent examination is carried out in various ways. The volume of a good-sized bottle of from two to six litres capacity and provided with a well-fitting stopper, may be taken by carefully filling it with mercury, and then measuring the volume of the mercury by pouring it into a *glass measure;* and the air of any given place may be collected by filling the bottle with distilled water or mercury, and emptying it in the place in question, or by pumping the air into the bottle with a pair of bellows, or by previously pumping the air out of the bottle and then allowing the air to be tested to enter it.

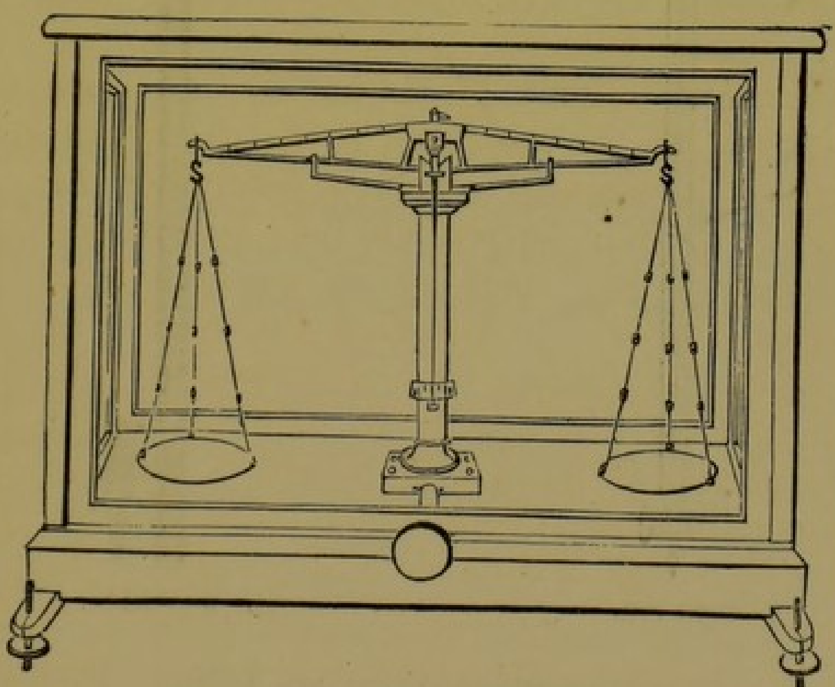
A measured volume of air having been obtained, an estimation of the carbonic acid is effected by absorbing it by means of a measured volume of lime water, the strength of which is known, and then determining the quantity of lime which has *not* combined with the carbonic acid. We thus know the quantity of lime which has entered into combination, and knowing further that exactly 56 parts by weight of lime unite with 44 parts by weight of carbonic acid, we arrive by a proportion sum at the number of parts by weight of carbonic acid present in the measured volume of air. The lime-water is measured out in a *pipette*, divided into cubic centimetres and tenths of a cubic centimetre. Its strength is determined by means of a "standard" solution of *Oxalic Acid*, which acid unites with lime to form oxalate of lime. A certain number of grammes of oxalic acid are exactly weighed out on a *Chemical Balance* dissolved in pure water to a definite volume, say 1 *litre* (1000 cubic centimetres) in a *graduated flask*, thus giving a solution, every cubic centimetre of


PIPETTES.

which contains a known weight of oxalic acid. Supposing the weight of oxalic acid in each cubic centimetre of solution to be exactly capable of uniting with one *milligramme* of lime (this being the usual strength of oxalic acid employed), it is clear that the number of cubic centimetres of oxalic acid solution required to exactly combine with or "neutralize" the lime present in a definite volume of a sample of lime water will be equal to the number of milligrammes of lime present in that definite volume. For instance, if 10 cubic centimetres of lime-water required 12 cubic centimetres of the oxalic acid solution to combine with all the lime, then the 10 cubic centimetres of lime-water will contain 12 milligrammes of lime in solution. The measured volume of lime-



GRADUATED FLASK.



CHEMICAL BALANCE.

water is put into a convenient vessel and the oxalic acid solution added from a cubic centimetre *Burette* until all the lime is combined, a fact which is ascertained by employing an "indicator," such as the change of colour of *blue litmus paper* when brought into contact with an acid. So soon as the oxalic acid has combined with all the lime, the liquid in the test vessel turns the blue paper red. Instead of litmus paper, litmus solution may be used in the above process; or again, paper coloured yellow with an infusion of *turmeric*, which is turned brown by alkalies such as lime, the brown colour disappearing when there is enough acid to neutralize the lime.

There are several modifications of the processes above described, by which with more or less accuracy the proportion of carbonic acid in air can be determined. The use of *baryta* water instead of lime-water is more convenient

BURETTE.

BURETTE.

and exact if proper precautions are taken. In accurate work of this kind, it is necessary to determine the temperature of the air examined and the barometric pressure at the time, in order to avoid the obvious errors due to change of volume produced by alteration of pressure and temperature.

Wanklyn's Process.—Good results may be obtained by making use of this process, which is thus carried out :—

From 2 to 3 litres of air (2000 to 3000 cubic centimetres) are shaken up with a measured volume, say 100 cubic centimetres, of baryta water, which is rendered more or less turbid by the formation of carbonate of baryta. The solution is poured out into a cylinder made of thin glass, and the *degree of turbidity*, which is evidently proportional to the amount of carbonic acid present, is imitated in another precisely similar thin glass cylinder by mixing with another 100 cubic centimetres of the baryta water, measured volumes of a standard solution of carbonate of soda, which forms a precipitate or turbidity more or less pronounced according to the amount of carbonate added. The standard solution is measured from a burette and is made of such a strength that 1 cubic centimetre contains 1·97 milligrammes of carbonic acid (in combination with soda) which is equivalent to 1 cubic centimetre of carbonic acid.

Organic Matter.

Air always contains some organic matter, derived from animal or vegetable sources, or both. The precise nature of the organic substances is not accurately made out, but there is no doubt that those which are hurtful are chiefly nitrogenous.

Air loaded with organic matter possesses a peculiarly unpleasant odour, particularly evident in close, over-crowded rooms, and in narrow streets and courts. Prof. de Chaumont has shown that it is possible to graduate, by means of the sense of smell, the pollution of air by organic matter, with a close approach to the truth as indicated by the estimation of carbonic acid and by other chemical processes to be immediately described.

Attempts have been made to estimate the extent of organic pollution by means of permanganate of potassium, a salt which contains a large quantity of "available" oxygen, and which readily gives up some of its oxygen when placed in contact with organic matter, burning up the latter to a greater or less extent according to the nature of the organic substances present. The permanganate dissolves in water, forming a deep purple solution. The process depends upon the extent to which a measured volume of the air will destroy the pink colour of a weak standard permanganate solution delivered from a burette. There may exist, however, in polluted air, other impurities which also decompose the permanganate, and the process is now only used as a qualitative test.

A common method for dealing with the organic matter in air consists in polluting a certain measured quantity of absolutely pure distilled water with a known volume of the air; and then subjecting the polluted water to analysis. The water may be most conveniently examined by the *ammonia process*, shortly to be described under the head of Water. Ammonia, viz., the gaseous compound of nitrogen and hydrogen, is very easily produced by the decomposition of organic matter containing nitrogen, and may thus be made an approximate measure of nitrogenous organic matter. In order that the ammonia process may be successful in the case of air, it is necessary that a large quantity of air be washed in as small a quantity of water as possible. This may be accomplished in different ways. By means of an *aspirator*, or vessel of known capacity filled with water, which can be run out by means of a stop-cock at the bottom, air is drawn through a flask or series of flasks containing pure re-distilled water free from ammonia, the volume of air which has passed through being obviously equal to the volume of water which has run from the tap of the aspirator. Or the air may be washed by injecting it, by means of a caoutchouc ball of known capacity, into a cylindrical vessel containing a little pure water with a spray-producing apparatus, and thus washing the air by means of a water spray.

Microscopic Examination.

The solid particles suspended in the air vary of course with the locality and with other circumstances. Mineral particles, salt, soot, fungi, starch granules, pollen, and vegetable spores may be detected in air. In the air of hospital wards, pus globules, epithelium, and various forms of bacteria have been detected. The extent to which ordinary air is loaded with solid particles may be well observed by passing a beam of sunlight or of the electric light through a darkened room.

The collection of air-dust for microscopic examination is easily effected by drawing the air through a tube plugged with purified cotton wool or glass wool, by means of an aspirator. The wool acts as an efficient filter and the dust collected upon it may be examined.

Or a glass tube has one end connected with an aspirator and is provided with a small funnel at the other passing through a cork, and terminating inside the tube in a fine point; opposite this point a thin glass disc moistened with glycerine is placed. The air being drawn in at the funnel strikes against the glass disc, which accordingly becomes coated with some of the suspended matters of the air, and may then be examined microscopically. Other plans are as follows :—

1. The air is drawn by means of an aspirator through a glass tube cooled by a freezing mixture. The moisture of the air is condensed and arrests some of the solid particles which thus remain inside the tube.

2. The air is filtered through pure *gun cotton*, the latter is then dissolved in alcohol and ether, and the dust left behind is examined. (Pasteur.)

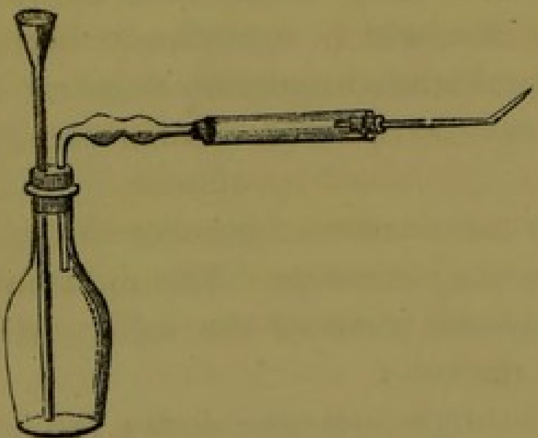
3. Fine glass threads moistened with glycerine, arranged in the tube connected with the aspirator, are sometimes used as traps to catch the suspended matters.

4. The "Montsouris" plan is also a good one. It is essentially the same as one previously described. The air passing through a small tube is made to impinge on a glass disc covered with glycerine and protected by a bell-jar.

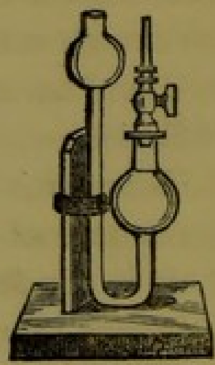
The dust obtained by any of these devices is examined under a high microscopic power—a magnifying power of from 500 to 1000 diameters being generally used.

Metallic Poisons.

Both in the gaseous form and in the form of dust some metals and their compounds are occasionally found in the air. Copper and lead have been detected in the air surrounding smelting works, arsenic in the form of arseniuretted hydrogen, of Scheele's green (arsenite of copper) and of other compounds has been found in the air of rooms papered with arsenical papers. The wall-papers of suspected rooms and the dust deposited in them have therefore frequently to be examined. If a very large quantity of air containing arsenic be drawn through a tube heated to redness by a gas flame, a "metallic mirror," or ring of metallic arsenic will be formed in the tube, which is



MARSH'S APPARATUS.



MARSH'S APPARATUS.
(*Another form.*)

recognizable by its peculiar crystalline structure and by other tests. Wall-papers may be most satisfactorily examined by *Marsh's test.* The suspected paper is treated with warm hydrochloric acid, and the solution thus obtained is introduced into an apparatus evolving hydrogen, from pure zinc and pure sulphuric or hydrochloric acid, and provided with an exit tube terminating in a fine jet. The arsenic unites with the hydrogen forming arseniuretted hydrogen, which may be lighted at the jet, and burns with a peculiar bluish flame, the flame depositing on a cold porcelain plate exposed to it, a "metallic mirror" of arsenic.

Gaseous Impurities.

In addition to those already referred to there are several other gaseous impurities which may under some circumstances be present in the air. Those which are evolved from various manufacturing operations are as a rule very easy of detection.

The principal ones are:—

Carbonic oxide, carburetted hydrogen or marsh gas, sulphurous acid, sulphuric acid, sulphuretted hydrogen, ammonium sulphide, hydrochloric acid, chlorine, ammonia, nitric acid, and organic vapours (from sewage, bone-boiling, etc.)

The suspected, air containing one or more of these substances, having been collected as before described, special tests are applied to it with a view of recognizing the more common substances. Papers impregnated with

Blue litmus	reddened by acids,
Red litmus	blued by alkalies,
Turmeric	browned by alkalies,
Acetate of lead . . .	blackened by sulphuretted hydrogen,
Iodide of potassium and starch	blued by chlorine,

are slightly moistened and exposed to the air, either in the bottle, or are exposed under a glass shade to a stream of the air, which is made to pass through it by means of an aspirator or otherwise. A proper investigation must then be made by washing the air with distilled water, and examining the watery solution obtained.

WATER.

The ordinary waters used for drinking hold in solution a large number of substances. The purest natural water is obviously rain-water collected in the open country—inasmuch as it has merely passed through the air, and has not percolated through various strata or through surface soil more or less contaminated, and thereby become charged with some of the substances contained in the strata or soils. Taking ordinary pure spring water, we have to deal with a solution containing several salts, dissolved gases (chiefly those of the air), and a small quantity of organic matter. Carbonates, sulphates, nitrates, and chlorides of lime, magnesia, soda, and potash, and silica, are the principal mineral substances held in solution; minute quantities of the salts of iron and alumina are generally present, but the number and the proportion of the constituents is of course somewhat variable. Organic matter derived from animal or vegetable sources, or both, and salts of ammonia, may be present in drinking waters, and constitute the points of most hygienic importance.

Drinking water may be polluted in very various ways by organic matter, as from cesspools, and leaking drains in proximity to the well, vegetable filth allowed to accumulate, house refuse falling into the well, or finding its way into it by means of unsound drains, or from foul air coming up the waste-pipe into the cistern; poisonous metals, such as lead or zinc may also be present, and occasionally the water may be found polluted chiefly with gaseous substances.

The object of the analyst in the case of water is, firstly, to determine the presence or absence of impurities; secondly, the nature and quantity of such impurities, and, thirdly, to form an opinion as to the wholesomeness of the water on the data he has obtained. The most important point, and the chief difficulty, is to deal with the organic matter.

Organic matter, though at a given time harmless, may at any moment become extremely dangerous, and so long as a water is polluted to any appreciable extent with organic matter it should be condemned. The taste and the smell of a water are first noticed, and its appearance and colour when viewed in a two foot tube placed on a white slab, so that the observer can look through two feet of the water; or when looked at in a decanter or flask capable of holding about a quart. Pure water should have no sweet, or salt, or other decided taste, and should be odourless. It should be clear and colourless, or should have only a very faint tinge of blue in a two-foot tube. In some cases, however, a water may possess a decided colour, such as the water of Loch Katrine, and yet be perfectly fit to drink —but nevertheless, yellowish and brownish, and greenish-yellow tints are always to be regarded with suspicion.

The Solid Matter.—The total amount of solid matter is measured by putting a known volume of the water into a *platinum dish* capable of containing the whole volume of water with ease, and which has previously been carefully cleaned, heated to redness over a Bunsen gas flame, and weighed. The platinum dish is placed on a *water bath* and the water is evaporated off; the dish is then weighed again, and the difference between the two weights is evidently the weight of solid matter contained in the measured volume of water. This is calculated into parts per 100,000, or into grains per gallon. If the number of grains per gallon of solid matter is to be known it is convenient to evaporate 70 c.c. of the water, inasmuch as 70 c.c. of water contain 70,000 milligrammes, and there are 70,000 grains in a gallon, so that in 70 c.c. the milligramme corresponds to the grain in the gallon; the number of milligrammes of solid matter found in 70 c.c. of water will therefore be equal to the number of grains of solid matter in a gallon of the same water. The estimation of the quantity of solid matter present in a water is a point of great importance, polluted waters as a rule yielding much higher quantities than pure waters. Further information as to the solids may be obtained by heating the solid residue over a lamp, gradually raising the dish to a red heat. Water residues containing even small quantities of organic matter will perceptibly alter in colour, and those which contain much will brown and blacken very markedly. The loss of weight on "incineration" was formerly used as an approximate indicator of the quantity of organic matter present in the water, but several other constituents are volatilised at a red heat, *e.g.*, carbonic acid from the carbonates and chloride of sodium, so that the test is not applicable in this respect.

At the same time, the determination of the volatile matter often affords very valuable information.

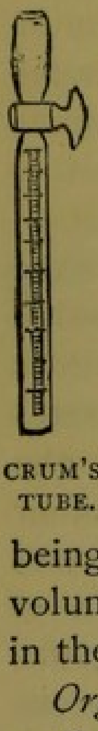
In certain cases it is necessary to make a complete analysis of the solid constituents of water; this is the case with mineral and medicinal waters. A large volume of the water must be evaporated to dryness for such purposes—as much as one or two litres—the residue dissolved in acid, and the various constituents, silica, lime, magnesia, potash, soda, etc., carefully and completely separated, and weighed in convenient forms.

Chlorine.—The chlorine in water is present chiefly as chloride of sodium, or common salt. Chloride of sodium usually accompanies animal matters. Urine contains large quantities of it, and waters polluted with sewage are loaded with it; hence it follows that the proportion of chlorine present in ordinary pure waters being known, an estimation of the chlorine in any given water is a matter of great importance. Should the source of the water be near the sea, or should it be water which has passed through salt-bearing strata, the chlorine determination loses in value in consequence of the excess of salt which such waters contain, and further it must be pointed out that water may be highly and dangerously polluted with organic filth of *vegetable* origin, and may contain a very small quantity of chlorine.

The estimation of chlorine in water is a very simple matter. Advantage is taken of the fact that silver combines with chlorine in the proportion of 108 parts by weight of silver to 35·5 parts by weight of chlorine to form the white insoluble chloride of silver. A standard solution of pure nitrate of silver is prepared by dissolving a weighed quantity of the salt in a measured volume of pure distilled water—generally 4·79 grammes of nitrate of silver are dissolved in 1,000 c.c. or one litre of water—furnishing a solution, every c.c. of which contains exactly the amount of silver necessary to unite with one milligramme of chlorine—$Ag\ NO_3 + Na\ Cl = Ag\ Cl + Na\ NO_3$. 50, 70, or 100 cubic centimetres of the water are placed in a clean white porcelain dish or in a *beaker* standing on a white slab, and the nitrate of silver delivered from a *burette*, with constant stirring of the mixture. The exact point at which all the chlorine present has united with the silver, is observed by means of a solution of pure *chromate of potassium*, a few drops of this solution having been placed in the water. Silver nitrate reacts on chromate of potassium to form chromate of silver, a blood-red substance. This it does so soon as it has united with all the chlorine present, for which it has a greater "affinity" than for the chromium, and the appearance of the faintest red tinge is an indication that the process is ended. The number of cubic centimetres is read off on the burette and is equal to the number of milligrammes of chlorine present in the volume of water operated on. This is by some calculated into chloride of sodium, or common salt, 35·5 parts by weight of chlorine uniting with 23 parts by weight of sodium to form common salt.

Oxidised Nitrogen.—Taken along with other evidence the presence and quantity of the *nitrates* afford very valuable information concerning the pollution of water. Nitrogenous organic matters decay and become oxidised and the nitrates are yielded by the process, so that supposing that the nitrates in a water do not come in any quantity from other sources they form a measure of the extent of nitrogenous organic pollution. By itself, however, the estimation of oxidised nitrogen is not to be taken as a trustworthy guide, any more than is the estimation of any other *single* constituent, or single product yielded by the constituents, of a water. Certain pure waters contain considerable amounts of nitrates, and a water may be highly charged with organic matter and yet contain but small quantities of nitrates. The estimation of oxidised nitrogen will frequently enable the analyst to discover that a water though not actually polluted is in danger of pollution at no distant date. A well drains the soil in its neighbourhood; should a cesspool or other source of filth be situated in the drainage area, the organic matters will percolate through the soil towards the well, and in passing through the soil these matters are in great part oxidised—nitrates being a product of the oxidation; the nitrates find their way into the well, and if the process continues, a time will come when the soil, being saturated with filth, is no longer capable of any purifying action, and the water of the well becomes highly polluted.

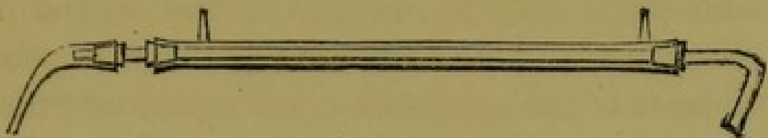
There are several methods for determining the quantity of nitrates. A measured volume of the water is treated with metallic *zinc* or *aluminium* and strong caustic potash, hydrogen is evolved and the nitrogen of the nitrate is thereby converted into ammonia. The mixture is distilled and the ammonia is determined in the manner immediately to be mentioned under saline and organic ammonia. Crum's method which is better, is essentially as follows:—A graduated tube open at both ends and provided with a stop-cock near to the top (see Figure) has the graduated part completely filled with mercury, the lower end dipping into mercury in a trough. A solution of the water-residue containing the nitrates followed by some sulphuric acid is introduced from the upper cup into the tube by means of the stop-cock; on vigorous shaking nitric oxide is given off, and its volume measured by means of the graduations. Corrections for temperature and barometric pressure being made, the amount of nitrogen is calculated from the volume of nitric oxide, and stated as nitric acid or as nitrogen in the form of nitrates.



CRUM'S TUBE.

Organic Matters.—The "Saline" and "organic" ammonia or the "free" and "albuminoid" ammonia, that is, the ammonia present in a water as such (free or saline), and the ammonia yielded by the destruction of the nitrogenous organic matter with an oxidising agent (albuminoid or organic), are taken as measures of the degree of pollution of the water. Most nitrogenous substances can be made to yield some of their nitrogen in the form of "ammonia," for instance *Urea*, the principal constituent of urine, is converted into carbonate of ammonia by the action of ferments in water, and thus the amount of free ammonia may be an important point.

A measured volume of water—generally half a litre—is placed in a *distilling flask* or a *retort*, which is then connected with a *Liebig's condenser*, a small amount of carbonate of soda having previously been added to the water. The latter is distilled and the distillates are received into measuring glasses in volumes of 50 cubic centimetres. These distillates are "Nesslerised." The first 50 c.c., for example, is placed



LIEBIG'S CONDENSER.

in its cylinder on to a white porcelain slab, and 2 c.c. of "Nessler's" solution added to it, and the mixture stirred up. Nessler's solution, which contains iodide of potassium, bichloride of mercury and caustic potash, strikes a yellow or deep brown colour with a solution containing a very minute quantity of ammonia—with large quantities a brown solid substance is obtained as a precipitate. The colour obtained is then imitated by means of a standard solution of chloride of ammonium (NH_4 Cl) containing the $\frac{1}{100}$ part of a milligramme or the $\frac{1}{100000}$th of a gramme in every cubic centimetre. A measured volume of this solution is mixed up with 50 c.c. of distilled water *free from ammonia* and 2 c.c. of the Nessler's solution added. The water having been distilled until no more ammonia is found by the Nessler test the distillation is stopped, and 50 c.c. of a strong solution of permanganate of potash and caustic potash are added, distillation is continued, and the distillates Nesslerised as before. The ammonia now obtained (organic or albuminoid) is that whose formation is due to the decomposition of the nitrogenous matters by the action of permanganate of potash.

The number of cubic centimetres of the solution of chloride of ammonium required to give the same tint as that obtained in any given distillate is obviously equal to the number of $\frac{1}{100}$ths of a milligramme of ammonia present in that distillate. The total amount of free and albuminoid ammonia yielded by the water is thus arrived at.

Combustion Process.—This process is too long and complicated to admit of its being fully described here. A measured volume of water, not less than one litre, is evaporated to dryness with certain precautions to avoid loss and gain ; and the residue having been scraped up, is mixed with pure dry oxide of copper, introduced into a hard glass combustion tube, and heated strongly in a furnace. The copper oxide parts with its oxygen to the organic matter, which is destroyed, and the carbonic acid and nitrogen, which are the products of the combustion, are measured ; the actual quantity of "organic carbon," and "organic nitrogen" present in a given volume of water are thus obtained.

It should be clearly understood that in all these processes it is necessary to adopt certain standards for guidance. In the case of albuminoid or organic ammonia, for example, the limit 0·15 parts per million, meaning thereby 0·15 parts of ammonia (grammes, ounces, &c.), yielded on distillation by one million parts (grammes, ounces, etc.) of water, has been fixed upon as the result of experience. Pure waters known to be uncontaminated not yielding *more* than this amount, and polluted waters not yielding less. If we find less than 0·1 parts per million of albuminoid ammonia *other evidence to the contrary being absent* we conclude that the water is not polluted ; for in order that such a water may be polluted it is necessary to assume in the first place that it was originally of very exceptional purity, and secondly, that the pollution had taken place to an extent far slighter than occurs in almost every case where there has been any pollution at all.

A limit of some kind, determined in a similar way, must of course be used in any process. Other things being equal for example, the solid residue of a water should not rise much beyond 40 or 50 grains in the gallon. The limits for organic carbon and organic nitrogen are of course also based on experience.

Microscopic Examination.—This is a most important part of the hygienic examination of water and should never be omitted. The usual mode of obtaining the suspended matter in water for microscopic examination is to allow some of the water to settle in a good sized conical glass, the sediment being taken out with a pipette. A *stop-cock* flask or *straight burette* can also be used for the purpose, and these are in some respects more advantageous. The presence of fibres of cotton, wool, silk, etc., is evidence of pollution with house refuse. Bacteria of various kinds, fungoid growths, epithelium and muscular fibres may be detected, the conclusions to be drawn from the presence of such substances being obvious.

Poisonous Metals.—The metals which may be present in drinking water and which have to be considered as regards their poisonous action, are lead, copper, zinc, and iron. The presence of an excess of lead, iron, or copper is at once detected by placing 70 c., or 100 c.c. of the water in a clean porcelain dish and adding two or three drops of sulphide of ammonium. If the water contains more than $\frac{1}{10}$ of a grain of these metals per gallon a more or less dark coloration is produced, due to the formation of the sulphides of lead, copper or iron. Zinc, which appears to be not unfrequently present in water, has to be sought for in a strong solution of the residue of the water, the sulphide being white.

Hardness.—A water is said to be "hard," when it contains a considerable amount of the salts of lime and magnesia, and to be soft when these salts are present in but slight quantity. The softest natural water is of course rain-water; among the hardest are those proceeding from springs in chalk formations. The salts of lime and magnesia decompose *soap,* and hence a hard water requires a much larger quantity of soap than a soft water to form *a lather*—a lather being only possible when undecomposed soap is present. The degree of hardness of water is determined by means of a standard solution of soap, of such a strength that 1 cubic centimetre of it contains the amount of soap that will be decomposed by one milligramme of lime. 50 or 70 c.c. of the water are placed in a stoppered bottle, the soap solution added, and the bottle vigorously shaken after each addition until the point at which a permanent lather begins to form is reached. The number of cubic centimetres of soap is then equal to the number of milligrammes of "hard" salts in the water: one cubic centimetre is deducted as it is found that 70 c.c. of water itself consumes that amount of soap solution.

Temporary and Permanent Hardness.—By boiling a measured volume of the water for some time, the dissolved carbonic acid is driven off and the carbonate of lime and other salts held dissolved by the carbonic acid are deposited in the form of a crust. The number of c.c. of soap solution, less one, required to produce a lather in the water after it is boiled, gives the amount of permanent hardness, and the difference between this and the total hardness is equal to the temporary or removable hardness.

An approximate opinion as to the hygienic quality of a water may be arrived at without going through a series of accurate quantitative operations.

A number of tests may be applied to the water as follows:—

1. The reaction of the water is taken with litmus papers to note any acidity or alkalinity.

2. About 25 c.c., of the water are boiled with a solution of chloride of gold. In proportion to the amount of organic matter present the gold is thrown down as a blackish powder.

3. About 100 c.c. of the water are treated with a few drops of very weak permanganate of potash solution, and allowed to stand; the extent to which the permanganate is decolorised is judged of by adding the same number of drops to the same volume of pure distilled water.

4. To about 50 c.c. of the water about 2 c.c. of Nessler's solution are added, and the colour produced is compared with that obtained in the same volume of pure distilled water similarly treated.

5. Nitrate of silver solution is added, and the amount of precipitated chloride of silver observed.

6. About 50 c.c. of water are evaporated to dryness and the residue heated to redness, and the extent to which blackening or browning takes place is noted.

7. To about 25 c.c. of the water are added a few drops of a solution of brucine and a little pure sulphuric acid. If nitrates are present (even in very small amount) a pink colour of greater or less intensity is produced.

8. Oxalate of ammonia solution is added and the lime is precipitated as oxalate of lime. The amount of the precipitate is noted.

9. Barium chloride solution, with a little nitric acid, is added, and the sulphates present are precipitated as sulphate of barium.

10. Finally the water may be tested for phosphoric acid by means of a solution of molybdate of ammonia and nitric acid, and boiling after their addition. The presence of phosphates is indicated by a yellow coloration, and a yellow precipitate.

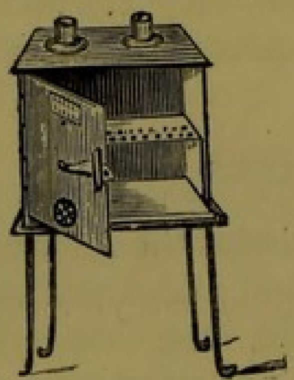
FOODS AND DRINKS.

The hygienic analysis of food includes the determination of the composition of the chief natural and artificial foods in their natural and pure state, the detection of alterations, of impurities and of adulterations, and the estimation of the extent and amount of these should they exist. It is obvious that in order to form a satisfactory opinion as to the dietetic value of a given food, as to its general quality, and as to whether it has in any way been altered or falsified, a knowledge of its normal composition, and in the case of an artificial mixture, of the normal composition and properties of its constituents, should be as far as possible obtained.

The matter of greatest importance consists in separating and in estimating the quantity of the *proximate* constituents. The proximate constituents of a substance are the various definite chemical compounds entering into its composition, whereas by its *ultimate* constituents are meant the elementary bodies which build up these compounds. For example, the chief *proximate* constituents of milk are:—water, fat, caseine, milk-sugar, mineral matter (including common salt and phosphate of lime); the principal *ultimate* constituents being the elements oxygen, hydrogen, carbon, nitrogen, calcium, phosphorus, sodium, and chlorine.

The isolation and the determination of the respective total quantities of the ultimate constituents of such a substance as milk is a comparatively easy matter, but we do not thereby obtain very much information as to its value as a food, or as to the purity or non-purity of a particular sample of it, such information being rather obtained by a study of its proximate constituents.

In greater or lesser quantities the following substances and classes of substances enter into the composition of the great majority of foods:—Water, mineral matters



AIR OVEN.

WATER BATH.

(such as common salt and the carbonates and phosphates of lime), fats and oils, sugars, starches, cellulose or woody fibre, gums, nitrogenous compounds (such as caseine in milk, gluten in bread, gelatine, etc.), and alcohol.

In addition certain foods have of course certain specific and characteristic constituents, to which reference will be made.

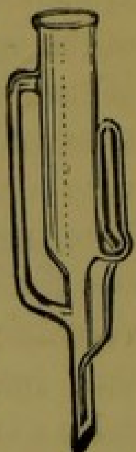
Water.—The amount of water in a substance may be accurately determined by carefully weighing out a small quantity in a convenient vessel, such as a platinum, porcelain, or glass capsule, and heating it by steam on a *water-bath* or in an *air oven*, until it ceases to lose weight. The final weight deducted from the weight of substance taken gives the quantity of moisture contained in that weight. The employment of this method pre-supposes that the substance under examination is not altered or affected by the heat to which it is exposed, except as regards the loss of the water it contains. Means are of course taken to dry the substance in a condition which shall ensure the loss of its moisture with the greatest facility. As a rule, it is powdered and arranged in as thin a layer as possible in the evaporating vessel. It is occasionally necessary to dry in a vacuum at the ordinary temperature of the air, this being generally accomplished by placing the substance under the receiver of an air-pump together with a vessel containing strong sulphuric acid, a body which possesses the property of absorbing water-vapour with great avidity.

Mineral Matter.—The total amount of mineral matter is approximately determined by burning a weighed quantity of the substance to be examined, and weighing the amount of ash obtained. It must be borne in mind that some mineral substances, such as common salt, are volatilised at a very high temperature, and that some, such as carbonate of lime, are partially decomposed by loss of carbonic acid, but the estimation of the percentage of ash yielded affords valuable information as to the impurities and adulterations that may be present in certain foods. The amount of substance taken for examination is regulated by the quantity of ash that different foods are known to yield, and the burning off of the organic constituents is always managed at as low a temperature as possible.

Analysis of the Ash.—An analysis of the ash is sometimes called for and, as in the case of the analysis of the solid residue of a water, is carried out by separating the different constituents from a given weight of the ash and weighing them. For example, valuable indications are afforded by determining in the ash of milk, the percentage of chlorine and of phosphates; in the ash of beer, the percentage of common salt; in the ash of coffee-mixtures, the percentage of silica, and in most ashes the proportion of matter soluble in pure water to matter not thus soluble.

Fat.—To estimate the quantity of fat, advantage is taken of the fact that certain organic liquids, such as *ether*, possess the property of dissolving fat, and of depositing it when they are evaporated. A weighed quantity of the substance—which may previously require some preparation, as in the case of milk, from which the larger part of the water must first be removed—is digested with ether at the boiling temperature of that liquid, this treatment being continued until the whole of the fat has been extracted; the etherial solution is passed through filtering paper, received in a previously weighed vessel, such as a platinum dish, and the ether evaporated off by immersing the vessel in hot water. The increase in the weight of the platinum dish is the weight of the fat. A very perfect extraction of fat, by means of ether, may be secured by placing the substance in a flask provided with an upright condenser, covering the substance with ether or other volatile extracting liquid, and boiling the latter. The vapour of the ether being condensed, falls back into the flask, and a very concentrated solution of the fat may thus be obtained. A *Soxhlet's extractor* is a convenient apparatus for such purposes—as large a quantity of fat as possible being dissolved in as small a quantity of ether as possible, a point of much importance as regards facility and rapidity of work.

FLASK, WITH UPRIGHT CONDENSER.



SOXHLET'S FAT EXTRACTOR.

Sugar.—There are a great many processes for the estimation of sugar, both chemical and physical. The amount of carbonic acid evolved during the alcoholic fermentation of a saccharine substance has been proposed and used as a measure of the quantity of sugar to which the fermentation is due; and the specific gravity of the saccharine liquid has also been used to estimate the percentage of sugar. These two processes are not, however, now in use; the most usual method is perhaps that of Fehling. This process depends upon the action of grape sugar (or glucose) on sulphate of copper in the presence of a strong alkali. Certain organic substances, grape sugar among the number, possess the property of influencing several chemical reactions. If caustic potash solution be added to a solution of sulphate of copper, a bluish precipitate of hydrated oxide of copper will be produced—and if the mixture be boiled it will become black, owing to the formation of the black oxide of copper. But should the smallest portion of grape sugar be present, on boiling, the mixture will become red to reddish brown in consequence of the formation of the red sub-oxide of copper, a substance, as its name implies, less highly oxidised than the ordinary oxide. A standard solution of sulphate of copper with strong caustic potash is prepared of such a strength that each cubic centimetre contains the quantity of copper that will be exactly reduced to the sub-oxide by the action of 5 milligrammes = ·005 grammes of pure grape sugar. A known volume of the solution of copper is placed in a white porcelain dish, is heated to boiling and the saccharine liquid delivered into it from a burette, until the whole of the copper has been converted into sub-oxide, as is shown by the point of disappearance of the blue colour of the solution in the dish.

Cane-sugar has no action on the solution of copper ; but its quantity may nevertheless be determined by it, inasmuch as by boiling a solution of cane sugar with a few drops of acid, the cane sugar is converted into grape sugar. The sub-oxide of copper precipitated by a measured volume of grape sugar solution may also be separated, washed, dried and weighed, and is of course a direct measure of the quantity of grape sugar which has precipitated it.

Starch and *Woody-fibre* may also be estimated by taking advantage of the fact that by prolonged boiling with acid they are converted into a substance which is chemically identical with grape-sugar or glucose, and reacts on the copper solution in a precisely similar manner and to the same extent. It must, however, be understood that should both these substances be present in the material under examination, this method enables no distinction to be made between them, and their separation must be effected in other ways. Where the complete separation of a number of chemically similar substances is required, the difficulties of the problem are of course greatly increased, and methods more or less complicated must be devised to cope with it.

Starch.—The chemical composition of the various starches is identical, although the forms of the granules, or corpuscles, differ greatly according to the plant from which the starch comes. It may be estimated by the process above mentioned. The specific characters of the granules of starch from different plants are very easily made out by the microscope, and fairly close approximations may be made tc the true percentages of starch in certain mixtures—such, foı instance, as mustard and flour, or cocoa and arrowroot, by making up mixtures of known quantities of the starch in question with pure mustard, pure cocoa, etc., as the case may be, and counting the number of starch granules in miscroscopic preparations of the same quantities of both the standard and the suspected substances.

Starches are all coloured intensely blue by iodine, and the latter substance is accordingly employed as a very delicate test for the presence of starch. Granules of starch under the microscope may thus be identified with the greatest ease.

Of non-nitrogenous bodies we have examples in the fats and the carbo-hydrates (sugar, starches, gums, etc.), all of which are compounds of carbon, hydrogen, and oxygen alone.

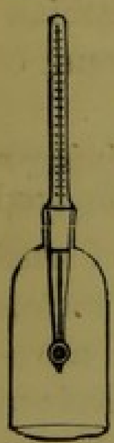
Nitrogenous Compounds.—Nitrogen is present in food-substances combined with other elements in a great variety of ways, forming a number of more or less complicated compounds ; and several classes of nitrogenous bodies have accordingly to be distinguished. For example, of the compounds of carbon, hydrogen, oxygen and nitrogen alone we have some of the *alkaloid class* such as theine in tea and coffee, and theobromine in cocoa. These bodies act as strong poisons on the animal economy. The most important nitrogenous bodies as regards food, however, belong to the so-called *albuminous* class, which, in addition to the elements mentioned, contain sulphur, and in some cases phosphorus. Such for instance as casein in milk, gluten in the cereals, albumen (white of egg) and fibrin in blood, flesh, etc., and vegetable albumens. Gelatine obtained from skin, tendons, and bones, belongs to another sub-class.

Our knowledge of these substances is still extremely imperfect. Many of them, formerly regarded as separate and definite compounds, are now well made out to be mixtures of several. The absolute separation and estimation of many of these compounds is therefore not always possible in the present state of our knowledge with regard to them; and it has consequently been usual to estimate the total quantity of nitrogen contained by the body under examination, that quantity being a measure of the total amount of nitrogenous matters present.

Such a determination may be carried out by mixing a carefully weighed portion of the dried substance with oxide of copper, introducing the mixture into a long tube of hard glass, and having removed the air from the latter by means of a pump, heating it to redness in a furnace. The nitrogenous substance is decomposed, and the nitrogen is evolved and measured, by allowing it to bubble up into a graduated tube filled with mercury and standing in a bath of mercury; corrections for temperature and barometric pressure being of course made.

In thus determining the total nitrogen in a substance used as food, or in any particular portion of such a substance, we are not justified in assuming that the whole of the nitrogen is present in such combinations as are valuable for feeding purposes, such, for example, as the albumens. Much of the nitrogen *may be* present in compounds which are comparatively valueless as foods, and in order to obtain further information as to the state of combination of the nitrogen, it is necessary to employ some process for the estimation of albuminous matter. Such processes depend as a rule upon the property possessed by most albumens of *coagulating* when treated with acids or other re-agents.

Alcohol.—In the examination of beverages, the determination of the percentage of alcohol is generally the first step taken. There are several very accurate methods. Pure or absolute ethylic alcohol is a mobile, colourless, and neutral liquid of specific gravity 0·815 at 0° Centigrade and boiling at 78·3° Centigrade. The alcohol in an alcoholic liquid is extracted by distillation. One hundred cubic centimetres or more of the liquid, (beer, wine, spirits, etc.), are placed in the distilling apparatus and distilled until the matters in the retort or flask are nearly dry. The distillate having been received in a flask fitted air-tight to the end of the condenser is made up to the same volume as the volume of liquid experimented on (100 c. c. or more, as the case may be,) with distilled water. The specific gravity of this distillate at 0° C. (32° Fahrenheit) is then accurately taken in a specific gravity flask. Inasmuch as bulk for bulk alcohol is lighter than water, as ·815 is to 1, it follows that the more alcohol there is in the distillate the weight of the latter will be *pro tanto* lessened. A hydrometer is also frequently used for this purpose; it consists of a glass tube with a weighted bulb, which sinks in the liquid to a depth varying with its density, the latter being indicated by graduations on the stem. Tables have been constructed giving the specific gravities of mixtures of alcohol and water in all integral proportions, and by referring to one of these the amount of alcohol in the 100 c.c. of distillate is at once seen. Since the distillate has the same volume as the liquid experimented on, and since all the alcohol in the latter is contained by the distillate, the percentage of alcohol required is arrived at.


SPECIFIC GRAVITY FLASK.


HYDROMETER.

We now proceed to describe and explain some of the simpler processes of food-analysis, more particularly those which are of hygienic interest.

Milk, Cream, Butter, and Cheese.—The milk of different animals varies somewhat in composition, so far as the actual percentages of the typical ingredients are concerned; but the milk of any healthy animal, such as the cow, even when the methods of feeding are different, varies within well-ascertained and tolerably narrow limits, so that the analyst, knowing the average composition of the milk of healthy cows, can find whether, in a particular case, there is a departure from it. We are not for the moment concerned with departures from the normal composition, such as those which occur in milk from diseased or starved animals, or with milk which for other reasons is of abnormal character. By determining the total quantity of solid matter, of fat, of sugar, of caseine (curd), and of ash, as well as the specific gravity, the analyst is able to ascertain whether milk has been sophisticated by abstracting fat (cream), or by adding water, or by both these processes. It must be remembered that these sophistications may be of a very dangerous character. Milk is admitted to be a perfect food for the young, containing as it does a proper proportion of the ingredients of a typical food, viz., the nitrogenous, saccharine, and mineral constituents, and the lowering of its value as a food has been shown to have much to do with infantile mortality; on the other hand, the water with which a milk is adulterated may be, and very often has been polluted, and the poisons of various diseases, which find a congenial soil in such a substance as milk, are thus often carried over a wide area, and may produce their specific effects in a large number of persons.

The normal composition of healthy cow's milk, having a specific gravity of 1029 and upwards, is as follows (Parkes):—

Water	86·8
Albuminates	4·0
Fat	3·7
Carbohydrates (sugar)	4·8
Salts	0·7
	100·0

According to Wanklyn, there are in 100 c.c. of average country milk :—

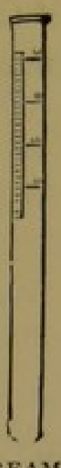
Water	90·09 grammes
Fat	3·16 „
Caseine	4·16 „
Milk sugar	4·76 „
Ash	0·73 „
	102·90 „

Specific Gravity.—Considering milk as a watery solution of lactin (milk sugar), caseine and salts (*i.e.*, compounds of magnesium, potassium, sodium, and iron, with chlorine, and with phosphoric and sulphuric acids), holding fat globules in suspension, it seems at first sight that the addition of more water should lower the weight of a given volume of milk, and hence lessen the specific gravity. The fact that fat is lighter than water must, however, not be lost sight of, and that, in consequence, increase of fat means lowering of density. The commonest instrument used in examining milk by a specific gravity test is that known as the *Lactometer.* This is simply a hydrometer applied to milk—a bulb-tube and stem weighted at the bottom. It is floated in the milk and it will sink more or less, according to the density of the liquid in which it is immersed. The lactometer may be graduated, by marking on the stem the points to which it sinks when it is placed in mixtures of normal milk with water in different proportions, or it may be graduated into specific gravities. As a matter of fact the lactometer is a very untrustworthy instrument. A more accurate method is to fill a specific gravity flask with the milk and weigh it at a particular temperature. By comparing this weight with that of the same flask filled with pure water at the same temperature the density of the milk is obtained. The specific gravity of pure milk varies from 1023 to 1035, the average being 1029. The total amount of solid matter may be determined by drying up on the steam bath, about five grammes

LACTOMETER.

of milk weighed out in a platinum capsule, and by burning this residue the percentage of ash (mineral matter) is arrived at. The amount of solids yielded by pure milk varies from 11·5 to 14 per cent.; when the percentage falls below 11, the milk is very poor, and has probably been sophisticated. The fat is obtained by extracting about 10 grammes of the milk, previously evaporated to a semi solid consistence, by means of ether; the solution of the fat in the ether, passed through a filter and collected in a weighed vessel, is evaporated in the latter until the whole of the volatile solvent has disappeared, and the weight of fat thus obtained.

After the extraction of fat there remain caseine, milk-sugar and mineral matter. By treatment with alcohol and water the milk-sugar, and part of the ash are removed; the residue consists of caseine and a little phosphate of lime, which may be dried and weighed, burnt, and the ash weighed; the latter, deducted from the first weight, gives the quantity of caseine. The milk-sugar may be determined in the weak alcoholic extract above mentioned, by means of Fehling's copper solution, as previously described under "Sugar"; or a given weight of milk may be "coagulated" with acetic acid, and the clear whey may be taken for the determination of sugar. The "solids not fat" that is, the caseine, salts, and lactin, obtained by direct experiment or by deducting the percentage of fat from the percentage of total solid matter, is a fairly constant quantity, *i.e.*, is not subject to the variation of the single constituents. This percentage is taken at 9·3, and knowing that 100 parts by weight of pure milk will yield 9·3 of "solids not fat," it is of course possible to calculate how much pure milk there is in any particular sample.



CREAMO-METER.

The percentage of cream thrown up by milk in a given time, is determined by an instrument called a *creamometer*. This is a long tube in which the milk is allowed to stand and which is graduated to give percentages.

Many ingenious adulterations of milk have been devised and practised with a view of increasing the difficulty of detecting fraud by analysis, but they are all susceptible of detection by some modification of the processes just sketched out, and it cannot be too widely known that attempts to cheat the analyst, however clever they may be, can only in the long run result in failure. Among the other adulterations of milk the following have to be guarded against, most of them, however, being extremely rare; starch and gum (to conceal thinness), annatto or turmeric (to give colour), glycerine, syrup, emulsions of seeds (almonds, &c.,), chalk, sodium carbonate.

Apart from the discovery of adulteration in milk, its characters when it has been altered by decomposition, or when it has been obtained from starved or diseased animals, have to be considered. The alterations in chemical composition, although in some cases very striking, are not as yet sufficiently made out to be distinctive, and the microscopic appearances are therefore chiefly to be relied upon. Milk from diseased animals soon decomposes. Blood discs, pus cells and fungoid growths can be at once detected by the microscope. The characteristic appearance of the so-called "blue milk" is due to a microscopic growth. Minute moving organisms have occasionally been detected in milk from suspicious sources. A peculiar clustering of the milk corpuscles is noticed in certain diseases.

Cream.—The composition of cream is similar to that of milk, except that it contains a much larger amount of fat. The following is the analysis of a very thick cream (Wanklyn):—

Water	50·00
Fat	43·90
Caseine and Milk Sugar . .	5·63
Ash.	0·47
	100·00

It has been found adulterated with starch and gum, as well as with mineral matters. White of egg has also been used. The analysis is carried out in the same way as in the case of milk, but is somewhat more difficult owing to the large amount of fat. It hardly enters into the scope of the present work to describe the necessary analytical modifications which must be applied in the case of cream.

The analysis of condensed and prepared milks and milk foods, is also beyond our present scope. In these cases the addition of large quantities of cane-sugar for the purpose of preservation, considerably complicates the methods employed.

Butter.—Butter consists principally of cohered milk fat. It contains varying quantities of salt, water, and caseine. The following is an analysis of a pure butter.

Fat	83
Curd	5
Salt (ash)	3
Water	9
	100

The average amount of water varies from 5 to 10 per cent., but may be much higher even in genuine butter. For the purpose of increasing weight, butter is beaten up with water; an excess of the latter can be detected by drying a given weight of the butter on the water bath. By simply melting the butter in a narrow tube, the fat rises to the top, the water, containing the salt in solution, and the curd, sinking to the bottom; if the amount of water is very large, this test makes the fact at once evident. Butter may also be loaded with an excessive amount of common salt. This may easily be determined by extracting with water, and estimating the quantity of salt in the solution, by means of standard nitrate of silver as in the analysis of water. The most important point, however, is the substitution of some cheaper fat. Butter fat is a mixture of the Glycerides of certain fatty acids, some of which, viz., Palmitic, Stearic and Oleic acids, are insoluble in water, and not volatile; the others Butyric, Caproic and Caprylic Acids being soluble and volatile. For detecting and estimating foreign fat, advantage is in the first place taken of the facts, (1), that butter-fat possesses a different specific gravity to that of other fats, and (2), that it melts at a different temperature.

The fat having been separated by melting in the narrow tube and filtering it through coarse filtering paper into a dry bottle, the specific gravity may be determined by the flask as in the case of milk. The melting point, by drawing some of the melted fat into a very thin and narrow tube, allowing it to congeal therein, and placing it in a beaker of water, together with a thermometer. The beaker is nested in a second containing water, to which heat is then applied, and the temperature at which the fat *runs up the tube* is noted on the thermometer. Another valid plan is to note the temperature at which a small glass bulb will sink in the fat to be tested.

By determining the percentage of insoluble fatty acids, the analyst is able to calculate the extent to which a sample of butter has been sophisticated with foreign fats. The fatty acids insoluble in water are tolerably constant in butter fat, being about 88 per cent. of its weight, most other fats yielding about 95·5 per cent.

A given weight of the fat is "saponified" by heating with caustic potash and alcohol; the process of saponification consisting essentially in the combination of the fatty acids with potash, to form compounds called *soaps*. Some of the more volatile substances being driven off by the heat used in the process. The soap obtained is decomposed by sulphuric acid, preferably in a 'butter-flask,' a modified separating flask, and the resulting mass of fatty acids washed with hot water, the washings being allowed to escape by means of the stop cock.

The insoluble fatty acids are thus obtained in the flask in the form of a cake, which can be dissolved in ether, the solution collected in a weighed dish, the ether evaporated, and the fatty acids weighed. The soluble fatty acids may also be separately estimated.

In most samples of butter which contain foreign fat, the specific gravity, the percentages of insoluble and soluble fatty acids, and the melting points, are all entirely different from those obtained with genuine butter. For instance, genuine butter contains about 6 per cent. of soluble, and 88 per cent. of insoluble fatty acids, whereas "butterine" contains only 0·6 per cent. of soluble, and 95·5 per cent. of insoluble fatty acids.

Cheese.—Cheese is made from milk by coagulating the caseine by the action of *rennet*, and pressing the mass obtained. It is not a much adulterated article; but it is of importance occasionally to examine the rinds for poisonous metals, not only because of the custom of using protecting foils containing lead, but also because arsenical and other metallic solutions have been applied in order to prevent the attacks of insects. The examination of cheese is carried out in the same way as that of milk and butter.

Wheat Flour and Bread.—The following is the composition of wheat flour of average quality:—

Water	16·5
Fat	1·2
Gluten, &c.	12·0
Starch, &c.	69·6
Ash	0·7
	100·0

Bread is flour made into a paste with water, treated with carbonic acid gas, which is liberated in the paste, either by the action of yeast, or by mixing it with a strong solution of the gas in water; and subsequent baking.

The colour, smell and taste of flour and bread often yield valuable information as to quality; indeed, these tests are valuable in the examination of all food substances. The microscope detects the presence of fungi, of which several have been found in flour, and which also occur in bread; their presence indicating that the article is diseased or damaged. Certain animal parasites are also found in bad flour; and a point of much importance is the detection of adulteration with other starchy substances. The characteristic appearances of the different starches under the microscope enables this to be done with ease in the case of flour; but with bread, inasmuch as the process of manufacture alters these appearances, the starch granules swelling and bursting, the problem is much more difficult.

The chemical examination of flour resolves itself chiefly into determining the percentages of Water, Gluten, Ash, and the presence of Alum, and its quantity, if present.

The amount of water in flour is ascertained by drying one gramme in a dish, and the amount of ash by burning two or three grammes. For bread larger quantities are necessary. The more water the less is the value of the article; flour should be rejected if it contains more than 18 per cent. If the ash be more than 2 per cent. mineral adulteration or impurity is present. An easy method of detecting large quantities of mineral impurity is to shake up the flour with chloroform, when the flour floats, and the foreign mineral impurities fall to the bottom of the vessel. Gluten is estimated in flour by washing away the starch from a weighed quantity: good flour contains from 8 to 12 per cent.

Alum in Flour and Bread.—The presence of alum is most easily detected by treatment with a tincture of logwood and carbonate of ammonia. If alum is present, a blue or green colouration is obtained; the flour should previously be well mixed with water and the bread should be allowed to dry. If a blue colour be obtained a further examination is necessary, and the exact amount of alumina present must be separated out from a weighed quantity of the flour or bread and weighed. The process is a somewhat long one, and it will hardly be necessary to describe it here.

There have been rare cases of poisoning which have occurred through the presence of lead in flour, which has been introduced through the repairing of mill stones with lead. Arsenic has also been found in flour, having been introduced accidentally, and plaster of Paris (sulphate of lime) has been fraudulently sold with flour.

Tea, Coffee, Cocoa and Chocolate.—The examination of tea does not present much difficulty. The presence of foreign leaves, of sand, and other mineral substances, and the use of exhausted leaves are the chief points to be seen to. The Chinese themselves have invented a method of adulteration which consists in steeping the leaves in gum and rolling them in sand. This they call "lie tea"; and most samples of the cheaper kinds of tea contain small quantities of it.

The tea to be examined is boiled up with water, and the leaves can then be picked out and examined. The structure of the tea leaf is very characteristic. The shape, serration, and the venation, especially the latter, being distinctive. The primary veins run out from the mid rib nearly to the border, and then turn up sharply. Foreign leaves can therefore be at once detected by their special characters. The vessel in which the tea has been boiled will contain any sand or mineral substances which may have been adhering to the leaves. The chemical examination of tea essentially consists in the determination of Water, Ash and Soluble Ash, Extract, Theine and Tannin. The extract is obtained by treating a weighed quantity of tea with hot water and evaporating a measured bulk of the solution to dryness, and weighing the residue. If exhausted leaves are present, the amounts of extract and of ash soluble in water, &c., will be obviously lower than those obtained from good tea. The amount of the total ash will be high in case of the presence of much mineral impurity.

Coffee.—It is of course in the ground state that coffee is most liable to adulteration. The chief adulterations are chicory, roasted wheat and beans, acorns and burnt sugar. By far the most common is chicory. The analysis of coffee is very similar to that of tea. Chicory may be detected by the microscope, its dotted ducts and large loose cells being very characteristic. If coffee containing much chicory be sprinkled on the surface of some water in a jar the chicory will sink, colouring the water a deep brown as it does so. Pure coffee gives a hardly perceptible colour to the water, and scarcely sinks at all. The alkaloid of coffee, viz., caffeine, is identical with theine.

Cocoa and Chocolate.—These articles, as they come before the analyst, are "prepared," and are subject, consequently, to various adulterations. The various forms of prepared cocoa are simply the ground seeds previously roasted and deprived of their covering, and mixed with starch and sugar. The microscope at once shows the nature of the mixture. There is no essential chemical difference in the composition of cocoa and chocolate. Both cocoa and chocolate are rich in fat.

Alcoholic Beverages.—This is a very wide subject, and cannot be more than alluded to here. In all cases, of course, the determination of the quantity of alcohol is the first essential point. There are several methods, the one most usually employed being as follows: A measured volume of the liquid is distilled, and the distillate made up to the same volume as the liquid taken. As previously explained, the specific gravity of the distillate at once gives the percentage of alcohol present by reference to a specific gravity table.

Special adulterations and impurities, as might be expected, have to be looked for in different beverages, *e.g.* artificial colouring matters in wine, bitter principles and salt in beer, "fusel oil" (amylic alcohol) in spirits. The addition of water to spirits is a criminal offence, but so far as health is concerned it is perhaps an advantage.

Condiments—Vinegar, Pepper, Mustard, Pickles.—Vinegar is more or less impure acetic acid. It contains from 3 per cent. to 5 per cent. of acetic acid (glacial); 3 per cent. is the minimum allowable. It is adulterated, (1), by the addition of water, (2), of sulphuric acid or other strong mineral acid, and it may contain lead, copper, or zinc, due to the action of vinegar on the vessels in which it has been kept, or on the apparatus used in its manufacture.

By taking the specific gravity the addition of water can be detected. It is preferable to distil a measured bulk of the vinegar, and to take the specific gravity of the distillate. The percentage of acetic acid is then obtained as in the case of alcohol.

The total acidity of the vinegar may be determined by means of a standard alkaline solution. The acidity is calculated as acetic acid, although other acids may be present. If the specific gravity is low and the acidity high, sulphuric acid or some other mineral acid may have been added. The processes for determining the amount of free sulphuric acid in vinegar cannot be detailed here. It may be pointed out that the ordinary methods of estimating sulphuric acid, by precipitation and weighing as sulphate of barium, do not admit of differentiating between the added sulphuric acid and natural sulphates in the vinegar. However, there is a rapid qualitative test which may be easily applied :—10 c.c. of vinegar are evaporated to dryness and burnt ; the ash is then dissolved in a little water, and the reaction of the solution taken with litmus paper. If the ash is alkaline the vinegar cannot contain an excess of free sulphuric acid, if *neutral* it very likely does, the reason being, that the ash of natural vinegar consists chiefly of alkaline carbonates, but if excess of sulphuric acid is present, neutral salts will be obtained in the ash, owing to the decomposing action exerted by the sulphuric acid during evaporation.

Pickles.—The vinegar used may be examined as has just been described. The presence of such metals as copper and lead, and their quantities if present, can be determined by incinerating a given weight and using the ash for analysis. The presence of copper in pickles can be detected by inserting the bright blade of a steel knife, on which the metal is deposited as a thin red film.

Mustard.—The microscopic characters of mustard-seed are very distinctive, and the presence of adulterating ingredients can therefore be very readily made out, the more so as it contains no starch. There exist in mustard a number of very well-defined compounds, some of which contain sulphur. An estimation of the total quantity of sulphur present in a sample can be made an approximate measure of the actual quantity of pure mustard in it, as can also a determination of the percentage of *oil*, the common adulterants of mustard containing neither of these substances in more than very small amount. The most common adulterations of mustard are wheat-flour and turmeric. The microscope at once reveals their presence and an approximation to the true percentages can be made by comparing the sample under examination with standard samples made up of pure mustard with varying quantities of the adulterants. By treating mustard thus adulterated with iodine the blue colour which the latter strikes with starch shows the presence of flour, and caustic potash solution added to mustard containing turmeric, reveals the presence of the latter by a bright red colouration of the turmeric specks. From the hygienic point of view there can be no doubt that the use of *pure* mustard with food is not desirable, and that the addition of a little starch is an advantage.

Plaster of Paris, chromate of potash (a yellow substance), clay, and gamboge, are all stated to have been found in mustard. Special tests must be made for these substances should the microscope or the percentage of ash give rise to suspicion. There is no doubt of the occasional use of gamboge, although it is rare, and it is certainly a most objectionable adulterant.

A percentage of ash higher than 5 would show mineral, and lower than 4 organic adulteration, the average ash of mustard being 5 per cent.

Pepper.—Unlike mustard, pepper contains starch, the granules being very small. It is found adulterated with ground rice, wheat-flour, linseed, and mustard-husk, and with sand. These are the only common adulterations; although some observers give a formidable list of the substances used. The determination of the ash, which varies from 1·5 to 5 or 6 per cent., and should never exceed 7 per cent., detects mineral impurities such as sand. The microscope shows the presence of ground-rice, this being indeed the commonest adulterant.

Condensed, Prepared, and Preserved Foods.—The very large number and variety of such articles renders it impossible to do more than allude to them as substances which come under the notice of the analyst in increasing number. Some of the cheaper tinned foods are occasionally deleterious, either through imperfect preparation and consequent decomposition, with accompaniment of fungoid growths, or from the action of the foods themselves on the metal of the containing vessel s; but the extremely rare occurrence of cases of poisoning does not warrant the scare which seems to exist with regard to them.

Examination of Soils.—The complete analysis of a soil is a very long and tedious process. It will be enough to indicate that for the purposes of the hygienist the determination of the percentage of water contained, of the power of holding water, of the amount of loss and behaviour on incineration, together with a microscopic examination, is as much as is generally required for practical purposes.

Arsenical Wall-papers and Pigments.—These are now well recognised as fruitful causes of disease. There are several methods of detecting arsenic, one of the best being Marsh's, which has already been described.

Disinfectants.—The principle of the method usually employed to judge of the value of a particular disinfectant consists in comparing its preserving power in solutions of different strengths with that possessed by some standard disinfectant, such as carbolic acid. Milk or meat is perhaps the most convenient substance for such experiments. Equal volumes or weights are treated with measured volumes of the disinfectant solutions, and are examined daily by the microscope, and otherwise, for the signs of decomposition.

The foregoing sketch of hygienic analysis is necessarily very limited, but enough has been said to show the general nature of the plans employed, more particular attention having been paid to common adulteration and impurity, rather than to the processes used in the investigation of food-substances for purely scientific purposes. But it must not be supposed that the list of articles which find their way to the hygienic laboratory is by any means exhausted. The examination of articles of clothing and decoration, of the innumerable substances used as deodorisers and disinfectants, of soils and of drugs, opens up, as will readily be seen, an extremely wide field of work.

International Health Exhibition,
LONDON, 1884.

OLD AND MODERN

POISON LORE.

A LECTURE

DELIVERED IN THE

LECTURE ROOM OF THE EXHIBITION,
JULY 15th, 1884.

BY

A. WYNTER BLYTH, M.R.C.S.

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LECTURE ON OLD AND MODERN POISON LORE.

By A. WYNTER BLYTH, ESQ., M.R.C.S.

Dr. B. W. RICHARDSON, F.R.S., in the Chair.

THE CHAIRMAN : Ladies and Gentlemen, I understand it is the order of proceedings that I should introduce Mr. Blyth, but I think it would be much more in order that he should introduce me, considering that it is the first time I have had the pleasure of coming to one of these meetings ; but without further preface I will call upon him to read his paper.

MR. WYNTER BLYTH.—The modern word toxicology has a deep significance, it can be traced back to an ancient root, meaning " bow " or " arrow," or in a wider sense some " tool " used for slaying. The oldest poison lore was that of primitive races in various parts of the world, who, in remote unhistoric time, took a lesson from the snake, and remedied the imperfection of their weapons by steeping them in venom.

The arrow poison of the Gauls is said to have been hellebore ; that used by certain American Indians is curarine, a vegetable extract from plants of the strychnos order. Some races adopted snake poison, and others putrid blood; this last producing a disease termed in our day septicæmia, or blood poisoning. In this way the septic poisons may have been very early known.

Weapons soiled with the blood of former wounds would be found more deadly than clean, freshly-made weapons; and starting from this empirical fact, the arrows or spears would be steeped in all manner of offensive pastes and smeared with the vegetable juices of those plants which were deemed noxious; and as the effects were mysterious, they would be ascribed to the supernatural powers, and covered with a veil of superstition. The poisonous properties of arsenic, opium, henbane, aconite, and a few others were known to the ancients and handed down by oral tradition as a part of priestcraft, long before they were reduced to writing; the exact amount of knowledge thus transmitted in this way can only now be a matter of inference. On an Egyptian papyrus preserved at the Louvre, M. Duteuil read, "Pronounce not the name of I. A. O. under the penalty of the peach." Now peaches, as peaches, are perfectly harmless, but prussic acid can be distilled from them; the Egyptians were the first known to have practised distillation; hence, under the dread threat of the peach, it is clear enough that they meant prussic acid; this is probably the earliest evidence extant of the actual separation of a poison in a more or less pure state by a chemical operation. No mention is made of prussic acid among the early Roman writers, yet there is good reason to believe, that a knowledge of the deadly Egyptian distillate of peaches passed to the Romans. A knight, in the reign of Tiberius, accused of high treason, swallowed poison and fell dead at the feet of the senators; no poison but prussic acid, and that in a tolerably concentrated form, would have this effect.

The early treatise of Nicander of Colophon (204–138 B.C.), to which followed Dioscorides, however, shows that whatever use or abuse might be made of a few violent poisons, Greek and Roman knowledge of toxic substances was stationary, primitive and incomplete.

The Asiatic races used poison more than the northern or western nations; the ancient practice of the Hindoo widow—self-immolation on the burning pile of her husband is ascribed to the necessity the Brahmins were under of putting a stop to the crime of domestic poisoning. Every little conjugal quarrel was liable to be settled by this form of secret assassination, but the law seems to have effectually stopped the practice. The Asiatics knew the properties of arsenic, aconite, opium, and various solanaceous plants, but were not acquainted with prussic acid.

The part that poison has played in history is considerable. The pharmaceutical knowledge of the ancients is more graphically and terribly shown in the deaths of Socrates, Demosthenes, Hannibal, and Cleopatra, than in the pages of the older writers on poisons. In the early part of the Christian era, professional poisoners arose, and for a long time exercised their trade with impunity. In A.D. 26 poisoning was so much in use as a political engine that Agrippina refused to eat of some apples offered to her at table by her father-in-law, Tiberius. It was at this time that the infamous Locusta flourished. She is said to have supplied, with suitable directions, the poison by which Agrippina got rid of Claudius; and the same woman was the principal agent in the preparation of the poison that was administered to Britannicus by order of his brother Nero.

It was the custom of the Romans to drink hot water, and as no two men's tastes are alike, great skill was shown by the slaves in bringing the water to exactly that degree of heat which their respective masters found agreeable.

The children of the Imperial house, with others of the great Roman families, sat at the banquets at a smaller side table, while their parents reclined at the larger. A slave brings hot water to Britannicus, it is too hot; Britannicus refuses it. The slave adds cold water, and it is this cold water that is supposed to have been poisoned; in any case, Britannicus had no sooner drunk of it than he lost voice and respiration. Agrippina, his mother, was struck with terror, as well as Octavia, his sister. Nero, the author of the crime, looks coldly on, saying that such fits often happened to him in infancy without evil result; and after a few moments' silence, the banquet goes on as before. If this were not sudden death from heart or brain disease, the poison must have been either a cyanide or prussic acid.

In those times no autopsy was possible; although the Alexandrian school, some 300 years before Christ, had dissected both the living and the dead, the work of Herophilus and Erasistratus had not been pursued, the rudiments of human anatomy were only known, while as to pathological changes and their true interpretation, such knowledge had no existence. It was not, indeed, until the fifteenth century that the Popes, silencing ancient scruples, authorised dissections; and it was not until the sixteenth century that Vesalius, the first great anatomist, arose.

In default of pathological knowledge, the ancients attached great importance to mere outward marks and discolorations. They noted with special attention spots and lividity, and supposed that poisons singled out the heart for some quite peculiar action, altering its substance in such a manner that it resisted the action of the funeral pyre and remained unconsumed. It may, then, fairly be presumed that many people must have died from poison without suspicion,' and still more from the sudden effects of latent disease, ascribed wrongfully to poisons. For example, the death of Alexander the Great has been confidently ascribed to poison, but "Littré" has fairly proved that the great emperor, debilitated by his drinking habits, caught a malarious fever in the marshes around Babylon, and died after eleven days' illness. If, added to sudden death, the body, from any cause, entered into rapid putrefaction, such signs were considered by the people absolutely conclusive of poisoning—this belief prevailed up to the middle of the seventeenth century, and lingers still among the uneducated at the present day. Thus, when

Britannicus died, an extraordinary lividity spread over the face of the corpse, which they attempted to conceal by painting the face. When Pope Alexander VI. died, probably enough from poison, the rapid post-mortem change was noted, and considerable stress is laid upon it by the historian Guicciardini—but we know that such changes are utterly untrustworthy, some poisons indeed such as arsenic, retarding putrefaction.

An essay might be written entitled Royal poisoners. Charles le Mauvais, King of Navarre, gave a commission of murder to Woudreton, to poison Charles VI., the Duke of Valois, brother of the King, and his uncles the Dukes of Berry, Burgundy and Bourbon ; the infamous document is still extant ; it directs Woudreton to purchase sublimed arsenic, to sneak into the kitchen, larder, or any where else, and drop the powder into the soups or meats.

Charles IX. figures in the annals of human vivisection. There was a question whether bezoar was an antidote or not : the King decided the question by giving a cook convicted of some slight theft a lethal dose of corrosive sublimate, following it up with bezoar ; but the man dies in seven hours, although Paré gives him oil—a grim business. Our own King John, of memory far from spotless, is said to have shut Maud Fitzwalter the Fair, in the highest, chilliest den of the Tower, and when neither cold, nor hunger, nor solitude broke her strength, when she still disdained his shameful suit, he foisted on her a poisoned egg, of which she ate and died.

The part that dynamite is playing in this age was played between the fifteenth and seventeenth centuries in Venice and Italy by poison. The criminal dynamite school of the nineteenth and the criminal arsenic school of the fifteenth—in political basis, in reckless disregard of human life—are similar. The Council of Ten sat in Venice, decreeing the removal of this or that man. Curious enough, the proceedings of the infamous oligarchy were recorded in writing with the utmost fidelity and candour ; and in the strangest minutes ever penned, we may read now, the reasons for and against the proposed assassination, the number of votes on either side, the sum paid, and the success. I will give one example and only one. On the fifteenth December, 1513, a Franciscan brother, John of Ragubo, appeared before the Council of Ten, and offered his services to remove any objectionable person out of the way. For the first successful case he required a pension of 1500 ducats yearly, which was to be increased on the execution of future services. The presidents, Girolando Duoda and Pietro Guiarini, placed the matter before the "Ten" on the fourth of January, 1514, and on a division, ten against five, it was resolved to accept so patriotic an offer and to experiment first on the Emperor Maximilian. The bond laid before the "Ten" contained a regular tariff, appraising the value of the lives of most of the men of note of the day, and concludes—"The further the journey, the more eminent the man, the more it is necessary to reward the toils and hardships undertaken, and the heavier must be the payment." In the seventeenth century there arose a band of poisoners in Italy; the most notorious of whom was a certain Toffana; she used arsenic in solutions of various degrees of concentration; her solution was called Acquetta di Napoli. She is on fairly good grounds suspected of having removed, by means of Naples water, more than six hundred persons, among whom were two popes. With the Acqua Toffana, the Acquetta di Perugia played at the same time its part. It is said to have been prepared by killing a hog, disjointing the same, salting it as it were with arsenic, and then collecting the juice which dropped from the meat; the juice was considered far more poisonous than an ordinary solution of arsenic; and recent researches on certain compounds which arsenic forms with organic matters lend countenance to this view. Toffana had disciples; Hieronyma Spara formed an association of young married women, one of the objects of which was the assassination of their husbands.

Italian and Venetian annals are not alone stained with these detestable crimes. The curious may read in Voltaire's

History of Louis XIV.'s reign, the crimes of the Chambre ardente, of St. Croix, de Brinvilliers, the priest Le Sage, and the women la Voizin and la Vigoureux—of these Madame de Brinvilliers was specially infamous. She is said to be the inventor of "les poudres de succession," and essayed their strength on the patients at the Hôtel Dieu. She poisoned her father, brothers, sisters, and others of her family, but a terrible fate overtook both her and her instructor and master in villany, St. Croix—St. Croix was suffocated by deleterious vapours from his own chemicals; Madame de Brinvilliers' crimes being known, she fled and took refuge in a convent, from which she was lured by a detective, who disguised himself as an amorous Abbé; she was beheaded and her body burnt near Notre Dame, in the middle of the reign of Louis XIV.

The old poison lore, mixed up with legend, myth and superstition, culminated in the use of arsenic. Arsenic white, tasteless, and deadly, capable of introduction into the human frame in all manner of subtle ways, of killing slowly or quickly, and of simulating the effects of disease was at one time almost synonymous with poison. For more than a century, after the properties of arsenic were to some extent popularised, there was no certain method known for its detection; and as late as 1836, whatever evidence of arsenical poisoning might be afforded by collateral circumstances, the risk of detection by chemical analysis was not great; hence the invention of a certain test for arsenic is so important, that the date of its discovery marks a toxicological epoch, from whence we may fairly date the rise of the modern poison lore. The great chemist, Scheele, in the eighteenth century, observed that arsenic united with hydrogen and made a very peculiar and fetid gas. After him Proust also studied the gas, and observed that when arsenical tin was dissolved in hydrochloric acid, that the gas could be lit, and then when allowed to play upon a cold surface, stains of the metal arsenicum were deposited.

Trommsdorf next announced, in 1803, that when arsenical zinc was introduced into an ordinary flask with water and sulphuric acid, an arsenical hydrogen was disengaged, and if the tube was sufficiently long, arsenicum was deposited on its walls. Stromeyer, Gay-Lussac, Thenard, Gehlen and Davy later studied this gas, and Serullas, in 1821, proposed this reaction as a toxicological test. Lastly, in 1836, Marsh, a chemist at Woolwich, published a memoir in the Edinburgh New Philosophical Journal, entitled "Description of a new process of separating small quantities of arsenic from substances with which it is mixed." On the basis of the work done by the pioneers already enumerated, Marsh arranged an apparatus of great simplicity, which is known under the name of Marsh's test; the method is now in use, and will separate, with certainty, a millionth of a grain of arsenic—thus the most tasteless and the easiest administered poison in the whole world is also the one which it is easiest to detect.

Modern poison lore is distinguished from ancient poison lore by its extent, by its exactness, by the laborious compilation and verification of its facts, by the application of various instruments of precision, both at the bedside and in the laboratory. In modern times the throbs of the pulse, the respiratory waves, and even the functional enlargements of internal organs, are made to record their own movements on strips of paper, moved by clockwork, and adjusted by mechanism of an ingenious character; the number of degrees of temperature gained or lost is registered by thermometers; the channels by which the poisons leave the body is determined by chemical analysis, and by the same means we know much relative to the localization of a poison in different tissues.

It is just about as difficult for the toxicologist to say how many poisons there are at present known, as for the botanist to enumerate existing species. By varying methods of classification all kinds of numbers could be obtained in either case. In the following statement, I have counted such substances as lead, copper, arsenic, antimony, and the like, as single units; each of the metals named enter into a very large number of combinations, all of which are more or less poisonous, and which, if each compound were enumerated, would swell the total to a big figure. In like manner, although in the common foxglove (digitalis) there are several poisonous principles, yet they are so nearly allied that they may be all included under one head, and so on with other cases.

Inorganic solid poisons	19
Liquids, more or less volatile, and many anæsthetic, such as ether, chloroform, methylene, benzene, alcohol, etc.	18
Acids, both organic and inorganic	10
Alkaloids	51
Glucosides	20
Organic anhydrides	2
Complicated animal and vegetable poisons not yet fully classed	26
Gases	14
	160

Proceeding in this way I get a total of 160 poisons, as about the number at present known to science; but not more than 40 of these ever figure in the Registrar-General's reports as a cause of death, and over 60 are chemical rarities, not existing in ordinary commerce.

Previous to the nineteenth century, more than 70 of these poisons were either unknown, or only known as vegetable extracts; it is the glory of modern chemistry, to have separated from plants most of the active principles in a perfectly pure state, and to have shown that what was formerly considered simple is really complex. Take for example, opium; it has been known as a narcotic from the earliest times; before 1803 no one ever imagined that it contained more than one active principle, but in 1803 Derosne separated from it morphine and narcotine, and at the present time no less than 21 definite principles, all having different physical, chemical and physiological properties, some, indeed, antagonistic, have been separated from this wonderful drug; or take aconite, that has been from the most remote times, the favourite poison in India; aconite, or the common monkshood, contains six alkaloids;

two of which alone seem to be physiologically active. Digitalis, the common foxglove, contains at least seven closely related and yet not identical principles; and, in short, it is now evident that poisonous plants generally contain a family group of poisons.

Life mainly rests on a tripod, heart, brain, and lung; some poisons act specially on the heart, others concentrate themselves on the lungs, and others ascend to the brain, but a great majority irritate and inflame the fine velvet lining of the great convoluted tube of the body, and only act indirectly on the cardiac, nervous and pulmonary systems. I have calculated that about 19 per cent. of the 160 known poisons act directly on the brain and spinal cord, either lulling to preternatural sleep or exciting to preternatural activity; $5\frac{1}{2}$ per cent. affect the respiration, a little over 4 per cent. affect the heart primarily, while no less than 39 per cent. are irritants; as for the remainder, their action is so mixed that they seem to affect various organs at one and the same time.

I have no intention of describing to you the symptoms produced by toxic substances but take the opportunity of pointing out in a general manner the wonderful mimicry of disease produced by certain poisons.

The fatal bite of the Cobra de Capello not unfrequently produces all the effects of a somewhat rare malady known as glosso-pharyngeal paralysis, or in plainer English, palsy of the tongue and throat.

Atropine, the active principle of Belladonna, will produce a dry sore throat, a vivid rash on the skin, a quick pulse, a high temperature, with delirium: the resemblance to scarlet fever is completed by a slight desquamation, or subsequent peeling of the skin.

A large fatal dose of arsenic mimics cholera; there is the same excessive depletion of all the fluids of the body by one channel, the vomiting, the collapse, and rapid death. Phosphorus produces jaundice; strychnine simulates tetanus, and the symptoms have been mistaken many times for hysterical convulsions.

Madness has been produced by lead. Last year I saw in Dr. Rayner's clinique at Hanwell some remarkable examples of this; in nearly all cases there were illusions of sight, one patient saw wind bags blown out to look like men. These apparitions, to his great terror, floated after him.

A more terrible form of brain disease has been produced by an artificial poison. Some years ago Mercuric methide was prepared in a London laboratory, and two young chemists, engaged day after day in its manufacture, became ill from breathing the vapour; complicated symptoms of brain disease appeared, which culminated in idiocy, and they both died.

Mercuric methide is not, however, the only poison which may produce insanity or idiocy. The Dhatoora of the Hindoos, which is identical with Belladonna, has in Indian history played the peculiar rôle of a State agent, and has been used to produce imbecility in persons of high rank whose mental integrity was considered dangerous by the despot in power. It usually, however, produces but a temporary insanity; in one case after a toxic dose a tailor sat for four hours moving his hands and arms as if sewing, and his lips as if talking, but without uttering a word. The "insane root that takes the reason prisoner" may be found among the solanaceous plants. In an ancient cloister the monks ate in error Henbane root, and in the night were all taken with hallucinations, so that the pious convent was like a madhouse. One monk sounded at midnight the matins; some who thereupon thinking it was morn, came into chapel, opened their books but could not read; others declaimed—some sang drinking-songs of a character not befitting the place; and the greatest disorder prevailed.

Several poisons produce ulcerations and skin diseases. The remarkable malady, first described by Dr. B. W. Richardson, under the name of the Bichromate disease, is another example of similarity between an artificially-induced affection and one which seems to occur spontaneously. Potassic bichromate is made on a large scale, and the workmen who inspire the dust through the nose, suffer from an inflammation of the septum, which ultimately may be destroyed by ulceration. It also causes painful skin affections—eruptions like eczema and psoriasis, and very deep and intractable ulcerations. The effects of the bichromate are not confined to men; the dust gets in any crack the horses at the factories may have about their hoofs and causes an ulceration from the effects of which even the hoofs may be shed.

If glosso-pharyngeal paralysis, scarlatina, affections of the skin, tetanus, insanity, and idiocy, may be either simulated or produced by drugs; on the other hand, certain diseases simulate the symptoms of poisoning, and the most rational explanation in these cases is that the body itself manufactures its own poison. One of the best examples is that known as "diabetic coma." In diabetic coma, there is first mental confusion, in which the person may wander aimlessly about the streets, and have somewhat the appearance of ordinary intoxication; then follows irresistible drowsiness, and ultimately death,—altogether a series of phenomena which might be well mistaken for the narcosis of opium or alcohol.

The establishment of almost perfect antagonism between certain vegetable poisons belongs to modern poison lore; for example, atropine is antagonistic to pilocarpine; atropine makes the skin dry, pilocarpine causes in five minutes a profuse perspiration; atropine dilates the pupil, pilocarpine contracts it. The heart of an animal arrested by atropine, can have its tick tick restored by the direct application of pilocarpine. Poisoning by pilocarpine is relieved and cured by atropine; poisoning by atropine is relieved and cured by pilocarpine.

The relationship between chemical composition and the direction of toxical activity also belongs to modern poison lore; the alkaloid strychnine, which causes powerful tetanus, may be changed by the chemist into another alkaloid which produces the opposite effect—paralysis; morphine, a drug producing sleep, may also be transformed by a very slight chemical metamorphosis into an emetic.

In being obliged to avoid any detailed account of the symptoms of poisoning, I cannot omit to point out the errors of most of the popular descriptions. Few dramatists have been happy in the description of death from poison; the death of Cleopatra, described by Shakespeare as resulting from the bite of a venomous snake, is like no clinical description of fatal illness from bites of any class of snakes.

In Philip Massinger's play—"The Duke of Milan," Francisco dusts over a plant with a poisonous powder; this plant Eugenia holds; Ludovico Sforza kisses her hand twice, and from this slight contact very rapidly dies—why, it is doubtful whether pure aconitine itself, the most powerful of all known substances, and only separated within the last few years, could be inhaled under these conditions in sufficient quantity to do harm.

Beverley, in Edward Moore's "Gamester," takes poison in the fifth Act, after which he makes several pretty long speeches, and ultimately dies suddenly, but, so far as we can learn, with considerable calmness. Nathaniel Lee, in his tragedy, "Alexander the Great," provides a poison for the destruction of the Emperor, which is described as of "exalted force."

> "* * mixed with his wine a single drop gives death,
> And sends him howling to the shades below."

Nevertheless, after taking the poison, Alexander walks about, declaims much, kills Clytus, and goes through the latter part of the fourth Act, and most of the fifth, comfortably enough; then raves in delirium, regains his senses, and dies after a very fine speech. There was no poison known to the writers of the plays alluded to which would produce symptoms in any way similar. At the present day there is, however, a liquid made by artificial means, the effects of which are stranger than those imagined by play-writers—after it is swallowed, the person walks about for an interval of time varying from a quarter of an hour to two hours; his skin, and even the whites of the eyes, become of a strange purplish livid colour, but he may feel fairly well, then the fatal symptoms set in with appalling suddenness, and he dies in a few minutes. For anyone who delights in constructing stories of sensation, these occasional effects of nitrobenzene, just described—the weird blue colour, the interval allowing of acts and rhapsodies, and the abrupt termination, afford considerable, although perhaps not commendable scope.

If progress has been made in the discovery of new poisons, and new methods of detection, so also progress has been made in the treatment of poisoned persons; take, for example, the modern treatment of a patient suffering from a toxic dose of strychnine. In chloroform we have not a chemical but a physiological antidote. Death takes place from the terrific spasms affecting the breathing; if chloroform be inhaled, and the nervous system lulled to sleep, time is afforded for the elimination of the alkaloid by the natural channels, and a chance is given to an otherwise hopeless case. In turpentine we have a most wonderful antidote for poisoning by phosphorus; and the more complete, for it seems to follow and catch up as it were the phosphorus even when circulating in the blood.

Few of us contemplate the possibility of accidental poisoning in our own households; yet among the daily necessities of civilized life, very active poisons hold their place: bleaching powder, carbolic acid, salts of sorrel, and even some forms of washing blue are deadly enough, and from time to time are the cause of accidents; the proper antidotes for these ought to be in every house, and the elementary knowledge of the proper treatment of such accidents should be known by all.

There was an ancient myth, long believed, that certain stones changed their colour at the approach of poison, and that there was also a substance which would neutralise every poison. This is no longer thought probable or possible. Nevertheless, attempts have been made with some success to compound a liquid which plays the rôle of a multiple antidote. One of the best consists of a saturated solution of sulphate of iron 100 parts, magnesia 80, animal charcoal 44 parts, water 800. It is preferable to have the animal charcoal and magnesia mixed together in the dry state and kept in a well corked bottle ; and when required for use, the saturated solution of sulphate of iron is mixed with eight times its bulk of water, and the mixture of charcoal and magnesia added, with constant stirring.

The multiple antidote may be given in wine-glassfuls once every ten or twenty minutes in recent poisoning by arsenic, zinc, opium, digitalis, mercury, or strychnine.

As to immediate treatment of other common poisons.—In poisoning by acids use calcined magnesia, or carbonate of soda ; or any bland oil. In poisoning by caustic soda, vinegar should be given. A good domestic emetic is sulphate of zinc, which now may be bought of most chemists in the form of convenient tablets. With the simple remedies named : that is, multiple antidote, calcined magnesia, vinegar, sulphate of zinc tablets, and let us add, for phosphorus, a small bottle of French turpentine, a cupboard may be stocked, and thus, for a few shillings, precautions taken against an emergency which may arise at any moment.

The use of poison by man I have thus first traced to the barb of the arrow envenomed by vegetable extracts ; later, poisons were used in a more subtle manner ; the stroke in daylight was replaced by the poisoned chalice : but at the same time it was found that poisons were also medicines, and able, when used legitimately, to preserve as well as destroy life ; later still the very essences of the plant world were separated as pure crystalline forms, and (aided by instruments of precision) their properties studied in all manner of ways. Rays of light, from the development of physiological and other sciences, were brought to converge upon the general subject ; and modern toxicology, though far from perfect, has rendered the crime of secret poisoning a dangerous game to the player. An important part of modern poison lore has been built up by experiments on animals. All that has been done in the past in this direction I cannot justify ; but these experiments have for the most part been undertaken by noble and humane men, for noble and humane purposes. If these experiments have increased the ways of death, they have multiplied the means of recovery; they have given to the physician many a potent elixir, charming away pain and restoring health; they have enlarged our knowledge of the action and nature of remedies, and have proved safeguards against illicit criminal practices. These experiments have shown that certain poisons are so potent and subtle in their action as to almost equal the wonders in tales told of charms condensed in necromancers' phials. The animal body can be played upon as if it were a machine. The strokes of the central pump can be slowed or quickened; the vital heat lowered or increased; the pupil of the eye expanded or narrowed; the limbs paralysed or convulsed; the blood sent to the surface or withdrawn to the interior; even the natural hue and colour of the body can be changed. If it be asked, cannot this strange science become, in the hands of an unscrupulous, abandoned and yet learned man, a power of destruction fearful to contemplate? The answer is, the risk of this is small. The higher kind of brain is a moral brain; the highest scientists are the most religious, it may not be a religion of special creeds, it may not even be a Deistical religion; but no one who has observed the phases of thought of the nineteenth century can with truth deny, that side by side with the evolution of physical and natural science, there has also been an evolution and practice of the purest doctrines of Krishna and Buddha; if indeed it were not so, and the most exalted intellects abandoned themselves to the secret destruction of their fellow creatures, the results would be disastrous. As for the ordinary criminal mind, like that of the Comte le Pommerais, who specially prepared a then almost unknown alkaloid, or the surgeon Palmer, or still more recent semi-scientific murderers whose names I pass over in silence; there is absolutely no ground for believing that they could escape detection, however cunning they may think themselves, however rare the agent they may employ, the toxicologist has weapons and means at his command to diagnose the sickness of nature from that of malignant art, and to separate and identify the poison.

THE CHAIRMAN.—Ladies and Gentlemen, I rise to propose a vote of thanks to the learned lecturer, for the splendid address he has given us; I do not remember to have listened to anything more comprehensive for a long time.

As he has passed from point to point, he has led me to make a note or two bearing upon what I have thought over and studied in the same directions, and I am glad to say we appear to view the subject very much alike. He said towards the close of his lecture that there was a great deal which we might be thankful for, as well as a great deal which we naturally very much dread, when we think what may and does occur in respect to the use of poisons. That was very true. Poisons are not always so bad as they are made to be, bad as they are; for to use a saying from our great national dramatist Shakespeare:

> "There is a soul of goodness in things evil,
> Would man observingly distil it out."

Now it is strikingly true with regard to some points which Shakespeare himself has brought before us. Mr. Wynter Blyth said that the dramatist's ordinary mode of describing death from poisons was altogether inaccurate. That was quite true; when you see on the stage death represented from poisons very rarely is it that it is at all accurate. I have never in my life, with one exception to which I shall soon refer, seen anything like a case of accurate representation. Some time ago a man died night after night on the stage from the effects of strong drink, his death taking place in *delirium tremens*, but it was altogether a false representation of what takes place in nature, and no person ever did or ever could die in that way. But our great dramatist has hit the mark correctly in regard to one particular poison. We always see correct representations of the effect of that poison in the draught which Juliet takes, with regard to which there is an extremely interesting history. You will find in Shakespeare frequent reference to mandragora; and when Friar Lawrence is giving Juliet a poison, that poison is the wine of the *Atropa Mandragora*, a plant which grows well in the Isles of Greece. That poison is equivalent to our Atropa, our Deadly Night-shade, but it is a little different in its effect, and it has had a remarkable history both as a poison and as a medicine of great power. The atropa mandragora, was also a medicine; and the ancient Greeks understood its properties well. Dioscorides described it, with regard to its use and its mode of preparation, and Pliny the Younger, in a later day, followed Dioscorides. Mandragora was a narcotic, and it had this peculiar property, that it produced a long deep sleep which resembled death while it lasted, and afterwards life returned. Mandragora was actually used by the Greek physicians in the same way as we use chloroform in these days. They made a wine of it, which they called "Morion," death wine, and before persons were submitted to the cautery—the hot iron,—or the knife, they took a draught of this, and the operation was performed while they were under the influence of the wine, the formula of which remains to this day as Dioscorides and Pliny gave it. The use of the wine went out about the fifteenth century, yet, according to the description given by Dioscorides, I was enabled twelve years ago, on the late Mr. Daniel Hanbury bringing me some of the root from Greece, to make some of the wine and gain evidence as to its action that was strictly in accordance with that which the ancients described. It is this wine I feel sure which Shakespeare makes Friar Lawrence put into the hands of Juliet. Where he got the description of it from I think it is very difficult to tell; he got it, perhaps from a book written by Apuleius, "*De Viribus Herbarum*;" Shakespeare has represented Juliet as taking that poisonous draught, in a description which is correct as to the working of it, but when she asks, before she swallows the poison which the Friar has given her to take, whether she shall hear "shrieks like mandrakes," he expresses a vulgar error. The mandragora was taken as some people take opium now, and they were called Mandragorates, that is, people who took mandragora; and in the period of the recovery from it they shrieked. Shakespeare has got correctly a fact, incorrectly an induction; he thinks it is the plant itself, when pulled up from the ground, that shrieks. That is not accurate, it was the mandragorates who shrieked. There was another use to which this mandragora wine is thought to have been put. During the period of the Grand Sanhedrim, when the Romans were ruling the Jews, the Jewish women, it is traditionally believed, went to the crucified of the Roman people, and gave them mandragora to take on the cross, in order that the sufferings while on the cross might be allayed. Some would escape death in this way; and it is inferred that when it was ordered that the legs of the crucified should be broken, that order was due to the circumstance that some recovered from the crucifixion, because though they seemed to die they did not. In the history of mandragora we see an illustration of what Mr. Wynter Blyth has said, that poisons are not always so bad as they are thought to be.

In the Middle Ages, at the period to which Mr. Wynter Blyth has referred, when there was a very common practice of poisoning, the vegetable poisons seem to have been out of use; but a science seems then to have been established for poisoning, and I note that terms were used which were very curious in their way. The professors specialized the mode of action of the poisons, the *haustu*, *gustu*, *odore*, and another, called "*contactu*," they used those words to describe the effects the poisons produced by draught, by odour, by taste, by touch or contact. They used arsenic, as stated by Mr. Wynter Blyth, and also corrosive sublimate, although it is difficult to understand how they got anybody to swallow it; and some of them used cantharides, an animal poison, the same as the Spanish fly. That is believed to have been a very common poison, and it is thought that Sir Thomas Overbury, on whom the Rochesters practised those arts, was subjected to cantharides, though killed at last by corrosive sublimate.

It is said that sometimes cantharides was put into pepper, and arsenic into salt, and corrosive sublimate into sweets. Then again it is said by some, that very finely powdered glass was administered for poisoning; but I cannot conceive that to be true; it seems to me to be altogether impossible that any person could have been got to swallow powdered glass. In the Middle Ages arsenic, cantharides, and corrosive sublimate, seem to have been the principal poisons used. Then some poisons were said to have been administered by contact, and there are many stories of the use of poisoned rings—rings which were poisoned on the interior, and had a sharp point to them, so that when a person grasped the hand wearing the ring the poison was passed into his body. I believe that to be altogether without foundation, because there is no kind of proof that the ancients had such a subtle poison as that. We have hardly got such a thing now, and I think it can scarcely have existed in the Middle Ages. This idea of wholesale poisoning of people by poisoned water has passed down from the time of Tophania to our own day. Tophania, I may say, would not have been executed but for a stratagem on the part of her prosecutor. She was under the protection of the Church, she was protected by an archbishop, and it was not until a suggestion was made by her prosecutor, the Viceroy of Naples, that she had poisoned the wells of the town, that the people demanded her execution. That idea of poisoning wells has come down to our own time. In my boyhood I was shown a well which in 1832 was believed to have been the cause of an outbreak of cholera at that time in the village. I was told that a Jew peddler had unfortunately drunk the water of that well, when he was taking his simple midday meal near it, and on that fact all the evil was laid. It was believed the man had poisoned that well. That idea is found also in other countries, so that it has evidently survived down to our own time. Poisoning, when it is carried out intentionally in these days, is often perpetrated by means of vegetable poisons ; aconite being, perhaps, most relied upon for the purpose, because it is difficult of detection. I think Mr. Wynter Blyth touched on a most important subject, when he directed our attention to poisoning which takes place by substances which affect the mind. He referred to one particular form of poisoning of this kind, poisoning by lead ; and he also referred to the effect of mercuric compounds. But there is another substance used in trade, the dangerous nature of which it is important for us to remember, and that is bi-sulphide of carbon. That substance is used in making the soft india rubber bladders, which children use as toys and which you see men carrying about the streets. Bi-sulphide of carbon is employed in making the india-rubber soft, so that it can be more easily worked for the purpose required ; and those who have to work with it are sometimes affected, unless the place is kept well ventilated, by a most peculiar disease of the mind, which has been well described, I think, only by Mr. Delpech. It consists of a peculiar delirium in the first instance, followed by salivation, want of power in the limbs, and cerebral paralysis. We have not had cases of this kind in our own country, but they have occurred in France ; and it is most important therefore, wherever this substance is used, as it is in the preparation of india-rubber, that there should be the most perfect ventilation, in order that persons working in it may not be subjected for long periods to this vapour, the effects of which are so deadly. Mr. Wynter Blyth referred to another point of great practical interest when he mentioned the possible formation of poisons in the human body. He struck out, you will remember, a very marked line of comparison between the action of poisons upon men and the diseases simulating them. Now this is a subject of great moment, and I may perhaps mention that I have myself written an essay upon it, which I have always thought is one that some day will demand considerable attention, because of the close analogies which we find between the action of some poisons and certain diseases.

Take somnambulism as an instance. I have not the slightest doubt that somnambulism is produced by the formation in the body of a peculiar substance, which may be derived from the starchy parts of the body, and has the effect of the chemical substance known as amylene. I believe that because I can produce artificial somnambulism by the use of that substance. Under its influence persons can be made to walk about unconsciously in the same way that the somnambulist does. Afterwards, when the effect goes off, the person becomes all right again; that is to say, when the effect of poison, for to that extent it is a poison, passes away. I remember the late Dr. Snow administering this curious substance to a boy, who was being operated upon by Sir William Ferguson; and while Sir William Ferguson was amputating the foot—that was the operation—the boy was playing unconcernedly with a ball, which he was throwing up and catching with the utmost precision. Other substances may be produced in the animal chemistry, which have strange effects; for instance, we have some substances which produce extreme melancholy. There is a peculiar offensive sulphur compound, called mercaptan. A little of that administered to anyone produces the intensest melancholy, tending almost to suicide. We can sometimes detect a similar offensive substance in the breath of patients who are suffering from melancholia. I have no doubt the day will come when it will be proved that many forms of mental derangement are due to substances resulting from mal-assimilation, and made in our own bodies.

I have touched upon a few points which our lecturer has brought before us; and I am sure I have not said half so much in favour of the admirable manner in which his work has been done as I ought to; but time presses, and Mr. Wynter Blyth will no doubt take the will for the deed. I will therefore propose at once that a hearty vote of thanks be given to him for the excellent lecture he has delivered to us.

Mr. Wynter Blyth briefly replied.