THE ACTION OF ALCOHOL ON MAN

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BY

ERNEST H. STARLING

C.M.G., M.D., Sc.D., F.R.C.P., F.R.S.

Foulerton Professor, late Jodrell Professor of Physiology, University College, London

WITH ESSAYS ON

1. ALCOHOL AS A MEDICINE

BY ROBERT HUTCHISON

M.D., F.R.C.P.

Physician to the London Hospital

2. ALCOHOL AND ITS RELATIONS TO PROBLEMS IN MENTAL DISORDERS

BY SIR FREDERICK W. MOTT

K.B.E., M.D., F.R.S., LL.D., F.R.C.P.

Pathologist to the London County Council Asylums

3. ALCOHOL AND MORTALITY

BY RAYMOND PEARL, PH.D.

Professor of Biometry and Vital Statistics, School of Hygiene and Public Health, Johns Hopkins University, Baltimore

WITH ILLUSTRATIONS

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PREFACE

THIS book has been written in response to a suggestion from my friend, Sir John Y. W. MacAlister, Secretary of the Royal Society of Medicine, that I should give an account of the action of alcohol on man in the light of our most recent knowledge.

As I found myself able to secure the co-operation of men of learning and experience to aid me in the presentation of those aspects of the subject with which I am less familiar, I did not hesitate to undertake the work.

I conceive that in a book such as this, written from the purely scientific standpoint, it will be possible to find material on which arguments might be based for or against the use of alcohol. I hope, however, that those interested in the problem will not be satisfied with sentences taken from their proper context, but will study the evidence as a whole.

I cannot pretend to foretell what will be the effect on the unbiassed reader of the evidence here presented. As regards myself, it has convinced me that in a civilized society such as ours the abolition of all alcoholic beverages from among our midst, even if carried out by universal consent, would be a mistake and contrary to the permanent interest of the race. If it were enforced by legislation against the wishes and convictions of a large proportion of the members of the community, I believe it would be little short of a calamity. While it would not result in the long run in the improvement of national health and efficiency, it would diminish that respect for the Law and that identification of self with the Law which are essential for the stability and welfare of a democracy.

ERNEST H. STARLING.

University College,
August, 1923.

TABLE OF CONTENTS

APPENDICES

THE ACTION OF ALCOHOL ON MAN

CHAPTER I

ON FERMENTATION AND ON FERMENTED LIQUORS

THE use by man of alcoholic drinks and of fermented liquors dates back to a time long antecedent to the beginnings of history. In all the ancient civilisations of which we have a record, the wealth of a country was measured by its production of corn, wine, and oil. The origin of these necessities of existence was ascribed to the gods. The ancient Egyptians attributed to Osiris the cultivation of the vine, and the process of the manufacture of wine as well as the manufacture of a species of beer from grain. By the Greeks and Romans the introduction of the vine was regarded as one of the beneficent acts of the Dionysiate Bacchus. Hebrew tradition ascribed to Noah the first cultivation of the vine, and the discovery of the way to make wine from the juice of the grape. Noah also is related as having indulged too freely in the wine so produced, with disastrous results to one of his grandsons. It is worth noting that, in this early legend, drunkenness is regarded as something shameful, and the sin of Ham was in discovering the shame of his father. There are still extant records showing that the Egyptians were acquainted with many varieties of wine five thousand years before Christ. Thus it was the custom from the most remote times to carve on the tombs a list of the offer-ings made to the deceased for his use in the life beyond the tomb. Among these we find almost always the mention of five kinds of wine, viz. wine of the delta, wine of Pelusis, wine of Latopolis, white wine, and red wine. The Egyptians also used as a beverage the fresh juice of grapes, squeezed by the fingers of a slave into a wine cup.

From classical writings it is possible to make a long list of the different species of vine with the characters of the grapes they bore. An enumeration of the wines thus produced would extend over seventy varieties, and the wine lore of the Ancients would be little inferior in extent to that of the present day. But it is doubtful whether many of the wines of classical times would appeal to modern palates. The Greeks were accustomed to mix sea water with their wines, either in the process of manufacture or before drinking. They added all kinds of substances which, to our tastes, would entirely destroy the flavour of the wine. Among these substances were resin (still used in Greece), pitch, myrrh, aloes, poppies, wormwood (as in the modern vermouth), cassia, chalk, etc. Moreover, the wine was exposed for some years in the fumarium to the smoke and warmth of the domestic fire, to hasten its ripening, and in many cases became so inspissated as to be quite thick when poured out. The wines were almost always drunk well diluted with water, as is the case in Italy and France (for *vin ordinaire*) at the present day.

The manufacture of wine has been co-extensive with the distribution of the grape vine and characteristic of a settled civilisation. The vine does not begin to bear till three years after planting, whereas it is possible to raise a crop of corn within a year, including the preparation of the soil. The possession of a vineyard thus became synonymous with a settled existence in one place and corresponded very much to our idea of home. It seems probable that the invention of wine is synchronous with the birth of civilisation and the living of men in settled communities. Hardly any savage tribe exists which does not make fermented liquor of one sort or another. Where the grape is not present, fruit juices or the sugary sap of plants, e.g. of the Toddy Palm, are used for this purpose. In northern countries honey from the wild bees served as the starting-point for the manufacture of mead. Among the Tartar tribes it is the sugar of milk which is made to undergo fermentation and to yield koumiss. In all these cases some form of sugary fluid serves as the raw material for the manufacture of the fermented liquor.

We know that sugar and starch are closely allied and that starch may be converted into sugar by means of many ferments occurring in plants or in moulds. This conversion also takes place under the action of the digestive juices, e.g. saliva, as well as in the normal germination of starchy grains (barley, wheat, etc.). This conversion also was known practically before the beginnings of history. The Egyptians prepared a kind of beer from germinated (malted) grain and the invention of this drink was ascribed to Osiris, who had devised it on his travels for the benefit of the less fortunate dwellers in lands where the grape would not grow. Other races used, and use, rice as the starting-point, the conversion of the starch of the rice into sugar being effected by various kinds of moulds or ferments. The saké of the Japanese is made in this way. In the case of the Guiana Indians the conversion of starch into sugar is carried out by the women of the tribe, who chew the cassava root so as to subject it to the action of their saliva, and eject the products into a large bowl where they are allowed to ferment.

Thus, from the beginning of human time almost all races of men have prepared fermented liquors and have regarded them as one of the indispensable good things of existence and as gifts from the gods. Although the perils and dangers of the drunkenness which results from the immoderate use of these liquors have also been known and have been the subject of reproof and correction by the moral leaders and teachers in every age, it is only within comparatively recent times that an opinion has been widely expressed and acted upon to the effect that the invention of fermented liquors was a false step in the progress of man, and that, in spite of the large part played by these liquors in social and religious rites throughout all ages, their use must be condemned as unreservedly bad. It is claimed that the only method of ridding ourselves of this prehistoric curse is to be found in the total prohibition by every community of the use of such liquors by its members. It will be our duty in the following pages to examine the grounds on which such an opinion is based and to see how far they justify the far-reaching conclusions which have been drawn or the drastic legislative changes which have been advocated.

Before, however, we begin this part of our task it would be well to have some more precise ideas as to what we mean by fermented liquors, how they are made, what is their composition, and what characteristics are common to all. The process of the manufacture of wine from grapes differs only in detail at the present time from that which was in vogue among the ancient Greeks. When the grapes are ripe they are plucked by hand and taken to the wine press. In some cases the pressing out of the juice is effected by tramping under foot, but more generally by means of some sort of screw press. The juice, which is called *must*, is then transferred to large vats. In the case of red wines the skins are left with the juice, but for the production of white wines the skins are removed. In a short time the process of fermentation begins. Large quantities of gas are given off from the fermenting liquid, which seems to boil (hence the name 'fermentation' from *fervere*, to boil). The gas, rising in bubbles through the liquid, at first brings a thick layer of scum to the surface. In the process of fermentation the must, consisting of the sweet juice of the grape, is converted into wine, with the disappearance of a large part of the sugar of the grape juice. After six or seven days the main fermentation comes to an end, and the young wine is transferred to casks, where a slow process of fermentation continues for some time. During this process the wine throws down a deposit which is known as the *lees* of wine. In a few months' time the wine has deposited all its suspended lees, and the clear supernatant fluid is drawn off into clean casks. This process of 'racking' is repeated several times at intervals of three or four months. After keeping for another two to four years the wine is regarded as fit for bottling.

The process of manufacture of beer is similar to that of wine in its main essentials, but in this case the starch of the grain has first to be converted into sugar. This is effected in the process of *malting*. The barley grains are spread over a floor and kept moist until they begin to germinate. In the process of germination the starch of the grain is converted into sugar. The germinated grain is then dried by heat in order to stop the process and the dried malt serves as the source of the sugar which is to undergo fermentation. The crushed malt with a mixture of grain is suspended in water and the whole mixture kept warm. Under these conditions the whole of the starch becomes converted into sugar and passes into solution in the water together with other soluble constituents of the grain. The water extract of malt is termed 'wort.' This is transferred into a fermenting vat and dried yeast and hops are added. In a few hours fermentation begins just as in the case of the grape juice. Large quantities of gas are disengaged, the temperature of the mixture rises, and the yeast, which increases in amount during the process of fermentation, is carried by the bubbles of gas to the surface so as to form a thick scum. In four or five days fermentation is complete. The evolution of gas ceases and the fluid, which is now beer, is drawn off into casks. Beer is thus a kind of barley wine flavoured with hops.

In the above brief sketch of the mode of manufacture of the two chief kinds of fermented liquor, i.e. wine and beer, I have of course omitted a number of details which are essential if the product is to be palatable and to find a ready sale.

In spite of the diversity of origin of the different kinds of fermented liquors employed by man, they have from time immemorial been recognised as presenting some features in common, which impart to them their powers of making glad the heart of man and, if taken in excess, of producing drunkenness and oblivion. It was only natural, therefore, that attempts should be made to find some method of extracting the 'spirit' common to all these liquids. Although there is evidence that the process of distillation was known imperfectly to Aristotle, it was only after improvements in the method had been carried out by the Alexandrian School that we meet with any record of the production of spirit by distillation. If either wine or beer be heated and the steam given off condensed in a still, the first parts of the distillate are found to present many of the physiological properties of wine and beer in a more potent form, and were therefore spoken of as the 'spirit of wine.' Many other names more or less fanciful have been employed to designate this active principle of wine. It was found that the distillate could be still further concentrated by rectification over dry carbonate of potash (obtained by the calcination of cream of tartar), and this strong spirit was spoken of as 'vinum alcalisatum.' The word *alcohol*, which is so familiar to us nowadays, was first applied to the glittering native sulphide of antimony, and it seems to have been by some verbal confusion that the spirit *vinum alcalisatum* was later spelt *vinum alcoholisatum* which gave place to the name *alcohol vini*. This spirit of wine was first employed principally for medical purposes, and all sorts of fanciful properties were ascribed to it. It was regarded as a sovereign remedy in almost all the disorders of the human frame, and commended for its efficacy in improving the memory and strengthening the reasoning powers. It was extolled as the elixir of life and the preservative of youth and beauty. Raymond Lulley speaks of it as "consolatio ultima corporis humani."

We thus see that the essential factor in the preparation of fermented liquors is the conversion of sugar into alcohol. Sugar disappears from the fluid and alcohol takes its place, gas being disengaged in the process. Although the phenomenon of fermentation has been known to mankind from prehistoric times as a familiar natural process, and has served as a type of any chemical changes accompanied by frothing or giving off of gas, it is only within the last century that we have attained to clear ideas on its nature. The yeast which rises to the top of the fermenting liquid was looked upon as a sort of by-product in the process. As long ago as 1680 Leeuwenhoek described the microscopic characters of yeast, but it was not until the year 1837 to 1838 that the idea seems to have occurred simultaneously to three investigators, Cagniard-Latour, Schwann, and Kützing, that this yeast is a vegetable organism which grows in sugary solutions and that alcoholic fermentation is a result of the activity of the yeast organism. This idea was hotly combatted by the chief chemists of the day, but its accuracy was finally established by the researches of Pasteur from 1887 onwards. Pasteur regarded fermentation as a physiological process dependent on the life of the yeast, and declared that alcoholic fermentation never occurs without simultaneous organisation, development, and multiplication of cells or the continued life of cells already formed. The accuracy of this statement has never been impugned. It is true that from yeast a substance can be extracted, *zymase*, which is not living and which can effect the conversion of a certain amount of sugar into alcohol, but this substance is the result of the life of the yeast organisms and is only continued to be produced so long as the yeast survives.

The Chemical Changes involved in Fermentation

The sugar of ripe grapes is what is called invert sugar, and consists of a mixture of equal parts of two simple sugars, i.e. glucose, or grape sugar, and fructose, or fruit sugar. Both these sugars have the formula $C_6H_{12}O_6$. Any form of sugar or starch must be converted into a sugar of this formula before it can be transformed into alcohol by the yeast plant. In the case of wines the yeast cells are found on the surface of the grapes themselves, and the differences between various kinds of wine are to some extent determined by the nature of the yeast occurring naturally on different types of grape. When fermentation occurs in the compound sugars, such as cane or malt sugar, which have the composition $C_{12}H_{22}O_{11}$, these are first converted by ferments present in the yeast to the simple sugars, glucose and fructose, which then undergo chemical transformation under the action of the yeast cells with the production of alcohol. The gas given off during fermentation is carbon dioxide or carbonic acid gas. This gas is familiar as the product of the action of acids on chalk or marble or of the combustion of most organic materials, and is also the chief product of oxidation in the animal body itself. Thus, the air leaving the lungs in expiration contains about 5 per cent carbon dioxide. The chemical changes involved in fermentation were at first thought to consist of a simple dissociation of the sugar into alcohol and carbon dioxide, and to be represented by the equation $C_6H_{12}O_6=2C_2H_6O+2CO_2$ Pasteur found, however, that the whole of the sugar does not undergo this particular change, but that under ordinary circumstances 5 to 6 per cent are converted into other substances, especially glycerine and succinic acid, a certain proportion being built up into the yeast cells as they increase in amount. The exact proportion of glycerine formed varies according to the conditions under which fermentation takes place. Thus it was shown by Neuberg during the war that, if a large amount of sodium bisulphite were added to the fermenting liquid, very little alcohol was produced and the process was diverted into the formation of glycerine. In this way, in spite of the shortage of fats, which in the process of soap-making serve as the ordinary source for glycerine, the Germans were able to provide themselves with as much glycerine as they required by the conversion of grape sugar. This is an exaggerated example of the influence of conditions on the ultimate products of alcoholic fermentation, but it serves to show that according to the other substances present with the sugar in the must or wort, so the final product of alcoholic fermentation will vary. Thus, in the manufacture of spirits other alcohols are formed which, together with fatty acids and ethereal salts, are classed together under the term 'fusel oil.' In wines the characteristic aroma of each kind is due to the compound ethers which are produced by the interaction of alcohol and various organic acids. These different substances however, which are contained in wines only in minute quantities, are chiefly important in determining the peculiar flavour and palatability of the final product, and do not play any large part in producing the crude physiological effects resulting from the use of wine or beer as beverages.

The widespread use of fermented drinks among civilised nations is due to their content in alcohol. It is to its undesirable effects when taken in excess that is based the present opposition to their use among large numbers of people. So far as the immediate object of this book is concerned, the question of the composition of the various fermented liquors limits itself almost entirely to the relative proportion of alcohol each contains. Pure alcohol can be obtained from any of them by a process of distillation and redistillation, the final distillation being carried out over caustic lime. When obtained in this way, alcohol forms a colourless liquid with a pleasant smell, which is easily inflammable and, mixed with air, forms an explosive mixture. It is much lighter than water, having a specific gravity of about 0·8. It has a burning taste and coagulates animal tissues by abstracting water from them. In this country it is common to give the amount of alcohol in a liquid in terms of proof spirit. This is a mixture of water and alcohol containing 49·3 per cent by weight of alcohol or 57·09 per cent by volume. Spirit 25 degrees over proof means that 100 volumes of this spirit diluted with water yield 125 volumes of proof spirit, while a spirit 25 degrees under proof means that the liquid contains in 100 volumes 75 volumes of proof spirit. We shall not use this antiquated and confusing method of reckoning in this volume, but express the amount of alcohol in a fluid according to the amount of absolute alcohol it contains either by weight or by volume. The following table shows the approximate amount of alcohol by volume contained in the ordinary alcoholic drinks. Five per cent by volume means 5 cc. in every 100 cc. and is equivalent to about 4 per cent by weight, the specific gravity of alcohol being only four-fifths of that of water.

Percentage of Absolute Alcohol in Various Beverages

	Original Gravity.	Percentage of Absolute Alcohol by Volume.
SPIRITS—		
At 25 u.p. . . .	—	42·8
At 30 u.p. . . .	—	40·0
At 35 u.p. . . .	—	37·1
At 40 u.p. . . .	—	34·3
At 50 u.p. . . .	—	28·6
WINES—		
Port	—	20
Sherry	—	17
Champagne . . .	—	12·14
French Burgundy (red) .	—	10·12
French Burgundy (white) .	—	10·12
Bordeaux (white) . .	—	9·12
Bordeaux (red) . . .	—	8·12
Hock	—	9·12
CIDER (bottled) . . .	—	3·6
BEERS—		
Pale or Bitter Ale . .	1060·2	6·4
London Stout . . .	1064·6	5·5
Light Pale Ale . . .	1042·6	4·5
Mild Ale	1037·8	3·3
Porter	1041·5	2·4
Pilsener Lager (Pre-war) .	1054·0	5·4
Munich Lager (Pre-war) .	1057·0	5·0

Since the alcohol is the one thing common to all these drinks, it is evident that in the investigation of its action our chief task will be to determine what happens to this substance when taken into the body of man, and how it affects man's functions after it has been absorbed from the alimentary canal.

Note on other Forms of Alcohol

The term alcohol has been extended by chemists to include a whole series of bodies which have a chemical composition analogous to that of the alcohol which is obtained as the result of distillation of beer and wine, and which they distinguish as ethyl alcohol. To a chemist an alcohol is a substance obtained by the substitution in a hydrocarbon of one or more atoms of hydrogen by the group OH (hydroxyl). Examples of these are :

Methyl alcohol . . .	CH_3OH
Ethyl alcohol . . .	C_2H_5OH
Propyl alcohol . . .	C_3H_7OH
Butyl alcohol . . .	C_4H_9OH
Amyl alcohol . . .	$C_5H_{11}OH$

Those which have only one OH group are distinguished as monatomic alcohols. According to the number of OH groups we may distinguish di-atomic and tri-atomic alcohols. Glycerine is an example of this last group ; its formula is $C_3H_5(OH)_3$. The higher members of the group of monatomic alcohols present two or more varieties according to the arrangement of atoms in their molecules. Thus, in addition to propyl, butyl alcohol, etc., we have iso-propyl and iso-butyl alcohols. In this series there is a gradation of qualities ; as the number of carbon atoms in them increases, the boiling-point gradually rises, and the higher members of the group would be actually solids at ordinary temperatures. There is also a gradation in their physiological properties. Thus the minimal lethal dose for cats of these various alcohols have been found to be as follows :

Methyl alcohol . .	5·0 cc. per kilo
Ethyl alcohol . .	5·0 cc. ,, ,,
Propyl alcohol . .	2·0 cc. ,, ,,
Butyl alcohol . .	0·3 cc. ,, ,,
Amyl alcohol . .	0·15 cc. ,, ,,

Their effect in producing intoxication would vary in the same proportion.

Methyl alcohol, which is the chief constituent of wood spirit (obtained by the distillation of wood), is of some importance since it is contained in methylated spirit. When pure it forms a pleasant smelling liquid, not unlike ethyl alcohol, and having the same general physiological effects as the latter. Its effects are however very deleterious, and its use as an intoxicating agent for a few weeks has led in many cases to permanent blindness, due to atrophy of the optic nerve. Propyl, butyl, and amyl alcohols occur in minute quantities in most fermented liquors. They are produced by the action of the yeast, not from the sugar, but from the nitrogenous constituents (proteins and amino-acids) of the yeast or of the liquid that is being fermented. These higher alcohols form the main constituents of *fusel oil* which is obtained in the manufacture of alcohol by distillation and is contained in small quantities in all spirits. The quantity of these higher alcohols in potable spirits is however so small, that their physiological action hardly comes into play and is altogether masked by the action of the ethyl alcohol of which they are merely an impurity. Thus, 92 litres of cognac gave in one investigation 206 grammes of fusel oil, composed as follows :

Propyl alcohol . . .	12%
Iso-butyl alcohol . .	2·9%
Amyl alcohol . . .	85%

The amount of fusel oil depends on the efficacy of the process of distillation, so that there is much less of these higher alcohols in patent still whisky than in pot still whisky.

The flavour of wines and of cognac depends almost entirely on the *esters* which are produced by the interaction of the alcohol and organic acids. They increase in amount with age—but never form more than a minute proportion of the wine or brandy ; in some analyses carried out by the *Lancet* Commission, three star brandy contained 110 parts of ester per 100,000 parts of absolute alcohol as against 97·1 parts in a one star brandy. Although, these secondary constituents of wine and other fermented liquors are of extreme importance in determining flavour and cost, their physiological effects can be neglected owing to the very minute proportions in which they are present in any of these liquors.

Among these constituents the salts, which are contained in the ash both of beer and of wine, may at times play an important part. It is well known that some wines possess marked diuretic properties, and such properties are often popularly regarded as a merit of the wine in question. It has been recently shown by Professor K. N. Moss that miners working in very hot mines, in which the profuse sweating necessitates large drafts of fluid, are liable to violent attacks of cramp. This cramp is due to the loss of salts by the sweat, which are not replaced in the water drunk, so that the men suffer from water poisoning. In the case of the miners it is not customary to take any alcoholic liquors with them into the mines, where they drink large quantities of water. When they return to the surface, beer, on account of its salt content, would be preferable to pure water as a means of quenching their thirst and replacing the lost body fluids. Perhaps better still, though not so palatable, would be water in which small quantities of salts—0·2 to 0·4 per cent—had been dissolved. The salts lost in the sweat are chiefly the chlorides of sodium and potassium, so that an appropriate salt solution would be one containing about 0·2 per cent sodium chloride (common salt), and about 0·1 per cent potassium chloride. It seems probable that the salts in beer and cider act similarly in the case of haymakers and harvesters in hot weather. Thus, under special circumstances, pure water may be actually harmful, and this harm may be avoided by making use of weak alcoholic beverages such as beer or cider. It must be noted that the advantage is not due in this case to the alcohol contained in these drinks but to their salt content. It is possible that the loss of salts in the sweat may account for the craving for salt in hot countries.

CHAPTER II

THE FATE OF ALCOHOL IN THE BODY

THE value or the reverse of the use of alcohol by a community must be judged according to its action on the behaviour of man, that is to say, on his activities on behalf of himself and of the community. Regarded objectively, behaviour is made up of movements. These may be of a gross character, as in the case of a navvy or excavator, where we may express their value to the community in foot pounds of work done; or they may consist mainly of fine movements of the hands, tongue, or face, as in the case of the skilled workman, the clerk, or the higher grades of trades and professions. Without some form of movement no activity would be possible, and in fact life would come to an end. Thus, we may regard the human body as a mechanism or machine for the production of movement. Although these movements present an almost infinite variation dependent as we say on the will of the individual, the will itself is not free. The desires of a man are determined not only by his inherited constitution but also by the rule and custom of the tribe in which he has been brought up; and all the movements which he undertakes, coarse or fine, must have as their final object either survival of the individual or service to the community in which he lives, so that they may tend to the survival of the community. The movements are those adapted to these needs; any variation from their purposive character, from their fineness of co-ordination and direction, must be in some measure detrimental to the survival of the individual or of the community of which he is a member.

In dealing with the action of alcohol or alcoholic drinks on this wonderful mechanism of man's body, it is essential to have some idea of the manner in which the body is built up and the part played in the activities of daily life by its various organs.

The framework of the machine is formed by the skeleton, by a number of rigid elastic bones attached to one another by pliable ligaments with joints at the surface of contact, thus allowing of free movements of the bones one on the other in almost any direction. The whole skeleton is clothed with a mass of flesh or muscles. These consist of fleshy bands which run from one bone to another, as in the case of the biceps of the arm, or from a bone to a soft part, as in the tongue. These muscles have the power of shortening or contracting when stimulated by electric shocks or by impulses which reach them from the central nervous system, and when they shorten they approximate their bony attachments. They thus represent the motive mechanism of the body,

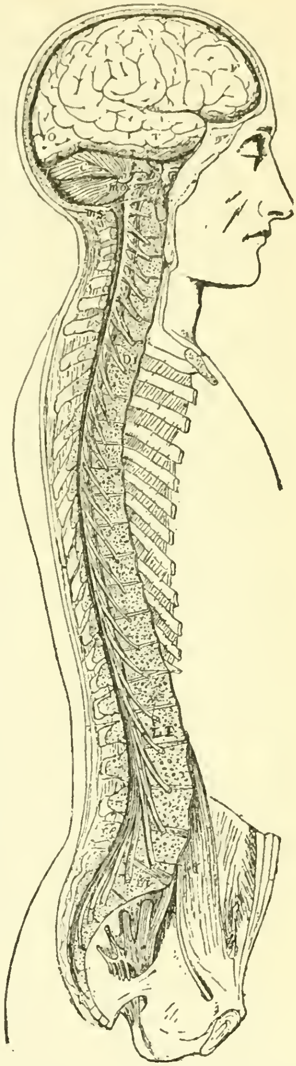

Fig. 1. View of brain and spinal cord of man. (After Bougerie.)

and there are no movements of the body which are not carried out by means of muscles. No movements occur without involving the contraction of a very large number of muscles, and the whole fineness of adjustment of a skilled movement depends on an exact balancing, or what is called co-ordination of the activity of the different muscles which are involved. This control and co-ordination of muscular movement is the function of the central nervous system, namely, the brain and the spinal cord, which for this purpose are connected by white glistening cords, the nerves, with every muscle in the body. If any of these nerves are cut, the muscles which they supply are paralysed, since no message from the central nervous system is now able to reach them. Besides the nerves to the muscles, the central nervous system receives other nerves from the surface of the body, which are called sensory or afferent nerves. Some of these nerves come from the organs of special sensation, such as the eye, ear, nose, etc. Others come from all parts of the skin, carrying sensations of pain, heat, cold, and touch, and some come even from the muscles themselves. In this way the central nervous system is made aware of or is excited by every change happening at the surface or outside the body, and the movements of the muscles which occur are determined by the nature of the impulses which arrive at the central nervous system. The dependence of movements on impressions arriving at the central nervous system from the surface of the body is illustrated by the sudden closure of the eyelid which occurs when the eyeball is touched, or the sudden drawing up of the leg when the foot is pricked. These relatively simple movements are spoken of as reflex actions; but a further consideration and analysis of the other activities of the body shows us that all are essentially of the same nature, but gradually increasing in complexity, so that the whole behaviour of man may be regarded as a series of reactions or adaptations to his environment, which proceed continuously throughout life from the very moment of conception to the death of the individual.

No movement can be effected without the necessity of overcoming some resistance, which may be only slight, as the movements of the lips, tongue, and fingers in speaking and writing, or may be very considerable, as in the movements of digging or climbing. They thus involve the expenditure of energy. Moreover, all the higher animals, birds, mammals, and man, are warm-blooded. The temperature of their bodies is kept constant at about 37° C. (98·4° F.) which under normal conditions is higher than the temperature of the surrounding air, so that there is a continual loss of heat going on from the surface of the body. The heat loss must be replaced by the production of heat in the body itself. We know that energy is neither created nor destroyed, and it is easy to show that the energy which the human body is continually discharging is obtained from a process of slow combustion or oxidation of all the tissues of the body and especially of the muscles. When a candle burns, or when we use coal for feeding the furnace of some engine, similar changes take place. Paraffin wax consists of the elements carbon and hydrogen. When a match is applied to the wick impregnated with paraffin, the paraffin is decomposed by the heat and the carbon and hydrogen combine with the oxygen of the air with the production of carbonic acid gas and of water. The changes may be expressed by the following equation: $xC + yH + O = xCO_2 + \frac{y}{2}H_2O$

If a candle be allowed to burn in a confined space, it goes out as soon as it has used up all or the greater part of the oxygen of the air, because the oxidation which produces the heat of the burning candle comes to an end. The same effect may follow the accumulation of the product of combustion, namely, carbonic acid gas. In the same way, during the whole of existence, the body is burning away slowly, and to maintain this process of slow combustion the body must be continually supplied with oxygen, i.e. with *air* containing a fifth of its bulk of this gas, and must be able to get rid of the carbon dioxide produced as the result of the oxidative changes.

The ventilating mechanism of the body is represented by the lungs. In respiration or breathing, oxygen is being continually taken into the body and carbonic acid gas discharged. If we analyse the ordinary air which is drawn into the lungs at each inspiration, we find it has the following composition: nitrogen, 79 per cent, oxygen, 20·96 per cent, carbon dioxide, 0·04 per cent. If we collect the air which is breathed out of the lungs in expiration we find it contains in round figures: nitrogen, 79 per cent, oxygen, 16·4 per cent, carbon dioxide, 4·6 per cent. Thus the air in passing in and out of the lungs has given up oxygen to the body and has taken up carbonic acid gas.

But the chief oxidative changes go on, as I have pointed out, not in the lungs but in the working tissues, namely, the muscles. It is therefore necessary that the oxygen should be carried from the lungs to the muscles, that is to say, all over the body, and the carbon dioxide returned from the muscles to the lungs in order that it may be discharged into the surrounding atmosphere. This transport of the two gases is effected by the blood, a red fluid which owes its colour to the fact that it consists of an enormous number of small red corpuscles suspended in a clear, light yellow fluid, the plasma. The red corpuscles will take up oxygen from air containing this gas and will give it up again to air which has been deprived of oxygen, changing colour in the process, the oxygenated blood being a bright scarlet colour while the blood deprived of oxygen has a purple colour. These two kinds of blood are known as arterial and venous blood respectively. The blood is carried to the tissues, such as the muscles, through a network of fine thin-walled capillary tubes, with which every tissue of the body is closely beset. In order to maintain a continual circulation of the blood between lungs and tissues, these capillaries are connected by tubes with a single pump, the heart, which is placed in the chest. The heart is a hollow organ with muscular walls and presents four cavities, the orifices of the cavities being provided with valves. When the muscular walls contract, blood is driven out of the heart; when the walls relax, blood flows into the heart; but owing to the presence of the valves the movement in and out must occur in certain definite directions. The course of the circulation is shown in the diagram.

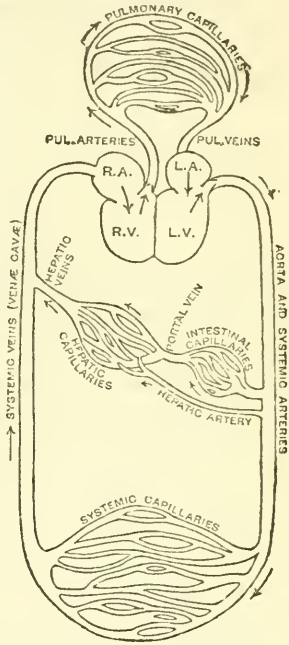

Fig. 2. Diagram showing the course of the circulation.

From the left side of the heart the blood passes by large arteries to all the tissues of the body, where it flows through the capillaries. From the capillaries the blood is collected into thin-walled tubes, the veins, which run together into two large veins entering the right side of the heart. The blood from these passes into the right ventricle and when this contracts is forced into the pulmonary artery and through the capillaries of the lungs, returning from the lungs once more to the left side of the heart.

On opening a living animal we find that the arteries going to the tissues contain bright red arterial blood; the blood leaving the tissues has lost its oxygen and contains more carbonic acid—it is termed venous blood. This passes through the heart into the lungs and in the lungs is changed once more into arterial blood. There is a corresponding difference in the gas content of arterial and venous blood. Every 100 volumes of blood contain the following amounts of gas:

	Oxygen.	Carbon Dioxide.
Arterial blood	20 volumes	38 volumes
Venous blood	8–12 ,,	46 ,,

The fact that carbon dioxide is continually passing from the tissues to the lungs and then being got rid of into the surrounding atmosphere shows that a process of slow combustion is going on in the tissues. These must therefore steadily diminish in amount, just as a candle burns away, and it is easy to show that between meals a human body is losing weight all the time. This loss of weight must be replaced unless death from starvation is to occur, and it is for this object that the animal takes food. Just like the oxygen, the food which is to replace the loss of the tissues in oxidation has to be supplied to every tissue element, and must be carried to the tissues by the blood. In order to fit the food for transfer by the blood and for utilisation by the tissues, the whole alimentary system is provided. We know that food is taken into the mouth, and if we trace it through the body we find that it passes from the mouth down the gullet into a large sac, the stomach. Both in the mouth and in the stomach it is subjected to the action of digestive juices, which break up the food and render it soluble. From the stomach the food is passed on in small quantities at a time into the small intestine, where it meets other digestive juices which carry on the process of solution. The small intestine is about thirty feet long and communicates below with the large intestine, the lower end of which opens on the surface of the body. As we trace the digested food down the small intestine we find it is getting less and less in amount. On examining the inner surface of the small intestine we see that it has a velvety appearance, each thread of the pile being a little finger-like process known as the *intestinal villus*, richly supplied with blood vessels. These villi, as they dip into the digested food, take up its dissolved constituents into the blood vessels, whence they are carried by the circulating blood all round the body, and so are available for replacing the loss of the tissues by oxidation. Only a small amount of undigested material arrives at the large intestine to be turned out of the body as *fæces*. A large organ, the *liver*, is placed on the course of the blood coming from the stomach and intestines, and this organ helps to regulate the amount of the food which gets into the general circulation and also modifies its properties, so as to keep the composition of the circulating blood constant whatever the requirements of the active tissues.

As a result of the oxidative changes in the tissues, besides carbon dioxide, other waste products are produced, which are derived especially from the nitrogenous foodstuffs contained in meat, eggs, etc. Though not gaseous they are soluble, and a special organ is provided for clearing them out of the body, namely, the *kidneys*, which form the urine, containing the soluble waste products from the activity of the tissues. These also are carried round the body from tissues to kidneys by the circulating blood.

Thus a man's body is a complex mechanism, the activities of which are all directed to the preservation of the individual or of the community of which he forms a part. The direction and co-ordination of these activities are determined by the central nervous system, while the material interdependence of all parts is rendered possible by the fact that they are all bathed by the same common fluid, the blood, which is maintained in continual circulation by the action of the heart.

In some experiments alcohol has been administered to animals by drawing the air which they breathe through alcohol, so that this substance was absorbed into the blood stream through the lungs. Although certain valuable results have been obtained in this way as to the action of alcohol, to which we shall have occasion to refer in a later chapter, we are at present mainly concerned with the fate of alcohol which is drunk, and, therefore, must enter the body by way of the alimentary canal, since this is the ordinary method in which it is taken by man. As the alcohol passes rapidly through the mouth and gullet no appreciable amount of absorption occurs before it reaches the stomach. Alcohol is not altered by any of the digestive juices. On the other hand, it disappears from the alimentary canal, so that it must be taken up by the blood circulating through the capillaries in the wall of the canal. Ordinary food, when taken into the stomach, undergoes, as we have said, digestion, a process of solution, and is mixed with the gastric juice poured out from a number of fine pits or glands on the inner surface of the stomach. No absorption takes place in the stomach either of water or of the products of digestion of ordinary foods, so that if there is an obstruction to the passage of the stomach contents into the small intestine, the stomach, after a time, contains a greater amount of fluid than has entered it from the mouth, the bulk of the food being added to by that of the gastric juice which has been secreted. If the lower opening of the stomach is obstructed the patient will die of thirst, since however much water he drinks it will only serve to distend the stomach more.

Alcohol differs from all the other constituents of a meal in that it is absorbed to a certain extent by the stomach itself. When taken on an empty stomach, as much as 40 per cent of the alcohol may disappear from the stomach. In most cases the greater part will pass on into the small intestine, and here it is rapidly taken up by the villi and enters the blood stream. The time taken for all the alcohol to be absorbed into the blood will vary according to the conditions of administration. When taken in strong solution on an empty stomach the whole of it may be absorbed within half an hour. If given with food, or much diluted, absorption occurs more slowly, but will in every case be complete within two and a half hours.

It is easy to show that the alcohol reaches the blood unchanged. If blood be drawn from the veins of an animal, half an hour after the administration of a considerable dose of alcohol, and be subjected to distillation, alcohol is found in the distillate, and this method is employed for determining the amount of alcohol in the blood at any time after administration.

Thus alcohol undergoes no changes either in digestion or absorption, but is taken up into the blood unaltered. In this respect it differs from most of the foods, but not all. For instance, if grape sugar be taken with the food it is absorbed into the blood without change. There is, however, one important difference between the absorption of grape sugar and that of alcohol. The organism has means of maintaining the concentration of grape sugar in the blood at a constant low level (from ·08 per cent to ·14 per cent), and the amount of this substance in the blood does not increase beyond these limits, even when 50 or 100 grammes of grape sugar are given by the mouth. After a considerable dose of grape sugar, the liver takes up the excess of this substance from the blood and turns it into an inert substance, namely, animal starch or glycogen, which is stored up in the liver cells to be let out gradually into the blood as sugar, in accordance with the requirements of the body. No such mechanism exists for alcohol, so that the amount of this substance in the blood increases with the dose and with the rate of absorption from the alimentary canal. But it does not all remain in the blood. Alcohol is extremely diffusible and passes with ease through all animal membranes. The amount we find in the blood therefore does not represent the whole of the alcohol that has been absorbed. As it is taken up by the blood from the alimentary canal it passes out into all the other tissues of the body, over which it is almost equally distributed, so that the concentration in the blood at any given time may be taken as a rough expression of the concentration of alcohol in the tissues and fluids of the body generally. According to Gréhant, the percentage amount of alcohol in the blood after absorption of a strong dose of this substance can be reckoned simply by knowing the amount of alcohol administered and the weight of the animal. Thus, an animal weighing 10 kilogrammes which has just absorbed 50 cc. of alcohol (a very large dose) would contain 0·5 per cent of this substance if distributed over the whole body, and according to Gréhant this is the amount which is found in the blood. Mellanby found that the percentage in the blood after large doses may be rather higher than would be calculated in this way. This however is only what one would expect, since the penetration of alcohol into the hard tissues, such as the bones, would be probably much less than into the soft and more fluid tissues, so that the weight of the bony skeleton, or part of it at any rate, would have to be subtracted from the total weight of the body in determining the percentage of alcohol in the body generally. The last named observer has recently carried out a number of careful experiments on the amount of alcohol in the blood after its administration by the mouth. The following table represents the results of administering a single dose of alcohol diluted with water to a dog weighing 13 kgms., and the results are represented graphically in the adjacent figure (Fig. 3).

Amount of alcohol taken cc.	Maximum concentration in blood. Gm. per 100 gms. blood.	Time after taking alcohol.	Alcohol in blood at maximum point per 10 cc. of alcohol drunk.
55	0·464	2 hours	84 mgm.
50	0·445	1 hour	89 ,,
30	0·265	1½ ,,	88 ,,
20	0·153	1¼ ,,	77 ,,

It must be remembered in judging of these results that the doses of alcohol are very large compared with those ordinarily taken by man. Thus, 55 cc. of absolute alcohol corresponds nearly to 100 cc. of proof spirit, and would be equivalent therefore for a man weighing 65 kilos. (an average weight) to 500 cc. of proof spirit, i.e. about three-quarters of a bottle of undiluted brandy or whisky (pre-war).

Mellanby has made actual determinations on man of the distribution of alcohol in the blood after the ingestion of a large dose. In Fig. 4 are given the results of three such experiments; the man weighed 70 kilos. and took on each occasion whisky containing 171 cc.

of absolute alcohol. As might be supposed, this large dose produced intoxication.

We see from the curves that the amount of alcohol in the blood rapidly rises to a maximum, the maximum being attained within one or two hours after the administration

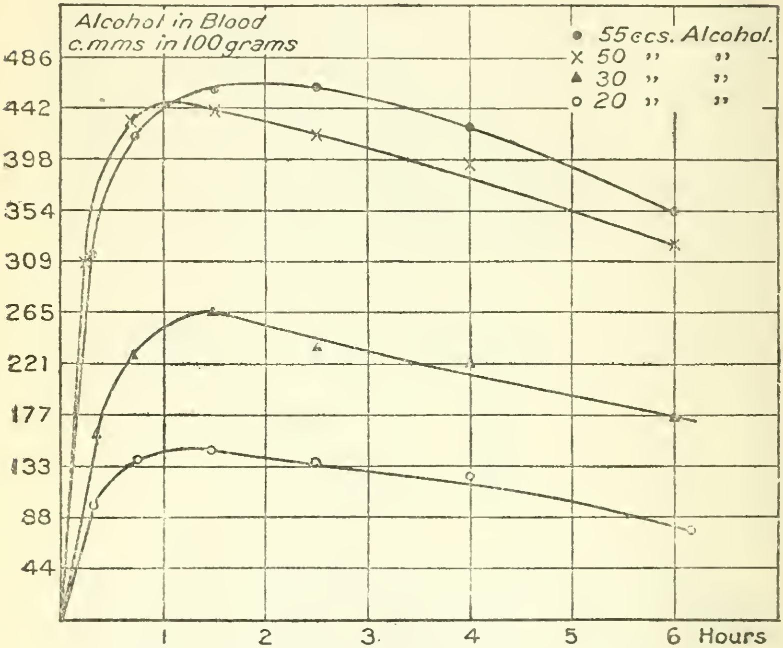

Fig. 3. Diagram showing the concentration of alcohol in the blood of a dog which was given on different days 55, 50, 30 and 20 cc. of alcohol in a 20 per cent solution. Note that in spite of the difference of amount in the blood the alcohol in every case disappears at the same rate. (Mellanby.)

of the alcohol. With large doses the amount in the blood at its maximum is proportional to the amount taken.

With smaller doses the concentration of alcohol in the blood is rather less than would be expected if this relationship held. After the attainment of this maximum the amount of alcohol in the blood slowly diminishes, the rate of diminution being the same whether small or large doses have been given. The fact that the rate of disappearance is the same is shown by the parallelism of the descending part of the curves. Thus after a large dose, some alcohol may still persist in the blood at the end of nineteen hours, and if a second dose be given, the maximum amount in the blood rises higher than after the first dose, the difference being determined by the small amount remaining from the first dose. Mellanby points out that this slow disappearance of alcohol from the blood explains why it is possible to produce intoxication by a second drink of an alcoholic beverage which, had it been the first drink, would have had no such effect, although the interval between the drinks may have been some hours. He also ascribes to this slow disappearance the feeling of ill-health on the morning following over-indulgence in alcohol, and the gradual improvement as the day progresses and the alcohol is cleared out of the body.

How can we explain this disappearance of alcohol from the blood? It is not due to the fact that the alcohol is leaving the blood, because, as we have already seen, the amount in the blood is an expression of the amount in the tissues generally. Nor is it due to the excretion of this substance by the lungs or kidneys. It is quite true that after a large dose of alcohol traces of this substance can be found in the expired air and also in the urine secreted by the kidneys. But the relative amounts lost in this way are quite small. It has been estimated that after moderate doses two per cent of the total amount taken into the body may be lost by the kidneys and lungs. The quantities excreted may be increased when very large doses are administered, but under no circumstances would the amount leaving the body unchanged exceed 10 per cent of the total quantity taken in.

It can be shown that the disappearance of alcohol from the blood and from the tissues generally is due to the fact that it undergoes complete combustion or oxidation in the tissues, just as happens to the fat or sugar of the food. The final products of the oxidation of alcohol are carbonic acid gas and water, and it is in these forms that the greater part of the alcohol leaves the body. This can be demonstrated by a careful measurement of the respiratory exchanges of an animal or man, and by comparing the amount of oxygen which is absorbed by the body with the amount of carbonic acid gas which is given off. The relation of these two amounts to one another will vary according to the food which is undergoing oxidation in the body. Thus, if sugar or starch is the sole substance which is being oxidised in the body, one volume of oxygen taken in will give rise to one volume of carbonic acid which is excreted. In the case of fats, one volume of oxygen taken into the body will produce ·707 volume of carbonic acid to be expired. If alcohol were burnt up the relation of carbonic acid to oxygen, generally spoken of as the 'respiratory quotient,' would be ·667, i.e. even less than that observed on a pure diet of fats.

When alcohol is administered to an animal at rest the respiratory quotient drops, showing that the alcohol is undergoing oxidation alongside of the ordinary food-stuffs or constituents of the tissues. The disappearance of alcohol from the blood is therefore a measure of the rate of its oxidation. In the dog from which the diagrams have been taken oxidation went on at the rate of ·185 cc. per kilogramme weight per hour, and was not altered by altering the total dose given. The bigger the dose, the longer was the time necessary for the complete elimination of this substance from the body and from the blood.

In Mellanby's experiments on man it can be calculated from the curves that 10 cc. of alcohol per hour underwent oxidation. This rate of oxidation would produce 54 calories of heat per hour, or at the rate of 1300 calories in the 24 hours. This would amount roughly to about 40 per cent of the total energy production in the day.

Mellanby has also studied the conditions which affect the rate of absorption of alcohol from the alimentary canal. He finds, in the first place, that alcohol is absorbed more slowly into the blood, and therefore attains a somewhat lower maximum concentration, when it is given in a 5 per cent strength, corresponding to stout or bitter ale, than when it is given in a 20 per cent strength. The relative rates of absorption of alcohol from different beverages are not, however, determined entirely by their percentage strengths in alcohol. Thus, the absorption of stout containing 5·5 per cent alcohol occurred more slowly than that of whisky diluted to the same alcoholic strength. This difference is probably due to the large proportion of other substances of a nutritive character present in stout and beer, since a very marked difference was found to be caused in the rate of absorption by the administration of alcohol with food. This was marked whatever the nature of the food, but was especially pronounced when milk was given, and the figure (Fig. 4) shows the effect of giving the same dose of alcohol in water, in separated milk, or in whole milk.

In the experiments on man the administration of the whisky with a pint of milk, or two hours after taking a pint of milk, not only slowed the rise of the concentration of alcohol in the blood, but diminished the maximum concentration attained (Fig. 4). In this case the slowing effect of milk on the absorption of alcohol and the smaller concentration in the blood was evidenced also by the diminution in the symptoms of intoxication produced by the large dose.

The slow absorption of alcohol under these conditions is due to the fact that it pervades the food in the stomach or in the intestine, and therefore does not come at once

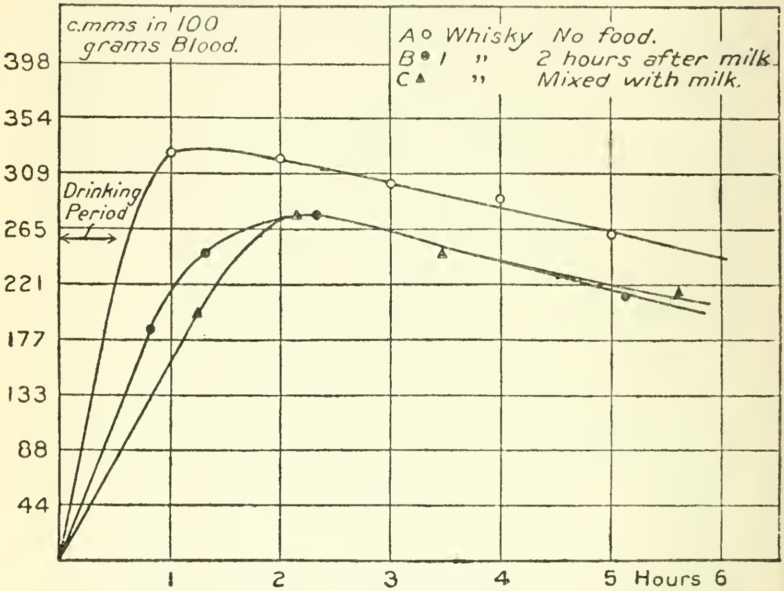

Fig. 4. Diagram showing the concentration of alcohol in the blood of a man who, on three occasions drank whisky containing 171 cc. of absolute alcohol: (*a*) on an empty stomach; (*b*) two hours after taking a pint of milk; and (*c*) diluted with one pint of milk. The rate of disappearance of alcohol from the blood indicates an oxidation of about 10 cc. of absolute alcohol per hour. (Mellanby.)

into contact with the absorbing surface of the gut. The fat of the milk having a special affinity for the alcohol is especially efficacious in this effect. Thirst was not found to increase the rate of absorption, in fact, a previous dose of water so as to relieve thirst made the absorption of alcohol more rapid.

We may sum up the results arrived at in this chapter as follows.

1. Alcohol taken into the stomach is rapidly absorbed both from this cavity and from the small intestine, absorption being complete in from half an hour to two hours.

2. Absorption takes place into the blood stream, by which it is carried to all parts of the body and is more or less evenly distributed throughout.

3. The alcohol undergoes no change, either under the action of the digestive juices or in the process of absorption. The amount in the blood and tissues, after absorption is complete, therefore varies with the size of dose which has been taken.

4. The rate of absorption is more rapid when the alcohol is administered in strong solution and on an empty stomach. It is slowed by dilution of the alcohol and by its administration along with or shortly after food. Milk is especially efficacious in slowing its absorption.

5. The alcohol, after attaining its maximum concentration, gradually diminishes in amount. The rate of diminution is not altered by increasing the dose, so that the bigger the dose the longer is the time necessary to free the body entirely from alcohol.

6. Only a very small proportion of the alcohol is excreted by the breath and kidneys unchanged. This may amount, for small doses, to 2 per cent of the total alcohol taken, and never exceeds 10 per cent.

7. The disappearance of alcohol from the blood is due to its complete oxidation in the tissues. In one of Mellanby's experiments, after the administration of 50 cc. of alcohol to a dog, oxidation took place at the rate of 2·5 cc. of alcohol per hour. In an experiment on a man of 70 kilos. Mellanby found that, after the

administration of 170 cc. in the form of whisky, 10 cc. of alcohol were oxidised each hour, so that it would require 17 hours to free his body from a dose of this size (170 cc. absolute alcohol would be equivalent to about three-quarters of a pint of undiluted whisky).

CHAPTER III

FOODS, DRUGS, AND POISONS

ALCOHOL has been variously designated as a food, drug, or poison. It is quite legitimate to describe its action on the organism under these three headings, provided only that we have a perfectly clear idea as to what we mean by the terms we employ, and do not use one or other of these headings by way of extolling the virtues or denouncing the disadvantages of the consumption of alcohol by man. I propose in this chapter to discuss the meaning and scope of these three terms from the standpoint of our present physiological knowledge.

Foods

Most definitions presuppose so much knowledge of the thing we are defining that it is simpler to dispense with a definition and proceed to a description. We have to enquire what are the qualities and actions of the substances which all would be agreed in designating as food, even in the absence of accurate knowledge on the subject. We have seen that if a man is deprived of food he loses weight continuously. His tissues waste away because they are undergoing oxidation and serving as a source of the energy which he is giving off either as heat or as work. He loses weight chiefly in the form of the gaseous carbon dioxide which he expires, and in the form of water which he loses by the skin or, together with dissolved substances, in the urine. In order to maintain life, this continual loss of weight is made good by taking food into the alimentary canal at definite intervals. Loss of weight affects different parts of the body unequally. The body itself possesses stores of food contained in the living cells of different parts. These stores are of two kinds, namely, a starchy substance, animal starch or glycogen, and fat. Glycogen is found in limited quantities in the liver cells and the muscle cells of a well-nourished animal, and in minute traces in most living tissues. Fat is the chief constituent of the adipose tissue forming a layer under the skin, and enveloping many of the internal organs. When a man increases his energy loss in consequence of exposure to cold or by taking severe exercise, the chief drain is on the store tissues, namely, the animal starch or glycogen, and the fat, the glycogen being used up more readily than the fat. There is always a certain wear and tear, or wasting, of the working tissues of the body; but these are spared as much as possible, and it is only when the amount of stored material is deficient that the working tissues are drawn upon to any large extent. The use of the food being to replace the material losses of the body, we may regard its function also as two-fold, namely, to be used directly in furnishing energy to the working tissues, any excess serving to replenish the store material, and to replace the waste of the working tissues themselves. So that we can form a rough subdivision of the foods into those which have as their main function the supply of energy to the body, and those which are chiefly destined to repair the wear and tear of the working parts of the machine.

When we analyse the multifarious constituents of our food, we find that all food is made up of representatives of five classes of substances, which are called foodstuffs. These are as follows:

(1) *Carbohydrates* or starchy substances. These include starch, dextrin, cane sugar, milk sugar, malt sugar, grape sugar, and fruit sugar. They are all finally brought by the process of digestion into the form of grape sugar or glucose, or some closely allied sugar, and it is in this form that they are absorbed from the alimentary canal and travel round in the blood to the tissues.

(2) *Fats*. These include all the fats and oils, including butter and cream. They are combinations of fatty acids with glycerine. Both these classes contain carbon, hydrogen, and oxygen.

(3) *Proteins*. These are the chief constituents of white of egg, of flesh or meat, and occur also in milk, which indeed contains representatives of all the five classes. Proteins differ from the two classes just named in containing nitrogen and a little sulphur as essential ingredients, so that when burned they give off ammonia and produce an odour of burnt feathers. Proteins form the main constituents of the working tissues of the body, and are therefore the chief substances found in muscles. We eat muscular tissue in the form of meat.

(4) *Salts*. These occur in all our foods, though it is usual to add a certain amount of common salt, or sodium chloride, by way of a condiment. They include chlorides, phosphates, and sulphates of sodium, potassium, calcium, and magnesium.

(5) *Water*. Water forms almost three-quarters of the weight of the human body and its presence is necessary for the occurrence of all vital processes.

These last two classes differ from the first three in that they furnish no energy to the body. They are essential constituents of the tissues and in the growing animal have to be stored up as part of the body. They are being continually lost by the respiration, the sweat, and the urine, and therefore in the adult, when growth has come to an end, a sufficient amount of both salts and water must be supplied to replace loss. Although the quantity of salts given may vary within wide limits, too much and too little are both bad. Thus the growing animal cannot form its bones without an adequate supply of calcium salts, since these are the most important constituent of bone. Complete deprivation of salts will kill an animal rather more quickly than would complete starvation, and we know that in the same way an animal dies rapidly if entirely deprived of water.

On the other hand, carbohydrates, fats, and proteins are all sources of energy. If dried, they could be burned in a furnace of a boiler and used to drive a steam-engine. We can in fact measure their value to the body by finding out how much heat they produce when completely burned. The unit of heat is a Calorie, which is the amount of heat required to raise the temperature of a kilogramme of water one degree Centigrade, and we are accustomed to express the value of a food in terms of Calories. Thus an average man in the course of a day takes from two to three thousand Calories in his food, while a man engaged in strenuous work, such as a navvy, may require food with a Calorie value of four to five thousand. Although all can be used as sources of energy to the body, they are not all equally useful for purposes of repair ; while the fats and carbohydrates serve to make good the store depots, proteins are necessary to replace the losses of the working tissues by wear and tear. All these foodstuffs are more or less modified in digestion. As we have seen, the starchy foods are converted into grape sugar and absorbed in this form. If given in excess of the instant requirements of the body, part of the excess is stored up in the liver and muscles as glycogen, the rest undergoing a chemical conversion into fat and adding to the fat depots of the body. In the fattening of animals for food purposes, it is starchy foods or carbohydrates which are chiefly employed, since they are the cheapest of the three classes of foodstuffs.

Fats undergo but little change in digestion, the changes being limited to those that will fit them for traversing the wall of the gut. When they get into the circulation they are in the form of very fine globules of fat which are carried by the blood round to all the tissues of the body.

Proteins undergo a very profound change in digestion. Every working cell of the body possesses its own specific constitution, so that it is necessary to take each protein molecule contained in the food entirely to pieces, in order that its constituent parts may be absorbed into the blood and presented to the cells of the body, each cell selecting those parts of the molecule which are necessary to build up the distinctive protein of the cell in question. Not only does protein differ in this respect from fats and carbohydrates, but it cannot be stored up to any considerable extent. The muscles for instance may be made to grow by exercise, but unless they have been diminished by previous starvation we cannot produce increased muscle by adding to the meat supplied in the food. Without this profound disintegration of the nitrogenous foodstuffs, they would act as poisons to the body. Thus, an injection of egg albumen into the blood stream may produce symptoms of shock, and if a very minute quantity be injected a fortnight or three weeks after a previous injection the shock may be so profound that the animal is killed.

When a man is deprived of food, he loses weight, the loss consisting partly of water and salts, partly of the energy-giving constituents of his tissues. The first to go is the starch store, the store of glycogen in the liver and muscles, then there is a gradual diminution of the fat, but all the time there is some loss of weight also of the working tissues of the body. The effect of giving food in the right proportions is to stop this loss of weight, and any excess of food over that required to make good the loss and to meet the energy expenditure of the body is laid down as glycogen and fat in the body. The administration of food has however a further effect. When an animal is starved it proceeds as economically as possible in the discharge of energy, and we can measure the rate of discharge of energy by measuring the heat loss of the body. This heat loss represents the amount of oxidation which is going on in the tissues themselves. When we give food, we not only stop the loss of weight, but we remove the necessity for economy, and so we find that there is a gradual increase in the rate at which oxidation is occurring. We can speak of this as a stimulating effect of food on metabolism, metabolism being the sum of the chemical changes continually going on in the body. This stimulating action is only slight in the case of the carbohydrates and fats. Administration of either of these to a starving animal will only increase the oxidative changes, i.e. the rate of metabolism, by 10 to 20 per cent. With proteins the stimulating effect is very marked, and the rate of oxidation of the body may be increased 30 or 40 per cent after a big protein meal.

During starvation the body is always losing nitrogen, pointing to a continual disintegration of the proteins of its working tissues. If carbohydrates (starch or sugar) be given to a starving animal, we find that the loss of nitrogen is markedly diminished. This is expressed by saying that carbohydrates have a sparing effect on the proteins of the body, i.e. on the working tissues.

We thus see that a number of ideas are bound up in our conception of a food. A food furnishes energy to the body which can be used for the production of heat or for muscular work. A food prevents loss of weight, either by making up the energy store depots of the body (carbohydrates and fats), by replacing the loss of the working tissues (protein), or by diminishing the call on the working tissues (sparing effect of carbohydrates). We shall have to enquire later how far alcohol corresponds with the idea of food to which we have just endeavoured to give some precision.

Drugs

A drug has been defined as "a substance which temporarily modifies the activity of the bodily organs . . . otherwise than by increasing the supply of available energy." We may adopt this definition if we include in the term "activity of the bodily organs" their powers of growth and repair, which we may term the nutritional activities, since the maintained structure of the cell is a necessary condition of its function. It is true that a drug may be of use in disease by reason of its deleterious effect on the micro-organism which is the cause of the disease, but even in this case we can say that the drug affects the activities of the bodily organs, its destructive influence on the infective agent being the means by which it modifies in the right direction the activity of the bodily organs depressed by the disease. A drug will as a rule act only so long as it is present in the body unchanged. Its action will therefore cease when it has been destroyed or oxidised in the body, or when it has been removed from the body by the excretory action of the lungs or kidneys. Some drugs may be altered by the processes of digestion themselves. In this case it is impossible or inefficacious to administer the drugs by the mouth ; in order that their full activity may be displayed they must be introduced into the body by injection under the skin or directly into the blood stream through a vein.

As an example of a drug we may take nitrous oxide, the ordinary laughing-gas. This is administered in the form of gas by a mask; the patient breathes in nitrous oxide instead of air, and the lungs become filled with the gas, which is rapidly absorbed into the blood. As soon as the concentration of the gas in the blood attains a certain degree, the functions of the brain are affected, and after a preliminary period of excitation the patient loses consciousness. When this occurs, the mask is removed, the short operation, such as tooth extraction, carried out, and the patient gradually comes round as he excretes the gas from his blood into the lungs and so gets rid of it with the expired air. The same sort of effect may be produced by the inhalation of the vapour of ether, but this is less volatile than nitrous oxide and remains longer in the blood, so that its effects may be prolonged. When the administration is stopped, the patient gradually gets rid of the ether, partly by excretion with the breath, partly in all probability by oxidation. When the percentage of ether in the blood falls below a certain small amount, the patient recovers consciousness. After a prolonged operation, when all the tissues are thoroughly saturated with ether, it may take a considerable time, even hours, for the patient to recover consciousness.

In these two cases we are using the drug to produce an abnormal condition in the patient, namely, one of loss of consciousness and of sensation. In other cases drugs are administered to restore a function which is deficient. Thus we may give a purgative when the normal action of the bowels does not take place, or we may administer an antipyretic to diminish the high temperature of fever. We cannot however say that a drug is only required by the body in disease or in order to bring about some abnormal condition such as unconsciousness, which may be of indirect advantage to the patient. Among the most striking achievements of recent physiological research is the demonstration that drugs, in the sense of the definition we have adopted above, play an important part in nearly all the normal functions of the body and are also essential constituents of the food of the healthy individual. It seems probable that almost every organ in the body produces, as a result of its activity, substances which may act as drugs in influencing the activity of other organs, to which these substances are transported by the blood. This means is employed by the organism for the correlation of the activities of its different parts. Thus, when the products of digestion in the stomach pass into the small intestine, there is immediately produced a secretion of a digestive juice from the pancreas. This was formerly regarded as a reflex action carried out by the central nervous system, but it has been shown that the secretion of pancreatic juice occurs even when this gland is entirely cut off from the central nervous system. The message from the intestine to the gland is in fact carried by the blood. As the acid gastric contents pass into the intestine, they act on its mucous lining and produce a substance known as *secretin*. This is absorbed into the blood, travels all round the body, and so reaches the pancreas. As soon as this occurs the pancreas begins to secrete its digestive juice. Secretin acts thus on the pancreas in a manner very similar to that of pilocarpine, a drug sometimes employed in medicine. In the same way the suprarenal glands, small organs lying just above the kidneys, in conditions of emotional stress, fright, etc., pour out a substance into the blood stream called adrenaline. This is carried by the blood to all the organs of the body. It excites the heart to increased action, it raises the blood pressure by contracting the small blood vessels, and causes the liver to pour sugar into the blood so as to provide food for the muscles in the efforts of the animal to escape or to defend itself from danger. Embedded in the pancreas we find little islets of a peculiar tissue whose main function appears to be the formation of a substance which has not yet been isolated in a pure form, but to which the name 'insulin' has been given. Normally this is poured into the blood stream in very minute quantities. It appears to be necessary to the cells of the body if these are to utilise properly the sugar always present in the circulating blood. When the islets are removed or destroyed by disease, the body loses its power, to a large extent, of dealing with sugar and the animal or man suffers from diabetes.

These chemical, drug-like substances which are produced in the body and are necessary to the normal functioning of its different parts, are called *hormones*, from a Greek word signifying *excite*. They are substances which excite changes in the growth or activity of the cells on which they act. All the three hormones which I have just mentioned are easily destroyed by oxidation or under the influence of digestion, and their effect is therefore minimal or absent when administered by the mouth. Another example of this type of substance is produced by the thyroid gland. It has been isolated from the gland in a crystalline form and has been given the name of iodothyrin. Its presence in the blood is necessary for the normal growth, and therefore for the development, of almost all the tissues of the body. If the thyroid be removed or destroyed by disease, the patient becomes affected after some months with a disease known as myxœdema, characterised by falling off of hair, thickening of the subcutaneous tissues, and slowing of all the mental processes, as well as of all the chemical changes of the body. If the gland atrophies in early life, growth ceases, and since the cessation of growth affects also the brain, the child becomes a cretin, i.e. an idiot. All these results of absence or removal of the thyroid gland can be abolished by administering either the dried gland itself, or the iodothyrin extracted from it, by the mouth.

It seems that other members of the same class of substances are involved in the wonderful correlation which occurs between the activity and growth of different organs of the body in response to growth and changes in the sexual organs. Thus the secondary sexual characteristics —those differences which distinguish a man from a woman —are determined by chemical substances produced in the sexual glands themselves, testis or ovary, and carried from these glands to all parts of the body by the blood. In the same way the growth of the breasts during pregnancy is due to hormones produced either in the body of the developing child or in the sexual organs of the mother.

We have been accustomed to regard interference with the bodily functions by the administration of drugs as an invention of man, but we see that man is in this case only using a mechanism which has existed from the very beginnings of life, and that the different elements of the cell community which make up the body accomplish their unity with and their mutual dependence on all other parts of the body by this same mechanism, namely, the discharge of drugs into the blood stream.

Recent investigation has shown that drug-like bodies are also a necessary constituent of the food of man. The division of our food into the five classes of food-stuffs only takes account of the material balance-sheet of the body, and the measurement of the amount of fats, carbohydrates and proteins which are oxidised tells us only of the energy available. We can however feed an animal on a well-balanced mixture of these five classes and yet fail to maintain it in health or to produce growth. It is necessary, if health and growth are to be maintained, that the food contain also minute traces of substances called *vitamins*, which appear to take no part in the energy changes of the body, but which are essential if the processes of growth and repair are to be normally carried out. At present three of these vitamins have been distinguished by their effects, although they have not been isolated. They are most easily described by observing the results of their absence from the diet. One of them, contained in the husk of food grains, in eggs, and meat, is necessary if the man is not to be afflicted with the disease known as beri-beri. Another, contained in most fresh vegetables and fruits, prevents the onset of scurvy. Still a third, contained also in green vegetables and in the fat and milk of animals fed on green vegetables, is essential for growth to occur. Young animals deprived of it are liable to be affected with rickets.

It is remarkable that man has not apparently developed any instinctive sense of the presence or absence of these substances in the food. Under natural conditions they are so widely distributed in the various food substances available that it is impossible to avoid taking them in with the food. But they are all easily oxidised or destroyed by heat, and modern methods of preparation of food may produce a dietary sufficient so far as its energy value and the proportions of the different foodstuffs are concerned, but from which all vitamins have been removed or destroyed. Such a diet would be one of white bread, margarine, dried vegetables, and tinned meat or bacon.

In view of the universal utilisation of drug-like bodies in the normal economy of the body and in the food, it is hardly surprising that mankind, even in savage conditions, in his search for substances in the world around which may serve him as food, has added considerably to the dispensary already present in his body and in the ordinary articles of diet. Thus, he has appropriated to his use a great variety of condiments which may give savour to his food and excite appetite, stimulating in this way all the processes of digestion. All these condiments are used in relatively small amounts; some of them in larger amounts may be very poisonous; for instance, death may be produced by eating a whole nutmeg. They have also found herbs which when infused and drunk have remedial effects, which remove or mitigate fatigue, or increase the sense of comfort and pleasure in their surroundings. Among these are the herbs which contain alkaloids, such as tea, cocoa, coffee, and coca, which act in small quantities chiefly as excitants or stimulants, tobacco acting as a sedative, opium, Indian hemp, and others, which act as narcotics. All these substances may produce deleterious effects when taken in excess. The limits for their employment are set by custom, and by a process of education of tastes and desires founded on the past experience of the tribe or race.

Poisons

A poison may be defined as a substance which so greatly interferes with the normal working of the bodily functions that it produces illness, or endangers life. It has also been defined as "one which can never do any good and always does harm." This second definition is however obviously incorrect, since there is hardly any substance which, under appropriate conditions, or in adequate doses, will not act as a poison. The poisonous action may be due to its local corrosive or destructive action on the tissues to which it is directly applied, e.g. the skin or the lining membrane of stomach, or it may occur only after absorption into the blood. In both cases its action may be acute or chronic. Thus, one large dose of arsenic may produce death within a few days, or severe illness may be occasioned by its repeated administration over long periods of time in small doses. Arsenic in fact is an excellent example of the necessity of qualifying our definition of a substance as a poison. It is true that relatively small doses will destroy life and that minute doses over long periods of time may produce illness, but the same small doses administered medicinally for some weeks may produce good effects on the body and help in the cure of disease.

I have shown earlier that even the ordinary foodstuffs may act as poisons if improperly administered, e.g. by subcutaneous or intravenous injection; most of the proteins would indeed act in this way. But in the normal individual food is only taken by the mouth and undergoes changes in the alimentary canal before it reaches the blood stream, and by these changes it is robbed of any of its poisonous qualities. Among the ordinary foods, grape sugar and its allied sugars are the only ones which undergo no changes in digestion and reach the blood stream unchanged. In this case the body is provided with an organ, the liver, which catches any excess of the sugar which would otherwise get into the blood, and stores it up in the form of glycogen or animal starch. In diabetes this power of the liver is seriously affected, and then we find that even ordinary sugar and the foods which may give rise to sugar in the intestines act as poisons if given in any but minimal quantities. Most of the salts of the food are absorbed into the blood unchanged. If administered in excess they are rapidly excreted by the kidneys, so as to keep the amount in the blood at its normal height. Without such a mechanism any excess in the diet would tend to produce symptoms of poisoning. A comparatively small dose of potash salts, if given directly into the blood stream, will kill an animal by stoppage of the heart, but large doses can be given by the mouth without evil effects. If they are given in too concentrated a condition, they may produce injury or destruction of the lining membrane of the stomach, but as a rule the sense of taste serves as a criterion for the amount taken and prevents therefore any considerable overdose of these substances. Hydrochloric acid is a normal constituent of the gastric juice. As this juice is secreted by the walls of the stomach it contains ·4 to ·6 per cent of the pure acid, i.e. about 1·5 per cent of the strong aqueous solution of the acid known as spirits of salts. Dilute solutions of hydrochloric acid are often administered where the secretion of this acid by the walls of the stomach is deficient or absent. If however the strong acid were administered in the form of spirits of salts, it would destroy the mucous membrane of the mouth, gullet, and stomach by its direct corrosive effect, and so act as a poison. The drug-like substances, which we have called hormones, produced in the body and a necessary condition of its health, may also act as poisons if produced in too large quantities. Thus, the administration of too large doses of the active principle of the thyroid gland may give rise to many of the symptoms of Graves' disease or exophthalmic goitre, and cases have been even recorded of death being caused by its excessive use. Graves' disease itself is due to an overgrowth of the thyroid gland and the production of more active principle than is required for the normal functioning of the other tissues of the body. The same thing applies to those substances which have been adopted or invented by man to improve the flavour of the food or to increase his powers of work, diminish his sense of fatigue, and improve his feeling of well-being. Thus, caffeine, the essential principle of tea and coffee, if taken in excess, gives rise to sleeplessness and irritability, and in excessive doses administered intravenously may act like strychnine in producing convulsions and death. So when we have occasion to deal with the poisonous or deleterious effects of alcohol, we are speaking of properties which it shares with a number of other substances normally present in the body or employed by man during many ages as constituents of the diet. There are always means for the protection of man against such poisonous effects. In the case of the foodstuffs the protective mechanisms are provided by the ordinary processes of digestion and absorption, aided by the sense of taste, deleterious matters, or substances such as salts in too great concentration usually being unpleasant to the taste. In some cases the criterion of taste is not sufficient, and then avoidance of a poisonous substance or of excess in its use becomes a question of education, which itself is the result of racial experience. In man living in communities such racial experience becomes expressed, with more or less distortion, in social sanctions and usages, or even in the tenets of religion. Sufficient individual control to conform to these sanctions and to subject immediate desires to the requirements of the tribe, as represented by its customs and laws, becomes therefore a question of the fitness of the individual for survival as a member of the community.

CHAPTER IV

ALCOHOL AS A FOOD

WHEN alcohol is drunk it is rapidly absorbed from the alimentary canal, passes into the blood and tissues, and undergoes oxidation, so that it disappears gradually from the body. With moderate doses 98 per cent of the alcohol ingested disappears in this way, only 2 per cent being excreted with the breath and urine. In this respect alcohol resembles the ordinary foodstuffs, sugar, fat or protein, and like them it must in the course of its oxidation give rise to energy in the form of heat. Certain other criteria must be met however, before we can conclude that alcohol may be regarded as a food. It has indeed been suggested that, although alcohol undergoes oxidation and produces heat in the body, this heat is of no value to the organism, since the loss of heat is increased to such an extent that the whole of the extra heat formed from the oxidation of alcohol is wasted. If alcohol is to be regarded as a food, it must be able to replace the other constituents of the ordinary diet, namely, fats, carbohydrates, or proteins. We have seen that food has a twofold significance for the body. In the first place, it supplies by its oxidation the necessary energy in the form of heat or work necessary for carrying on the vital processes, the beat of the heart, the movements of the respiratory muscles, and all the other movements of the body as a whole which are necessary for the capture of food or for carrying on the normal social avocations of the individual.

In the second place, it has to supply the wear and tear of the tissues. All three classes of food can be utilised by the body for the supply of energy. Their value for this purpose is measured by the amount of energy in the form of heat which they give out when they are oxidised to the same degree as they are in the body. We are accustomed, therefore, to estimate their value in units of heat—in Calories. Thus, if we allow for the losses in digestion, we can say that the food- or Calorie-value of each class of foodstuff is as follows for each gramme of material :

1 gm. carbohydrate	= 4 Calories
1 gm. protein	= 4 ,,
1 gm. fat	= 8·9 ,,

In drawing up a diet the first thing to determine is that its total Calorie-value is sufficient to meet the energy expenditure of the individual. An ordinary man doing moderate work is found to require about 3000 Calories a day, and this must be the total Calorie-value of his food taken in the same time. Within wide limits we can alter the relative proportions of the different foodstuffs, if only we take the precaution to maintain the total energy value at 3000 Calories. Thus a diet composed of 100 gms. of protein, 100 gms. of fat, and 500 gms. of carbohydrate, would have a heat value of about 3300 Calories and therefore would be amply sufficient. In this diet we can increase the fat and diminish the carbohydrate or protein, every 4 gms. of fat that we add to the diet enabling us to take away either 8·9 gms. of carbohydrate or 8·9 gms. of protein. We express this relation by saying that the foodstuffs are interchangeable in *isodynamic* proportions. This power of replacement is however limited. In the first place a certain amount of carbohydrate is necessary in the diet ; if the diet is very poor in carbohydrate, the body gets the sugar necessary for its functions out of the protein and there is a large wastage of protein for this purpose. It is therefore an uneconomical proceeding to reduce the carbohydrate to too low a figure. Moreover, of the three classes of foodstuffs there is only one that can make good the wear and tear of the working tissues, and that is the proteins, since only these contain the molecular groupings which are essential for building up the living tissue. In the normal diet of man, if sufficient be given of the other foodstuffs, the protein may be reduced to thirty or forty grams per day without the body losing nitrogen ; but if the fats, and especially the carbohydrates, be also reduced, then the body burns up its own proteins and the loss of nitrogen from the body is greater than the gain of nitrogen from the food. We have therefore two criteria of the sufficiency of a food for a few days. One is the fact that the body does not gain or lose weight (which would signify a gain or loss chiefly of fat), and in the second place that the body neither gains nor loses nitrogen, indicating that the working tissues of the body are not decreased or drawn upon for the supply of energy.

We cannot expect alcohol, which contains carbon hydrogen and oxygen in its molecule, to take the place of proteins. The question whether it can be regarded as a food resolves itself into the question whether it can replace fat or carbohydrate in their twofold functions, namely: (1) in serving as a source of the necessary energy of the body; (2) in sparing or diminishing the consumption of protein. Just as fat and carbohydrate can replace each other within limits isodynamically, so if alcohol is a food it should, again within limits (i.e. if given in moderate doses), be able to replace an isodynamic proportion of carbohydrate or fat.

The Calorie value of 1 gm. of alcohol is 7 Calories, so that 1 gm. of alcohol should replace $\frac{7}{8\cdot9}$ gm. of fat or $\frac{7}{4}$ gms.

of carbohydrate. This applies to the condition in which the diet has been adequate and the man or animal is neither gaining nor losing weight. It should be possible in such a case to replace, say, 70 gms. of carbohydrate in the diet by 40 gms. of alcohol and find the evolution of energy by the body, the rate of combustion, and the weight of the body, unchanged. On the other hand, if the 40 gms. of alcohol be added to the diet in such circumstances, so that the man is now taking $40 \times 7 = 280$ Calories per day more than he was before, the combustion of the alcohol should preserve some of the fat or carbohydrate from oxidation, since the energy demands on the body are not increased. The fat or carbohydrate remaining in the body, which is thus spared from oxidation, will be stored for the most part in the form of fat, so that the body weight should be increased and the respiratory exchanges should show us that this increase is due to the storing up of fat or possibly, to a small extent, of animal starch or glycogen. Moreover, if the man were on a sufficient diet before, and was neither gaining nor losing nitrogen, the replacement of part of the carbohydrate or fat by alcohol should not give rise to any increased loss of nitrogen and should not therefore disturb the nitrogenous balance. In other words, the alcohol should be able to take on the sparing effect which was previously exerted by the carbohydrate or fat which it is replacing in the diet.

Very many experiments have been carried out by different observers with a view to deciding these questions. Of these by far the most elaborately controlled experiments are those of Atwater and Benedict. They were made on three different men, the subjects being enclosed in a special chamber known as a 'respiration calorimeter.' By means of this apparatus we can measure the materials received by the body in the shape of food and drink and oxygen of the air, and the material given off by the body with the urine and, as carbonic acid, in the breath. Since the respiratory exchanges are measured, it is a respiration apparatus, but it serves also to determine the total heat given off by the body, and is thus a *calorimeter.* The chamber is furnished with a chair, table, and bed, and also contains a stationary bicycle on which the subject is able to do muscular work, if required, during the experiment. The experiments were continued during a period of four to twelve days and nights, during the whole of which time the man who served as the subject of the experiment remained in the chamber, being supplied with food through an aperture in the wall of the chamber, having tightly fitting caps on both ends. The production of heat by the body is measured by passing water through radiator pipes in the chamber, and measuring the extent to which the water is warmed by the heat disengaged by the man's body. The accuracy of the apparatus may be tested by burning alcohol within it or by generating heat by the passage of an electric current through a known resistance within the chamber. In a series of tests made in this way the apparatus was found to work perfectly and to have an error of less than 1 per cent. Throughout the research, observations on men on a diet free from alcohol were alternated with others in which the diet contained alcohol. In the alcohol experiments the usual daily dose was two and a half ounces of absolute alcohol mixed with either water or coffee. It was given in six small doses, three with meals, and the others at regular intervals between meals. In this way there could be at no time any large concentration of alcohol in the blood and tissues. We have seen that the human body can oxidise 7 to 10 cc. of alcohol per hour. In Atwater's experiments, 72 cc. were administered in the course of the day, equivalent to the amount contained in a bottle of claret or burgundy. Each dose amounted to only 12 cc., so that in a man of 60 kilos., assuming that the whole dose was rapidly absorbed, the concentration in the blood would probably not surpass 1 in 5000, i.e. ·02 per cent. Assuming not less than two-hourly intervals for the administration, the whole of one dose should have undergone oxidation before the next dose was given. It is necessary to keep these facts in mind as they have an important bearing on the conclusions to be drawn from the experiments. The results of experiments carried out in this way may be summarised as follows:

1. The Effect of Alcohol upon the Digestion of Food

This was determined by comparing the composition of the food taken in and of the waste material leaving the body in the fæces. Since a certain amount of the fæces is derived from the secretions of the alimentary canal itself, it is more correct to speak of the influence of alcohol on the *availability* of the food and of its several ingredients. By this term we mean the proportion of the food that can be used for the building and repair of the body and for the yielding of energy. The results of eight experiments without alcohol are compared in the following table with those of five experiments in which alcohol was administered.

Kind and number of experiments.	Coefficients of availability.			
	Protein %	Fat %	Carbohydrate %	Energy %
Without alcohol—8 experiments	92·6	94·9	97·9	91·9
With alcohol—5 experiments	93·7	94·6	97·8	92·0

From this table we see that the alcohol, under the conditions of the experiment, had practically no effect on the digestion of the food—the protein was in fact digested a little more effectively. But the difference between the two sets of experiments are such as might occur spontaneously in any series of experiments on the same subject, using the same food at different times under different conditions. We may conclude that alcohol administered in small doses at a time to a healthy individual does not affect the digestion or availability of the food.

In the same experiments it was found that of the alcohol taken at least 96 per cent was burned in the body, so that this figure may be taken as the co-efficient of availability of alcohol as compared with an availability of 98 per cent for carbohydrates, 95 per cent for fats, and 93 per cent for proteins, the alcohol being more completely oxidised than the ordinary constitutents of the diet.

2. The Utilisation of the Energy of Alcohol

In a number of experiments made by Atwater on men in his chamber, he found that the total output of energy from the body measured in the form of heat was almost exactly equal to the total income of energy as calculated from an analysis of the food supplied, deduction being made of the material wasted in the excreta. There are naturally small variations from day to day, but when a number of experiments are averaged, these small differences counterbalance each other, and in thirty such experiments the average daily income of energy was found to be 2718 Calories, while the daily output was 2723 Calories. If the energy derived in the body from the oxidation of alcohol can be utilised equally well for the normal processes of the body,—circulation, respiration, muscular work, preservation of body temperature,—the replacement of a certain proportion of the food (fat or carbohydrates) by an isodynamic quantity of alcohol (i.e. a quantity having the same energy value as the food which it replaces), should leave the general balance-sheet of the body unchanged. The potential energy of the alcohol oxidised in the body should be transformed as completely into kinetic energy and be used for the production of heat or muscular work just as well as the energy of the proteins, fats, and carbohydrates of the food. This was found to be the case. The following table shows two sets of experiments, one set in which no external work was performed other than the movements necessary for making the bed, taking food, etc., while in the other a measured amount of work was performed on the stationary bicycle ergometer.

Experiments with and without alcohol.	Energy of Income.	Energy of outgo measured as		
		Heat.	Muscular work.	Total.
	Calories.	Cal.	Cal.	Cal.
Rest experiments :				
Without alcohol .	2185	2221	—	2221
With alcohol .	2186	2221	—	2221
Work experiments :				
Without alcohol .	3668	3451	220	3671
With alcohol . .	3698	3461	215	3676

In both sets there is practical equivalence between the output and the income of energy, and the alcohol can replace as a source of energy either fat, carbohydrate, or protein.

3. The Protective Effect of Alcohol on the Tissues

When the fuel value of the diet is in excess of the needs of the body, the latter tends to increase in weight, the increase being sometimes in the form of protein, sometimes of fat or glycogen. If the energy-value of the food is deficient, then the body draws upon its stores of carbohydrates, fat or protein. If, having found a diet on which the body remains in equilibrium, we give an increased amount of any constituent of the diet, we should find an increase in body weight, assuming that the additional food can be digested and assimilated. One such series of experiments by Atwater may be quoted. These were made up of three successive periods of three days each on one individual. In this individual it had been found that he was practically in equilibrium on a basal ration containing 116 grammes of available protein and 2290 Calories of available energy. To this ration was added, in the first experiment, alcohol with an energy value of 500 Calories ; in the second experiment, none ; and in the third, sugar, also equivalent to 500 calories. On the alcohol there was a daily gain of 63 grammes of fat ; on the basal ration this was reduced to 9 grammes, while on the sugar it rose again to 60 grammes per day. Thus the gain of fat was practically the same whether the excess of energy above the daily requirements of the body were given in the form of sugar or in the form of alcohol.

Experiments on the sparing effect of a diet on protein metabolism are rather more difficult, owing to the marked variations in the excretion of nitrogen which occur in the normal individual from day to day ; but here also the sparing effect of alcohol was nearly but not quite as great as the sparing effect of carbohydrates and fats on the proteins of the body. When the administration of alcohol was continued, it seemed that at first there was a small increased loss of nitrogen which gave place to a gain of nitrogen to the body towards the close of the experiment. Atwater deduces from his experiments the following three conclusions :

(1) The alcohol caused a small loss of body protein, but this effect was temporary.

(2) Thereafter the alcohol protected the body protein.

(3) The alcohol protected fat throughout the experiments.

4. The Effect of Alcohol on the Loss of Heat from the Body

In considerable doses alcohol causes a dilatation of the peripheral blood vessels and so increases the loss of heat. This may be a serious effect when the subject is exposed to cold, and may cause a great lowering of temperature of the body. In the experiments carried out by Atwater, in which the alcohol was given in small doses spread over the day, this effect was negligible both in the rest and the work experiments. No considerable increase in the amount of heat radiated from the body was caused when 72 gms. of alcohol per day, furnishing 500 Calories of energy, were used to replace isodynamic amounts of fats and carbohydrates. On the alcohol diet there was indeed a slight excess of heat given off as compared with the other experiments, but the difference was only ·1 per cent. All these results show that alcohol, carbohydrates, and fats, under the conditions of these experiments, simply replaced one another as sources of energy and that, as alcohol was oxidised, the others were proportionately spared.

5. Alcohol as a Source of Muscular Energy

When we experiment on the isolated muscle we find that the energy of contraction is derived from the oxidation of carbohydrates in the form of sugar or glycogen. When however we extend our observations to the whole body, or even to the isolated contracting heart, we find that the energy for the work which is performed by the muscle can be derived from the oxidation of either proteins, fats, or carbohydrates. We know that proteins can undergo chemical changes in the body and be converted in part into sugar. Whether such a change occurs in fat is still a matter of speculation, but it is often assumed that when muscle has to draw its energy from fats or proteins, these substances must first be transformed, in the muscle itself or elsewhere, into sugar or some other form of carbohydrate. We have no evidence that alcohol can be directly converted in the body into either sugar or fat. There are some grounds for the conclusion that alcohol may be directly utilised as a source of energy by the contracting heart. But the ultimate changes in alcohol, as in fats and proteins, which enable them to be used as a source of muscular energy, are still unknown. In attempting to answer the question as to how far alcohol can furnish the energy for muscular work, we have to content ourselves, as in the case of fats and proteins, with experiments on the whole body such as those carried out by Atwater. These give a perfectly definite response. In the table on page 58, a series of work experiments without alcohol is compared with three other series of experiments in which alcohol was taken. In the first series the average muscular work per diem was 220, measured in Calories; in the alcohol experiments work equivalent to 215 Calories was done each day. In the first set of experiments the total output of energy was 3671 Calories, in the second set, with alcohol, 3676 calories. The amounts of material and energy transformed in the experiments with alcohol were thus very nearly the same as in the corresponding ones without alcohol, and while the utilisation of the energy of the whole ration was slightly less with the alcohol than on the ordinary diet, the difference in favour of ordinary food was so small that it cannot be regarded as of practical consequence. Thus the evidence that alcohol may serve as a direct source of muscular energy is as adequate as the evidence that fats can be utilised.

We must, however, be careful not to deduce more from these experiments than they actually yield. What they show is that an amount of alcohol practically equivalent to a bottle of claret, can be given to an adult in the course of the day, without interfering with the normal processes of the body, the alcohol taking its place and functioning as an ordinary food and serving as a source of energy which may be used for maintaining the heat of the body or for the production of muscular work. But we should be in error if we were to conclude that alcohol is a good food when muscular work has to be done. The work in these experiments was moderate in quantity and was of the simplest possible description, requiring only slight effort of attention and involving no complex co-ordination of the activities of the different muscles. The spacing of the doses of alcohol was purposely arranged so as to keep its concentration in the blood at a minimal amount, and thus to avoid so far as possible the effects of alcohol on the functions of the central nervous system, which we shall have to describe more fully in the following chapters. If the alcohol had been given in one dose and on an empty stomach, and if the work had been of a more arduous character, or had required greater skill in its performance, there is no question that it would have been found an uneconomical source of energy, not because of failure to utilise the energy of the alcohol by the contracting muscles, but because the effects of the alcohol on the central nervous system would have interfered with the fine co-ordination of the actions of the different muscles, and thus necessitated a greater expenditure of energy for the production of the same amount of work.

This result comes out clearly if we study the effects of a single dose of alcohol on the severe work required in ascending a mountain, as has been done by Durig.

Professor Durig, of Vienna, is a trained mountaineer, who has passed his holidays since boyhood in the Alps. Before beginning his experiments on the action of alcohol, he made a series of observations on his respiratory exchanges during the ascent of a steep mountain path. During the month that these observations lasted, his physical condition steadily improved as an effect of training. From the mountain hut in which he lived the path led with a gentle rise over meadows and then went steeply up an arête to the summit of the Bilken Pass. The apparatus to measure his respiratory exchanges he carried on his back during the whole course. It weighed between 18 and 19 kilos. By means of this apparatus he was able to sample the air which he breathed out and to measure its volume. In this way he could find how much oxygen had been consumed in a given time, and how much carbon dioxide had been exhaled.

Fig. 5. Figure showing the apparatus in experiments on the respiratory exchange in the high mountains. (Zuntz, Loewy, Müller and Caspari.)

From the comparison of these two figures he could judge of the amount of oxidation which had occurred in the body during the march, and therefore the total energy which had been set free by the body in the production of heat and work. The effect of training was shown by the fact that in the earlier experiments the horizontal march occupied one and a half hours and the steep ascent four and a half hours. Towards the end of the series the horizontal march only took 50 minutes and the ascent 2 hours 40 minutes. In the steep part of the ascent he raised his body through 780 metres. The total work of the ascent was 192,000 kilogramme metres in the 2 hours 40 minutes, whereas in Atwater's experiments the total work was only 90,000 kilogramme metres, which was spread over eight or twelve hours. In this process of training the amount of work done per minute increased from 800 kilogramme metres to 1300, and the efficiency of the human machine (i.e. the ratio of mechanical work done to the total energy evolved) from 25·6 to 29·7 per cent. In the later experiments he found that as he proceeded with the ascent the respiratory quotient, i.e. the ratio of carbon dioxide exhaled to the oxygen taken in, fell steadily. As we have seen, the respiratory quotient serves as an indication of the kind of food or body constituent which is being oxidised, since, when the carbohydrates, sugar, starch, and glycogen, are being oxidised, the respiratory quotient is 1, whereas, if the oxidation affected only the fats, the respiratory quotient would be 0·707. With alcohol the respiratory quotient would be still lower, namely, 0·67. The steady diminution in the respiratory quotient during the heavy work of 2¾ hours means that the body first drew on its carbohydrate stores for the energy of the work, and only as these became used up did it utilise in greater proportion the fats of the body.

Having determined his normal exchanges on an alcohol-free diet, Durig then made a number of observations on his respiratory exchanges under the same conditions, but after taking a dose of alcohol with the early morning tea and a scrap of bread. The dose of alcohol was moderate,—30 cc. of absolute alcohol in 125 to 250 cc. of water. This amount of alcohol would be equivalent to a pint of beer containing 5 per cent alcohol, or to a half bottle of claret. It must be noted that it was taken on a practically empty stomach. It produced, however, no subjective sensations, nor did Durig notice any disinclination to undertake the heavy exercise. But although subjective results were wanting, he found that the preliminary horizontal walk took ten minutes more than on the previous occasions without alcohol, and the ascent took 25 minutes more, namely, 3 hours 5 minutes instead of 2 hours 40 minutes. If we interpret this in terms of horse power, we would say that the trained man without alcohol was yielding ·275 horse power, whereas, when he did the same work immediately after taking a dose of alcohol he only yielded ·222 horse power. Although he was walking more slowly and the actual work per minute was diminished, the cost of the work, reckoned in oxidation of the body constituents, was increased and there was a diminished efficiency. This is shown by the following table :

	Kilogramme metres per minute.	Efficiency.	Cost per kilogramme metre in Calories.
With alcohol .	1009	25·62	9·2-
Without alcohol	1215	29·55	7·88

The actual measurements of the respiratory exchanges on the ascent began from one to one and a quarter hours after taking the alcohol. The figures given above are the average for the whole ascent, but if they are divided into four periods we find that the greatest difference between the normal and the alcohol experiment was in the first two periods of the ascent. That is to say, in the last fourth of the ascent the alcohol had practically disappeared from the body and the individual could be regarded as free from alcohol. In the alcohol experiments the respiratory quotient also behaved differently. Instead of falling in the course of the ascent it rose steadily and was highest during the last quarter of the ascent. This shows that the alcohol present in the body was consumed first in preference to the carbohydrate, so that the carbohydrate was protected while the alcohol was being oxidised and was available during the last period of the ascent, so raising the respiratory quotient.

Durig's experiments thus confirm those of Atwater and Benedict in proving that alcohol when administered takes the place of the other foodstuffs and is oxidised for the production both of work and of heat, its oxidation taking place actually in preference to that of the readily oxidised carbohydrates of the body. But they show, in addition, what did not appear under the easier conditions of Atwater's experiments, that the muscular machine on this fuel works more slowly and at greater expense of energy.

The experiment teaches us that we are not justified in concluding that alcohol is a good food for muscular work, even though we see powerful men carrying out severe work immediately after its consumption. If an untrained man had accompanied Durig on one of his alcohol tours he would have been astounded by the rapidity and ease with which Durig accomplished the ascent, and would himself probably have taken 4½ hours to do without alcohol what Durig with alcohol accomplished in three hours and five minutes. This, however, would have been no fair test. We must compare the performance of the same man with and without alcohol, or of men of equal strength and training for the work in question.

We then find that while alcohol can be and is utilised for the production of muscular work, it tends to result in waste of energy and is therefore disadvantageous for the man's efficiency. Few educated people would be found now to champion the old idea that the more beer a man was supplied with, the more work could be got out of him. It is true beer contains other nutritive material besides alcohol, but for full efficiency the alcohol will always have some detrimental effect. A man may do hard work on alcohol, but he will do it in spite of the alcohol and not in virtue of it. If the work to be done is neither difficult nor arduous, a moderate dose of alcohol taken with the midday meal, and not on an empty stomach in the early morning as in Durig's experiment, would probably make no appreciable difference. It becomes then a question of weighing the pleasure and enjoyment of the meal against the slight diminution in mechanical efficiency which might result from the alcohol.

We thus see that alcohol when administered in moderation can act as a foodstuff, i.e. it can replace the ordinary food constituents in supplying the energy to the body necessary for keeping it warm and for carrying on the vital functions during rest, and that it can be used also for the performance of muscular work. Moreover, the rate of its oxidation is quickened like that of the other foodstuffs, carbohydrates and fats, during muscular exercise. The effect of work on the rate of disappearance of alcohol from the blood is shown in the accompanying diagram.

Whereas, with very large doses, work does not appreciably alter the rate of disappearance of alcohol from the blood, there is with moderate doses a decided quickening in its consumption in the animal taking exercise as compared with the animal at rest.

But alcohol has other actions than that of a food, actions which we shall have to discuss more fully in

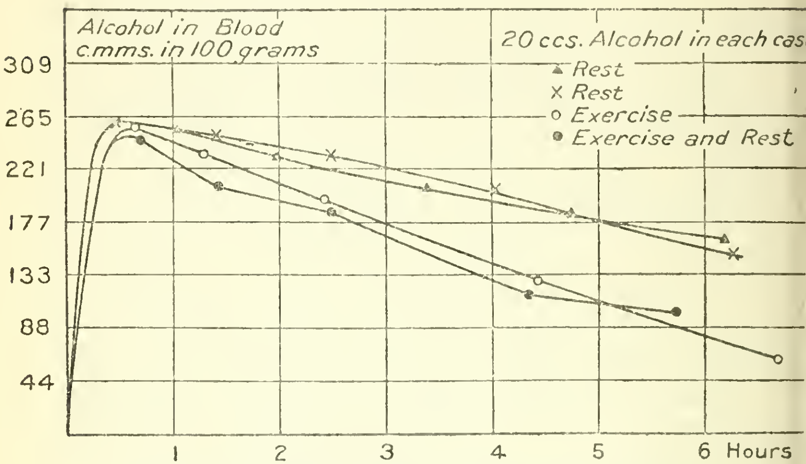

Fig. 6. Diagram showing the influence of exercise in hastening the rate of oxidation of alcohol in the body, and therefore the rate of its disappearance from the blood. In each experiment 20 cc. of alcohol were administered to a dog in 20 per cent solution. The two upper curves were taken from the animal at rest; the two lower from an animal which was encouraged to run about. (Mellanby.)

subsequent chapters. As a result of these actions, when a certain quantity is exceeded the co-ordination of bodily movements is more or less impaired, so that a given movement, being carried out more clumsily, requires a greater expenditure of energy. This effect may be imperceptible when the work is well within the limits of the man's capacity and requires no great effort or fineness of adjustment of movement. The slight deleterious effects of alcohol in such cases may be more than offset by the psychical effects of its consumption, such as the increased appetite or interest in the work resulting from the pleasant flavour of the particular drink employed, or a freeing of the mind from depressing ideas unrelated to the work and tending to divert attention. In such circumstances the total effect of a moderate dose of alcohol in the form of an agreeable and accustomed drink may be favourable rather than unfavourable. But whenever a man or animal is required to put forth his maximum efforts over a considerable time, as in the strenuous hill-climb carried out by Durig, or in a hard game of football, or where fine adjustment of muscular movements is necessary, as in feats of skill or acrobatic performances, alcohol is unsuitable *from the point of view of food.* We shall have to return to this point when we are dealing with the influence of alcohol on fatigue. Alcohol, if consumed at all, should be taken, not before or during work, but when the labours of the day are over, and its main justification will then be not its food value but the effects which it has on the different functions of the body.

Alcohol in 'Training'

We have seen above that, although alcohol can be utilised like the other foodstuffs as a source of energy for muscular work, its other physiological effects on the body render it a disadvantageous food for this purpose, so that its consumption before or during arduous feats requiring strenuous muscular activity or the finest co-ordination of movement is not to be recommended. These results have been taken by some to imply that, in order to attain the perfection of physical fitness requisite for the performance of athletic feats, it is necessary to practise a total abstinence from the use of alcohol during the whole period of preparation or training. Such a deduction from the facts which have been brought forward in this chapter is entirely unjustified. We might equally well say that because man cannot do his best immediately after a heavy meal, any large meals should be tabooed during the period of training. In training, a man is put into the conditions which are thought most suited for the attainment of a perfect state of health, so that his nervous system and muscles shall be 'in the pink of condition' at the moment when the supreme effort has to be made. Whether during this period alcohol is of advantage or the reverse is a point on which we have a great body of experience to guide us. The result of this experience has been to show that during a course of training, such as that undergone by the University crews for the Boat Race, or for other forms of athleticism, generally under medical advice, a moderate allowance of alcohol is usual, and in some cases is actually recommended. Most of the men drink half a pint of beer at lunch and a pint at dinner, and an occasional glass of port at the latter meal is not excluded. It has been found that insistence on total abstinence may conduce in some cases to excessive worry and to sleeplessness. It is more frequent to prohibit the use of tobacco than of alcohol. It must be noted that in every case temperance is strictly enjoined. The alcohol is taken at such times and in such doses that it will have undergone practically complete oxidation before the time arrives for the muscular exercise. Its value in training comes under the same category as its value in daily life, namely, in promoting repose both of mind and body, in increasing the pleasure and enjoyment of meals, and so aiding digestion and assimilation.

Alcohol in Disease

There are, however, conditions in which alcohol must be regarded as a valuable food for man. It must be remembered that alcohol requires no digestion. It is absorbed unchanged into the body with great rapidity, and this absorption begins even in the stomach, whereas all other foodstuffs only begin to be absorbed when the food reaches the intestine. According to the condition of the animal, 20 to 40 per cent of a dose of alcohol may be absorbed while it is still in the stomach. On this account alcohol may perform useful service as a food in cases of disease, weakness, or old age, where appetite is lacking and the processes of digestion and absorption are slow or fail altogether. Under such conditions the body may obtain a considerable proportion of the total energy it requires during the day in the form of alcohol. Mellanby has shown that an adult man can oxidise and utilise from 7 to 10 cc. of alcohol per hour. In order to prevent symptoms of intoxication in its literal sense, namely, of poisoning, it is necessary that at no time should there be any large concentration of alcohol in the blood and tissues. If 10 cc. of alcohol be given each hour, well diluted so as to avoid any injurious irritant effects on the mucous membrane of the stomach, the maximum concentration in the blood will not exceed ·014 per cent, and will vary between this figure and nothing at all. At this rate of administration 160 cc. of alcohol could be taken during the sixteen waking hours, allowing eight hours' sleep. This would be equivalent to about half a pint or 10 ounces of brandy, and such an amount, if properly spaced and diluted over the waking hours, could be given without causing any symptoms of intoxication in an ordinary individual. By this means the man would be obtaining in the form of alcohol about 900 Calories. A normal man at rest in bed gives out in the form of heat 1800 Calories in the twenty-four hours, so that it would appear possible to give in the form of alcohol as much as 50 per cent of the basal requirements of the individual. These figures are given as an illustration to show the possibilities of alcohol as a food. In most cases the intervals between doses could be longer, and a smaller total daily dose would be sufficient to supplement the other foods given at the same time. It is probable that the excellent results often observed in medical practice from the administration of alcohol in severe febrile diseases are to be ascribed mainly, if not entirely, to the value of this substance as an easily absorbed and assimilable food.

There is one disease, namely, diabetes, in which the food value of alcohol may be particularly important. In this disease there is a defective power of utilisation of sugar by the body. All the starchy foods, which are converted into sugar in the alimentary canal, pass into the blood, but, since they cannot be utilised, their concentration in the blood rises above the normal limits and all the excess is excreted in the urine, which thus becomes loaded with sugar. In order to excrete this sugar from the body, large quantities of urine must be passed, so that the patient suffers from thirst. Although the body cannot utilise sugar, at any rate to the normal extent, its tissues still require sugar, and to provide this the proteins of the body are broken down with the result that there is wasting of the muscular tissues. One of the purposes for which sugar is required by the body is to assist in the oxidation and utilisation of fats. This relation is sometimes described by saying that "fats burn in the flame of carbohydrates." In diabetes, the tissues are starved of sugar, though they are bathed in a fluid containing more than the normal amount of this substance. The defective oxidation of the fats of the food and tissues results in the formation of certain acids which appear in the urine and are spoken of collectively as 'ketone bodies.' It is the formation of these bodies which is responsible for the condition of insensibility and coma which often ushers in the death of the patient. Thus, in treating diabetes we are on the horns of a dilemma. If we give sugar or starchy foods in the diet we simply increase the excretion of sugar in the urine and the poisonous effects of sugar on the body generally. If we do not give sugar, the utilisation of fats becomes deficient and we get 'ketonuria,' acid intoxication and coma.

In the modern method of treating diabetes the diet is severely restricted as regards all classes of foodstuffs, but an attempt is made to administer just so much carbohydrate as the patient can assimilate. On such a restricted diet it is difficult to give enough Calories for the ordinary energy requirements of the body, and we cannot add any substance to the diet which would be transformed into sugar, nor can we increase the fats beyond a certain limit, because that would increase the tendency to acid intoxication. We have seen that alcohol can be used to replace the other foodstuffs in supplying the energy needs of the body, and that it replaces in the first place carbohydrates or sugar and so diminishes the carbohydrate consumption of the body. If administered to the diabetic it does not undergo conversion, like so many allied substances, into sugar, and therefore does not increase the excretion of sugar in the urine. On the other hand, it is not ketogenic, and therefore does not increase the risk of poisoning by the 'ketone bodies.'

We thus see that in diabetes, where the capacity of utilising sugar is wanting, alcohol can take the place of the sugar in furnishing the necessary energy to the body, without increasing the poisoning of the body as a result of deficient fat oxidation. On this account it has been recommended that in severe diabetes alcohol should be used as a food up to the maximum amount possible, i.e. as much as can be given without attaining the intoxicating limit of concentration in the blood. According to Mellanby we can administer to such patients as much as 160 cc. of absolute alcohol, properly diluted and spaced, with altogether beneficial results. In this way we may supply nearly half the energy requirements of the normal individual. Unfortunately it is not every diabetic patient that reacts favourably to this treatment —since it seems that in some, any increase of diet, even when the added substance like alcohol is not directly converted into sugar or ketone bodies, results finally in an exacerbation of the disease.

CHAPTER V

THE ACTION OF ALCOHOL ON HUMAN BEHAVIOUR

ALTHOUGH alcohol with certain limitations may be regarded as a food, it is not for this purpose that it is ordinarily consumed. The beverages containing it are regarded as drinks and as supplementing but not replacing the solid foods which compose the meal. If anyone were asked why he took beer or wine with his meals, he would probably reply that he did it because he liked it. The alcoholic drinks fall into the category which the Germans designate as *Genussmittel*, i.e. substances which add to the enjoyment of food, and which include the various condiments and spices, as well as the beverages, such as tea and coffee, containing the alkaloid caffeine as their active ingredient. Alcoholic beverages are in fact used to add to the pleasure in a meal and to the enjoyment of life. It is clear, however, that their value is not simply a question of their pleasant taste or aroma, however much prized these may be by the lover of good wines or of beer. To a man accustomed to its use, wine cannot be replaced by the finest cooking, and a plain meal with a bottle of wine is worth more than the highest product of the culinary art taken with water as the sole beverage. The widespread use of alcoholic drinks and their value to the individual is due to the alcohol they contain, the various admixtures with the alcohol in wine and beer serving only as an additional attraction to their use. We see this from the fact that a man accustomed to one kind of alcoholic drink will in its absence replace it by another. The increased enjoyment of a meal from the use of beer or wine is therefore chiefly a question of the action of alcohol. If we consider the effects of moderate doses—a glass of beer or half a bottle of wine—they will not be immediately apparent any more than they were in the experiments, recorded in the last chapter, on men in the respiration chamber. Indeed, objectively, we might say that such small doses had no effect, and on superficial observation we may notice little, if any, difference in the demeanour or behaviour of a man before and after a meal in which such small doses of alcohol have been taken. Subjectively however there is a considerable difference. He has obtained not only greater enjoyment of his meal, resulting in increase of appetite and consequent improvement in the processes of digestion, but the greater enjoyment is due itself to the fact that this small dose has given him repose of spirit from the endless little worries of the day's work. He has sat down to dinner fighting in his own mind the battles of the day over again, preparing for the work of the future, and seeking methods of warding off possible dangers to himself or to his plans. But for the moment these thoughts and cares are no longer of any value to him in his life's work; the time has come for repose and repair; and for complete digestion and assimilation he needs to free his mind of them. Under the influence of the alcohol past troubles cease to repeat themselves and to reverberate in his mind. The worries of the day fall off like a garment, and he acquires a restful and contented frame of mind, in which he takes a more sanguine view of the present and of the future, and leaves difficulties and dangers till the morrow, when he will be prepared to deal with them refreshed and restored by the night's sleep. All this a man dining alone keeps to himself, but in Society the effects on the man are evident to the onlooker. We need only compare the dull depression or the forced merriment of a teetotal party with the natural flow of spirits and good fellowship which distinguish an ordinary feast of which alcoholic drinks form a part. A man may go to such a dinner full of the cares and work of the day, with little or no interest in those he has to meet, whose occupations may be very diverse from his own, nervous of making any remarks to his neighbours for fear of making himself ridiculous or saying something in which they are not interested. After the first glass of champagne we notice the conversation, instead of being spasmodic and forced, becomes general and free ; the self-consciousness and preoccupation of each man with his own affairs become lessened. He is more receptive of the moods and interests of his companions. His emotional responses are more readily aroused ; the solemn man unbends, the critical become charitable and sympathetic, the silent man more loquacious. Each man thus not only reveals himself more to his fellows, but is more ready to appreciate the merits and conversation of those around him. In a word, the use of alcohol in moderation promotes good fellowship. With this greater freedom of interchange of ideas there is less restraint of gesture ; facial expressions become more animated ; ideas in every man seem to flow more freely and speech becomes more ready. It is not surprising therefore that alcohol has been often spoken of as a stimulant. As we shall see later, however, all these results can be ascribed to a paralysing effect of alcohol, which is the first stage of its influence as a narcotic and is due to a gradual diminution in control by the higher centres. This essentially paralysant action of alcohol is brought out if we continue the study of its action by increasing the dose, so as to bring about the effects of intoxication. These will be the subject of a later chapter. Here, however, we are concerned only with the effects of doses which are described as moderate, the later stages of the action of alcohol being evoked by its consumption in quantities for which the individual is unfitted.

The behaviour of man, as indeed of any living organism, must be regarded as a continual series of adapted reactions to changes in the environment. The fitness of the organism for survival is measured by the success of its adaptations in preserving the life of the individual and in making it possible for it to propagate its kind. In animals living in communities the needs of the individual are subordinated to those of the community, so that fitness of any reaction, the value of the behaviour of the animal at any time, is measured by its value to the community, the survival of which it is the object of all these reactions to secure. Thus, in some cases even the power of propagation may be lost, as in the worker bees, where the whole function of the reproduction of the community is taken over by the drones with the queen bee.

In all higher animals it is the central nervous system that is chiefly responsible for carrying out the reactions of the animal to peripheral stimuli and for fitting its behaviour to its environment. In unicellular organisms, such as the amœba, the whole surface of the body is sensitive, and the whole body is envolved in the adaptation which takes place to changes in its surroundings. With the development of multicellular animals by the division and differentiation of the units resulting from the primitive unicellular stage through which every animal passes, the greater part of the cells become withdrawn from the surface, and the function of regulating the adaptations of these different cells to environmental change is taken over by the specially differentiated tissue which forms the central nervous system. The sensitiveness of the surface becomes the special office of the sense organs, which are distributed over the surface of the body and are connected with the nervous system, while these latter, by means of nerve fibres passing to the muscles and other active tissues, are able to evoke movements or other reactions in response to the stimulation of the sense organs. Among these sense organs a certain number, which correspond to our organs of vision, of hearing and of smell, become specially differentiated to respond to changes occurring at a distance from the animal. Since these become aggregated towards the head end of the animal, they are able to bring information to the central nervous system of the external world towards which the animal is moving. They are thus organs of foresight, and the impressions aroused by their stimulation necessarily gain predominance over those stimuli which are excited by changes occurring in the surrounding medium which is in actual contact with the animal's surface. The front part of the central nervous system thus becomes the most important part of the whole system and exercises control over all the back parts. The growth in complexity of response which marks the rise in the scale of animal life becomes thus associated with an increasing relative size and preponderance of the front part of the central nervous system, with what in fact corresponds to the brain in the higher animals. In vertebrate animals a new factor makes its appearance in the central nervous system in the form of an outgrowth from the front of what we have called the brain; and in the course of evolution this outgrowth rapidly increases in size until in man it transcends in bulk and importance all the rest of the nervous system put together. This outgrowth forms what is known as the *cerebral hemispheres* or big brain. A special feature of the cerebral hemispheres when they appear is that they are apparently not concerned with the immediate reactions to environmental change. It seems that a small sample or image of each sense impression with its consequent reaction reaches the cerebral hemispheres and produces there a lasting effect of such a nature that the individual experiences of the animal become as it were registered in the tissue of the

Fig. 7. Diagram of the human brain, showing the cerebral hemispheres, mid-brain, hind brain, and cerebellum. The parts are separated from one another more than is natural, so as to show their connections. (Quain.)

A, cerebral hemispheres; B, cerebellum; C, Pons Varolii; D, medulla oblongata.

cerebral hemispheres. The higher brain is thus enabled to control all the activities of the lower parts of the body *in accordance with experience,* and the animal's behaviour loses its fatal machine-like character and becomes susceptible to education. It is evident that an animal whose behaviour is dictated by experience will have a great advantage over all those in which the reactions are immediately evoked by changes in the world around.

The phrase "a burnt child dreads the fire," is an expression of the interposition of the higher brain and the value of education in the preservation of the individual from harm. The brain thus becomes an organ of foresight much more effective than the lower parts immediately activated by the distance perceptors or sense organs, and in the course of evolution there is an ever-increasing growth and complexity of this part of the central nervous system with a transference of more and more of the reactions of the body to its province. Thus in man even the comparatively simple mechanisms of locomotion, standing, etc., have to be learned, and by the destruction of the brain are rendered impossible. In the rabbit and dog the movements of walking are carried out perfectly even though the cerebral hemispheres are entirely destroyed. The whole behaviour of man thus becomes susceptible of education and dependent on the individual experiences and on the constraint exercised on the individual by the society in which he lives. Among the reactions, the sum of which constitutes behaviour, we find different levels according to the time of their development in the history of the individual and of the race. Of these the most fundamental and present in all races are those tending to survival of the individual. These reactions, which depend little on education, so that they are spoken of as instinctive reactions or instincts, are represented in consciousness as emotions. Examples of these are the instincts of self-protection, attack, defence, or flight, with their corresponding emotions of anger and fear; instincts of nutrition, with their emotions of hunger and thirst, appetite or desire, and disgust. Equally primitive are those reactions which provide for the perpetuation of the species, the reproductive functions, with their emotional representation of love, jealousy, and hate. The first aim of education in its widest sense is to control these instincts and to modify or suppress the corresponding emotions so as to make them subservient to the interests of the community of which the individual forms a part. In this way the custom of the community becomes the habit of the individual, and by dint of constraint and repetition this impressed behaviour becomes itself automatic and the primitive instincts are suppressed, modified, or replaced so as to fit the individual for life in common with other individuals in the community. This part of education is complete when right social behaviour—morality—becomes itself instinctive and has its representation in consciousness as various altruistic emotions—generosity, sacrifice, patriotism, pity—while failure to conform to the law of the tribe is attended with emotions of shame or fear. The complex of emotional reactions thus resulting from education constitutes what is generally spoken of as conscience.

Even, however, when education has resulted in the production of an individual instinctively moral, i.e. conforming to the tribal law, it is still necessary for the individual to survive, and by co-operation or competition to maintain himself within the community. And it is this highest office which we may regard as the object of the intellectual part of all education. The individual's success in the community depends on the manner in which he has learned by instruction and experience his trade or his handicraft or other intellectual or manual activities which contribute to his support. On his skill in carrying out these activities will in the long run depend the survival of him and his family within the community. For this individual success a constant suppression of lower instincts is necessary in order that the inherent self-interest of the individual may be effective without going outside the custom of the tribe. The individual in all his acts is thus fettered by the necessity of doing them in conformity with public opinion and custom; and it is this necessity which creates the difficulty of each individual existence, the worries of business and the apprehension of failure.

It is amazing to find that the anatomical basis of the nervous reactions, which make up the life of man, is of a relatively simple nature. When we examine the structure and development of the central nervous system, we find it is built up of an enormous number—many millions—of nerve cells with their processes, which are called neurones. If we trace the paths of the impulses which effect a simple reflex-action, like drawing up the foot in response to a prick, we find that it starts in the skin and affects the process of a nerve cell. Up this process, which we call a nerve, it travels into the spinal cord. Here the nerve fibre divides and its branches go in various directions, but finally end in a series of little processes which are closely applied to other nerve cells. Some of these nerve cells send off another process which becomes a nerve fibre and passes down to a muscle fibre.

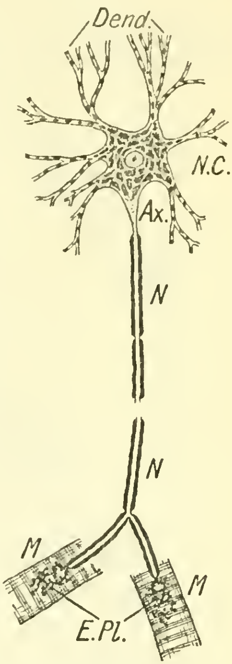

Fig. 8. Diagram of a nerve cell with its processes (motor neurone) sending a nerve fibre to supply muscle fibres. (After Barker.)
N.C., nerve cell; Dend. dendritis; Ax., axon; N., nerve fibre; M., muscle fibre; E.Pl., end plate.

Whether one or other reaction takes place depends on the cells which are finally excited and therefore on the path taken by the impulse in the central nervous system. This path is determined by the resistance between the endings of one neurone and the body of the neurone next in the series. The junction is spoken of as a *synapse.* The resistance in this synapse varies, according to previous states of activity, so that the final reaction or movement in response to stimulation depends not only on the immediate nature of the stimulus, but also on the previous activity of the body as a whole. Anything which diminishes the resistance in the synapse will increase the

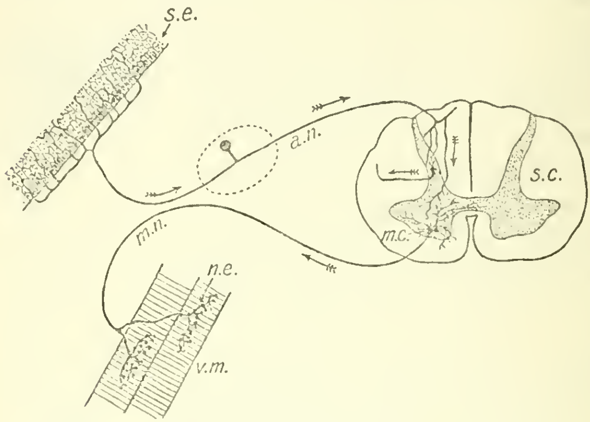

Fig. 9. Diagram of a reflex arc showing the sensory neurone sending one process to the skin and the other process to ramify in the spinal cord, and also a motor neurone in the anterior part of the cord, sending the nerve fibre to two voluntary muscle fibres. (After Van Gehuchten.)

s.e., surface epithelium; a.n., afferent nerve; s.c., spinal cord; m.c., motor cell; m.n., motor nerve; v.m., voluntary muscle; n.e., nerve ending.

rapidity of response, while anything which increases the resistance will have the opposite effect.

It has been stated that the best explanation of the action of alcohol on the body is afforded by the assumption that it increases the resistance at these synapses. It is evident that if it increased the resistance too much, it would stop all reflex activity and the animal would neither feel nor move. A slighter effect might simply delay the ordinary reflex actions. Whether this view be correct or not, it certainly serves to explain the effects, good and bad, on the individual which may result from the taking of alcoholic drinks. We may deal here with some of the more accurate observations which have been made on this subject. Such a statement, however, does not carry us much further in our enquiry into the action of alcohol on man. It would apply equally well to any member of the alcohol, ether, chloroform group of narcotics, and is merely another method of expressing the action of large doses of any of these bodies. It is true that any agent tending to increase the resistance to the passage of impulses through the central nervous system would affect in the first instance those paths which are more recently laid down as the result of education and experience, and their effect would tend to be more marked the greater the complexity of these paths. We should expect, therefore, the first effects of small doses of alcohol to make themselves felt on the highest level of brain function, i.e. at that level at which self is trying to emerge from the herd and to maintain itself as against other members of the community while observing the rules of behaviour which are the conditions of the tolerance of the individual by the tribe.

A very large number of experiments have been made to study the effects of varying doses of alcohol on special reactions or movements of the individual. By choosing such reactions as occur instinctively or involuntarily and which are present in all animals inferior to man, it has been thought possible to analyse the action of alcohol into its components, and to account for its action on the whole individual as a resultant of its effects on the isolated reactions. Such an attempt can only end in failure. There is no pure reflex action in man that is not subject to control, to reinforcement, or suppression, by the higher parts of the brain, and which cannot be altered in any direction according to the nature of those higher-level processes which we know in consciousness as thoughts, ideas, and emotions. Any effect on the more primitive reactions must therefore be secondary to the action of alcohol on the highest level functions of the brain. If however we bear these facts in mind, the results elicited by various observers are of interest in reference to the effect of alcohol on the body as a whole.

Among the simplest of the reflex actions of the body are those which have their origin in the muscles and have as their use the maintaining of the muscles of the body in a state of readiness or tone. The test of these muscle tone reflexes is afforded by what are sometimes called *tendon reflexes*, the most familiar of which is the '*knee-jerk*.' If a man sit with his legs crossed, the upper leg hanging loosely, a tap on the tendon of the knee-cap causes a brisk contraction of the muscles in front of the thigh and a kicking movement of the leg. It seems that in its simplest form the knee-jerk, which is excited by the sudden stretching of the muscles of the thigh, involves only one neurone and one synapse in the central nervous system, so that the loss of time or delay is shorter than that in any other reflex action and may be no greater than two-thousandths of a second. The variations in the lost time, however, are very wide even under normal conditions. Dodge and Benedict have investigated the action of small doses of alcohol—30 cc. or 45 cc. diluted—on the knee-jerk in a number of individuals. They found as the average of a large number of observations that the latent period of this reflex is increased under the action of alcohol by about 9 per cent. It would however be futile from these observations to conclude that these doses of alcohol appreciably affect the resistance of the reflex arc immediately concerned in the knee-jerk. The same or larger effect is produced by sleep, and the latency is enormously affected by mental and emotional states. A total cutting off of the cerebral hemispheres and forebrain results in an exaggeration of the knee-jerk, so that one might ascribe the lengthening of the latent period to an increased control by the higher centres, were it not that the same effect is produced by sleep. The whole question is in fact too complex to be capable of exact analysis. The phenomenon is part of the familiar influence of alcohol in diminishing the attitude of rigid attention and readiness for all eventualities and in promoting a state of repose and freedom from care and anxiety. It is possible that if similar doses were tried on an animal in which the lower centres had been entirely freed from the brain, as by section of the spinal cord, their influence would be found to be *nil*.

Another reaction investigated by the same observers was the rapid closing of the eyes in consequence of a sudden noise. Here also the latent period, i.e. the time intervening between the noise and the closure of the eyelids, was increased on the average by 7 per cent, though this effect was not noticeable in the case of two individuals in whom, as a result of boxing and revolver shooting, control had been acquired of the blinking reflex. In this case, therefore, the acquired control suffered no change under the influence of moderate doses of alcohol.

The same slightly diminished velocity of response was found in the eye movements and in the reaction time of the hand and speech organs. No change at all was found in the rapidity of memorising lists of words.

Very similar results were obtained later by Miles, working in the same laboratory.

A very large number of researches have been made on the effects of alcohol by means of ergographic method. In this method a limited group of muscles is employed to raise a weight repeatedly, and the movement of the weight is recorded on a blackened surface. The arrangement of such an experiment is shown in Fig. 10. The hand is kept motionless and one finger connected by a pulley with a weight. This weight is raised by bending the finger and the movement of the weight recorded. After a certain number of movements fatigue supervenes and the subject is entirely unable to lift the weight. On resting a little time he can once more make a series of move-

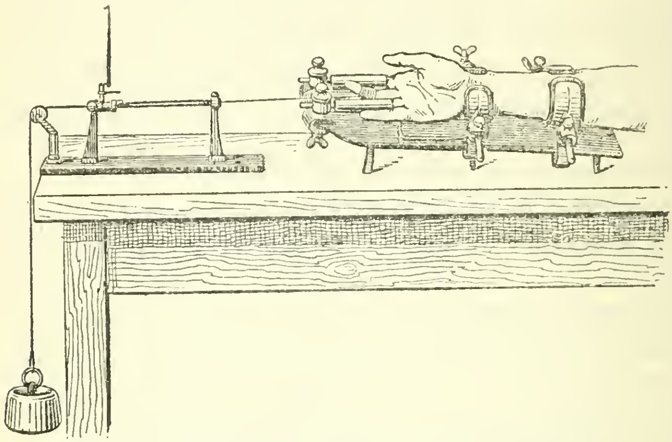

Fig. 10. Diagram showing the arrangement of the apparatus for carrying out ergographic experiments.

ments. Most observers have found an initial increase in the amount of work which can be done in this way after taking alcohol. Rivers has pointed out that the results obtained are extremely liable to the influence of suggestion. In Rivers' own experiments an attempt was made to avoid such sources of disturbance by giving alcohol disguised by strongly tasting other substances, so that on some days the subject of the experiment received a control mixture without alcohol, while on other days he received a mixture of the same taste but containing alcohol. In these circumstances he found that small doses, varying from 5 to 20 cc., of absolute alcohol had no effect either immediately or within several hours of their administration on the amount or nature of the work performed with the ergograph. He concludes that the results previously obtained by other workers were certainly due to defects of experimental method. With larger doses of 40 cc. he obtained evidence in one case of an increase in the amount of work, but the increase was uncertain and inconstant and might have been due to disturbing factors. With large doses, e.g. 80 cc., Hellsten found not only a distinct decrease in the amount of work, but also irregularities in the muscular contractions. After all, however, this is only what one would expect from ordinary experience. What is interesting is that moderate doses, such as would be contained in a pint of beer or half a bottle of wine, rather increase than diminish the power of carrying out the easy and monotonous muscular contractions which are investigated by the ergographic method. Rivers suggests that the improving effect of alcohol on such contractions is produced by the removal of some controlling influence which serves to keep in check muscular activity. Thus, both he and Mosso have found that in some persons mental fatigue may be associated with a decided increase in the output of work as recorded by the ergograph method. It may be that in both cases there is a dulling of the sensations of fatigue which normally diminish muscular effort and tend to bring it to an end. More important probably, in the apparent stimulating effect of alcohol as observed in ergographic experiments, is the modification of the state of consciousness that it induces. Emotional conditions have a very pronounced influence on the ergographic curve. Rivers says, "It is almost certainly through its emotional aspect that interest acts. It is also probable that pleasurable emotions have a greater effect on the capacity for work than unpleasant emotions. It is an undoubted fact that alcohol in most people produces a pleasurable emotional condition, and it is the production of this condition which has been the chief motive in making the use of this substance so widely prevalent among mankind. It is possible that there is some kind of relation between the occurrence of pleasurable emotion and the increase of the capacity for muscular work." In this sentence we find the real secret of the relation of alcohol to work. Successful activity requires as a condition not only pleasure in the work itself but also a state of contentment or joy in life, with all its concomitant effects on the circulation, nutrition, and other functions of the body. If moderate doses of alcohol can add to this pleasure without interfering with the execution of the work, its consumption will improve the quality and amount of the work done.

It may be interesting to mention here the results of some of the other attempts which have been made to test by scientific means the effects of alcohol on the more difficult or more complex processes of muscular co-ordination or intellectual effort.

For this purpose experiments have been carried out by Macdougall, using the 'dotting machine' as a means of measuring the effects of alcohol or drugs.

"This machine is a mechanical device whereby a continuous band of paper tape about one inch wide is drawn behind an opening or window in the top of the desk, by a weight-driven clockwork movement. Along the width of the band small red circles are distributed in as irregular a manner as possible, but at equal intervals. The test consists in marking the red circles with a stylographic pen as they pass before the subject's field of vision. For these experiments a length of tape six metres long was the standard. This consisted of 1200 small red circles, and the machine was so adjusted that the circles passed before the field of vision at a uniform rate of 5·8 a second. In each metre fifteen circles at irregular intervals were coloured blue beforehand, and these, when they appeared, were not to be dotted, but instead, the right hand had to be lifted to avoid marking the circle, while with the left hand a key to be tapped, which, being attached to a pen arrangement under the lid of the machine, marked the tape and thus showed if the key had been tapped. It was possible to get by this means a very fine test of one's power of inhibition.

Errors were of four types :

(*a*) A circle allowed to pass unmarked.
(*b*) A blue marked which ought to have been left unmarked.
(*c*) An extra dot inserted between two circles.
(*d*) Slight deviations in either a lateral or vertical direction from the circles aimed at."

In the experiments on the action of alcohol, a test was made on the subject and the number of errors made was noted. A dose of alcohol, varying from 10 to 30 cc. of absolute alcohol mixed with three parts of water (i.e. a stronger solution than port wine), was taken *on an empty stomach,* and one hour later the test was repeated. Macdougall found that in these circumstances, after a dose of 10 cc. there was an average increase in the number of errors of 21 per cent, after 15 cc. of alcohol an increase of 42 per cent, after 20 cc. an average increase of 39 per cent, and after 25 cc. an average of 113 per cent. Macdougall remarks that a quite common subjective effect in many alcohol experiments was a pleasant conviction that the dotting was very good, and this view persisted even after the delusive nature of the experience was known, so that the subject frequently thought that alcohol was not having its usual effect, only to find the customary increase in the errors when they were counted. It is worthy of note that in two or three cases with the smaller doses there was no increase in the number of errors and indeed a slight diminution ; in all these cases the observer described himself before performing the experiment as "very tired." We shall have occasion later on to revert to this point.

Macdougall also employed the memorising of a list of related words, e.g. mountain, plain, ugly, beauty, Venus, etc. The list was read to the subject at a uniform rate of one word in two seconds. After the list had been read through once, the subject, having been told the first word, had to reproduce verbally the complete list in right sequence. Here again, in contrast to the experiments on the memorising of unrelated words previously mentioned, the effect of 15 cc. of alcohol on an empty stomach was to increase the number of errors from an average of seven to an average of eighteen.

It is important to remember that these results were only obtained after taking a dose of strong alcohol on an empty stomach. When the experiments were repeated with the modification that the alcohol was taken with a meal, it was found that alcohol to the amount of 30 cc. had very little effect so far as these tests were concerned, and the subjective effects were equally little marked. The meal was a light one, usually tea, bread and butter, and an egg.

It is interesting to compare the results of alcohol with those of morphia or opium. The maximal effect of opium was obtained after taking 75 to 115 minims of the drug in the form of tincture ; the doses generally varied from 40 to 90 minims. In practically all the experiments opium caused a decrease in the average number of errors in the dotting test, varying from 20 to 30 per cent, and 58 per cent decrease in the average number of errors in the memorising tests. In the latter case the time also for reproducing the list of words was much diminished. This temporary increase of mental alertness and efficiency may be one of the reasons of the danger of opium, at any rate for the active brained European.

Our knowledge of the physiology of the nervous system is not sufficiently profound to enable us to give a complete description of the first effects of alcohol in purely physiological language. Although the mentality and behaviour of man falls into the schema worked out by a scientific study of the lower functions, for all the finer details we are compelled to use the common method of description, involving terms of consciousness, and the first results of alcohol on the behaviour of man can be as accurately described by a novelist who is a competent observer of his fellow-creatures, with no expert knowledge, as by a professed physiologist or physician. Although alcohol is commonly spoken of as a stimulant, its first effects on human behaviour are due, not to a process of stimulation, but to a diminution of function of the highest level neural mechanisms. Thus, in contradistinction to morphia, it diminishes a man's highest powers of performance and expression, but in so doing it releases the next level from control,—deliberation, self-consciousness, and self-criticism, as well as criticism and suspicion of his fellows being diminished. He becomes more self-confident, communicative, interested in his company, and reflecting its various moods. In some individuals, indeed, in whom the power of self-criticism and the habit of deliberation are developed to an abnormal extent, so as to produce an unwarranted diffidence or hesitation in action, moderate doses of alcohol may actually improve the efficiency of performance, and a man ordinarily reticent and apparently dull may become really witty and eloquent without needing an obfuscated audience for his appreciation. Such a man, for instance, may play a better game of golf after lunch with a glass of whisky, or may carry out a not too difficult surgical operation with greater brilliancy than in his normal hesitating condition. Such cases, however, represent the exception rather than the average, and it is evident that the effect of alcohol on the intellectual powers and capacity for doing things will depend on the extent to which these involve the highest and latest evolved nervous mechanisms. In proportion as this is the case we shall expect to find them slowed or adversely affected, though in any investigation on this point we shall continually meet with apparently contradictory results, due either to the removal of a hypertrophied and therefore injurious control, such as in the cases just mentioned, or to indirect effects due to the arousing of interest or induced by the environment. We have already seen that alcohol may have different effects or ergographic tests according as the individual experimented on knows whether he is taking alcohol or not. It has been claimed, with what truth I know not, that poets, musicians, and painters have derived inspiration from the effects of alcohol. It may be so if we take into account the increased receptivity to extraneous impressions and the freer play given to the emotions under the influence of alcohol. I do not think, however, that alcohol would facilitate the solution of the more complex intellectual problems, or the formulation of great generalisations of science. The same thing seems to apply to those feats which are merely muscular but which involve the finest co-ordination of movement. No professional acrobat or juggler would take a dose of alcohol immediately before he had to perform the feats on which his livelihood depends.

If we regard only the subjective effects of moderate doses of alcohol, it would seem that its chief value is in promoting repose and in affording a respite from the continual effort at adaptation to environment, and from the perpetual necessity of reconciling our personal advantage with the requirements of the society in which we live. As McCurdy points out: "The normal man endeavours to escape for a time from responsibilities which seem too great for him by drugging himself with cheap fiction, theatres, and moving pictures; he takes vacations, he indulges in vicarious prowess and adventure in watching games and prize fights; above all he forgets himself in social intercourse. But when a man is tired or oppressed with care, how can he forget his obsessing anxieties or his self-consciousness sufficiently to become sociable? He can take a drink, and he does. If he be normal a small amount of alcohol will give the necessary relaxation. Conviviality is more important for the maintenance of our mental stability and effectiveness than we realise. It is because alcohol contributes to sociability that it holds the strong position it does among so many people."

In this respect there is a wide difference between alcohol and the narcotic drugs, and the difference in the social attitude towards these two classes of substances is explained by the differences in their psychological effects. McCurdy remarks that an opium den shows little trace of sodality, while innumerable people, on the other hand, are made happier, and therefore healthier, by moderate indulgence in alcohol.

CHAPTER VI

THE EFFECTS OF ALCOHOL ON FATIGUE

FATIGUE implies a diminished capacity of the body to carry out any of its functions as a result of past activity. It is evident that many different conditions are included in the term fatigue. Thus, on the subjective side we can distinguish at least three types, namely: (1) local sensations of fatigue, especially in the muscles, which may amount even to pain; (2) a feeling of general tiredness and incapacity for effort; (3) the sensation we call sleepiness. Fatigue may result from muscular effort, from intellectual or mental work, or from deprivation of sleep. In many cases, if not in all, the feeling is protective in function and implies relative rather than absolute incapacity. Thus, if the arm is held out for some minutes, a disagreeable sensation is experienced in the muscles of the shoulder which becomes almost insupportable. But if the subject perseveres he may find that after a time the disagreeable or painful sensation grows but little more intense after the first few minutes, and he may continue to hold out the arm for another half-hour. In a condition of hypnosis an individual may hold up a limb against the force of gravity for a considerable time without showing any symptoms of fatigue. Evidently this fatigue is of the nature of a protection against the possibility of injury through excessive activity. In all these types of fatigue the relativity of the feeling is shown by the effects of a sudden new arousal of interest. Thus, after a tiring evening's work when we are ready to go to bed, we may take up an exciting novel and find as a result that all the tiredness and sleepiness disappear, and we may read well on into the morning until the feelings recur. Many a man has come in tired, after a hard day's climbing, and yet on hearing of a fellow-mountaineer in distress has been able to take part in a search party and to carry out active muscular efforts perhaps for another twelve hours.

These symptoms of fatigue are always the expression of changes in the central nervous system. We may refer them to an altered relation between the resistance at the 'synapse,' which has grown up as the result of previous activity, and the amount of nervous energy, produced by interest, emotion, or excitement, which is available for overcoming the resistance.

The protective character of fatigue is shown in all these cases by the greater fatigue ensuing after the added effort, and the longer period of time required for complete recovery from its effects. This conception of fatigue is, however, complicated by the fact that in one case at least, namely, when caused by loss of sleep, there is evidence of a distinctly lower resistance for some reactions. Thus, in some experiments by MacDougall and Miss Smith, undertaken in order to determine the action of alcohol on fatigue, this state was brought about by a voluntary cutting down of the normal amount of sleep for three nights. During the first night one and a half hours' sleep was taken, during the next night three and a half hours, and on the third night five and a half hours. This deprivation of sleep caused a fatigued condition which divided itself into two distinct phases.

(1) A phase of about three days' duration, when fatigue acted apparently as a stimulant; during this time the errors on trying the dotting machine test were fewer than in the normal state. (2) A second phase which lasted

about thirteen days, when the errors gradually rose to a number considerably higher than normal, followed by a somewhat irregular return to the normal. MacDougall suggests, to explain this peculiar result, that the nervous system, when subjected to strain, maintains its efficiency for a time by producing a substance similar in its effects to drugs such as strychnine, opium, and caffeine, and which, perhaps, like them is of the nature of a poisonous alkaloid.

It would hardly be expected, in view of the complex character of the conditions grouped together as fatigue, that we should be able to make general statements as to the action of alcohol on fatigue which shall be applicable to all manner of conditions. We must be content with recording the action of alcohol as it has been tested by common experience or by experiment in various circumstances. Sometimes in moderate doses it may remove fatigue, i.e. increase for a time the capacity for work. This effect may be due to its action as a narcotic in diminishing the intensity of the unpleasant sensations arising in the group or groups of muscles which are being exercised. In this way we may probably account for its reinforcing effect on the contractions of the isolated groups of muscles which are investigated in the ordinary ergographic experiments. Or the taking of alcohol may increase in some indirect way the amount of nervous energy available, so that the increased resistance to the passage of nervous impulses which has arisen as a result of previous activity becomes negligible. An agreeable taste may act in this way, as in those experiments in which the reinforcing effect of a dose of whisky on the ergographic tracing has been found to be more marked than that of a corresponding dose of alcohol of which the taste was disguised. Moreover alcohol renders the subject more susceptible to emotions impressed on him by the company or surroundings in which he happens to be, and these induced emotions may be responsible for furnishing the greater degree of nervous energy which is required to overcome the resistance of fatigue. It is a familiar experience for a man to go out to dinner tired out by his day's work, and under the influence of a small amount of alcohol and congenial company to throw off, as it is termed, his fatigue and spend many hours in lively conversation or even such muscular exercise as dancing. It is well known by mountain climbers, and confirmed by a man like Durig, who is at the same time a trained mountaineer and physiologist, that, when a member of a party is utterly exhausted and can proceed no further, two methods are open: either he must rest for a couple of hours before he resumes his journey, or, if the effort which remains to be done is a short one, he can be made to accomplish it by a dose of brandy. The effect of this dose is only temporary, but may be sufficient to get the man into a place of safety where he can be allowed to rest. It is not a method which can be repeated. On this account it is usual among mountaineers to avoid any form of alcohol until the ascent and the difficult part of the descent have been completed. In all such cases alcohol only puts off fatigue, and its use is not to be recommended when the effort must be extended over several hours.[1]

If we may draw general conclusions from these observations, we may say that in ordinary circumstances the use of alcohol will not ward off fatigue, its general tendency being to promote repose and so allow of recovery from fatigue. In exceptional circumstances a moderate dose of alcohol may for a time abolish the sensation of fatigue, or create an emotional drive which will enable an individual

[1] It is possible that the sleeplessness sometimes produced by alcohol may be of the same nature as the stimulant effect of deprivation of sleep which has been alluded to above.

to overcome temporarily the effects of fatigue, so making him capable of continuing his efforts beyond the period at which they would otherwise have come to an end. This increased work is in the nature of a call upon capital, which must be repaid later by a prolongation of the period of rest.

CHAPTER VII

THE INFLUENCE OF ALCOHOL ON DIGESTION

MANY different processes and functions of the body, both chemical and nervous, are involved in the series of acts which determine the digestion of the food. All these are directed so as to alter the food in such a way as to render its constituents soluble and capable of absorption through the walls of the alimentary canal into the blood, by which it may be carried to all parts of the body.

When food is taken into the mouth it becomes moistened by the fluid saliva, which is poured out into the mouth. This fluid is the product of secretion of the salivary glands, which are situated in the floor of the mouth beneath the tongue, and also at the back part of the cheek, and are connected by tubes—ducts—with the cavity of the mouth. The secretion of saliva depends on a reflex nervous mechanism set into action either by the chemical stimulation of sapid substances or by the mechanical stimulation afforded by the act of chewing. The use of this secretion of saliva is twofold. In the first place, it moistens the food, aids mastication, and renders it easy to swallow; in the second place, it begins the process of change and solution of the food, which will be continued in the lower parts of the alimentary canal. Human saliva is a slightly alkaline fluid containing a small proportion of solids and also small traces of a ferment called *ptyalin*. This ferment acts upon boiled starch, converting it into dextrin and sugar (maltose or malt sugar). If a weak half per cent solution of boiled starch is taken into the mouth, kept there for twenty seconds, and then expelled into a test-tube, it will be found that the starch has disappeared and that in its place the fluid contains a sugar. Starch gives a deep blue colour when treated

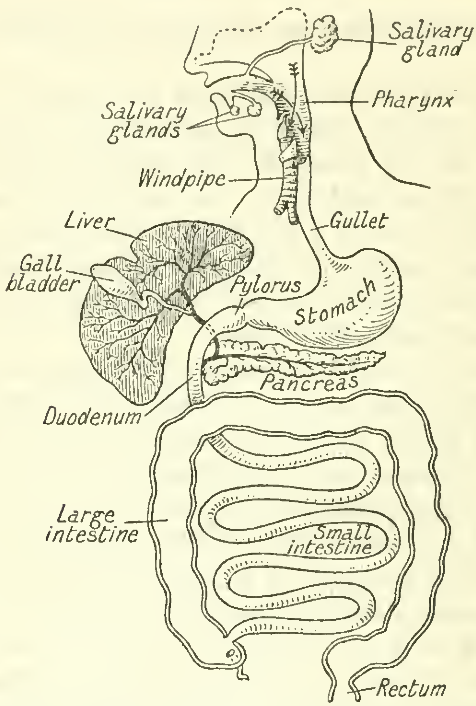

Fig. 11. General scheme of the digestive tract, with the chief glands opening into it.

with iodine; the fluid expelled from the mouth will be found to give either no colour or a red colour with iodine, and also to give the ordinary reactions for sugars (reduction of an alkaline salt of copper on boiling).

It is evident that the saliva will only have a short time to act on the food while it is in the mouth, but the action is continued for a while after the food has passed into the stomach, so that, twenty minutes after the food has been swallowed, the greater part of the cooked starch in the food will be found to have been converted into dextrin and sugar.

The stomach is a large distensible sac with thin muscular walls. The sac is lined with a mucous membrane, the surface of which presents fine pits, which are the openings of tubular glands forming the greater part of the thickness of the mucous membrane. The stomach is large enough to receive the whole of the food taken in at a meal and is designed so as to submit the food to a preliminary digestion and then to pass it on in small quantities at a time into the more delicate intestine, where digestion is completed and the products of digestion are absorbed. The process of gastric digestion is carried out by a digestive juice secreted by the tubular glands of the mucous membrane. This juice is strongly acid, containing in man about 0·2 per cent to 0·4 per cent pure hydrochloric acid. In the dog the percentage of this acid may rise as high as 0·6 per cent, equivalent to 1·8 per cent solution of the strong spirits of salt, the watery solution of hydrochloric acid which is generally sold under this name.

The ptyalin of saliva will only act in a neutral or faintly alkaline reaction, so that the first effect of the acid of the gastric juice is to stop salivary digestion and destroy the salivary ferment. The acid has also an important office in preventing putrefaction and destroying most micro-organisms, e.g. those of typhoid fever, so that the food after gastric digestion enters the intestine practically sterile. The gastric juice contains a special ferment, pepsin, which in the presence of dilute hydrochloric or other acid has a digestive action on the proteins or albuminous constituents of the diet. Under its action boiled white of egg or meat fibre is dissolved, and a series of soluble diffusible products are formed, which are known as albumoses and peptones. The gastric juice also dissolves the connective tissue framework holding the meat fibres together and surrounding the fat globules. In this way the fat is set free and prepared for digestion by the special ferments which it will meet on arrival at the small intestine. For the proper carrying out of gastric digestion there must be a secretion of gastric juice corresponding to the amount of food taken into the stomach. Two factors are concerned in this act of secretion, namely, nervous and chemical. The nervous mechanism is analogous to that responsible for the secretion of saliva. It is not however identical, because it seems to be excited, not so much by the presence of food in the stomach, as by the taking of food into the mouth. In this nervous act there is a strong psychical element. If we observe an animal in which a hole has been made into the stomach so as to be able to measure the amount of gastric juice secreted, we find that when it is hungry, merely showing it a piece of meat will induce, not only watering of the mouth—a phenomenon with which we are familiar in ourselves—but also a flow of gastric juice. Appetite and relish of the food are thus important factors in the promotion of a proper formation of gastric juice. When the secretion is well established it can be easily checked by any unpleasant emotions, such as fright, pain, or anger, and it is a familiar human experience that an unpleasant emotion in the middle of a meal will not only take away further appetite but will interfere with the digestion of the food already taken. In this case there can be no doubt that the effect of the emotion has been to inhibit or stop any further secretion of gastric juice.

The chemical factor is less subject to nervous control. It becomes important during the later stages of gastric digestion and seems to be due to the action of the first products of digestion. These products act on the mucous membrane of the further end (the pyloric end) of the stomach, causing the production of some substance, which is carried by the blood to all the glands of the stomach, exciting them to secrete, thus continuing the action inaugurated by the nervous mechanism.

Just before a meal the muscular walls of the stomach are contracted, and this organ is small. There may be occasional rhythmic contractions which travel slowly along the wall of the stomach and are associated with the 'hunger pains'—the indefinite sensations which may be experienced when a meal is delayed beyond its normal hour. As a meal is taken the walls give to the incoming food, escape of food in either direction from the stomach being prevented by two muscular rings, one at the junction of the stomach with the gullet, which is known as the cardiac sphincter, and the other at the junction of the stomach with the small intestine, known as the pylorus or pyloric sphincter. About twenty minutes after taking a meal rhythmic contractions begin in the wall of the stomach. The effect of these is to mix the food thoroughly with the gastric juice and to press it on towards the pylorus. At first the pylorus remains firmly closed, but as digestion proceeds and the contents of the stomach become more acid, it opens occasionally, allowing a few cubic centimetres of the fluid gastric contents to be expelled into the small intestine. The frequency of opening of the pylorus increases as digestion proceeds, the greater part of the contents of the stomach being expelled at a time varying from two and a half to three hours after a meal. The food is thus presented to the intestine in small quantities at a time and in a half-digested state, the solid particles having been broken up, the starches converted for the most part into sugar, the proteins into soluble albumoses and peptones, and the fat having been set free and floating as drops of oil in the surrounding fluid. No absorption, either of water or of the products of digestion, occurs from the stomach itself. Thus the bulk of solid and fluid which leaves the stomach is greater than that which has been taken by the mouth by the amount of gastric juice which has been secreted. The total bulk may thus be increased 50 per cent to 100 per cent.

As the strongly acid, semi-digested gastric contents are squirted in small quantities into the beginning of the small intestine, they come into contact with three digestive juices, namely, the intestinal juice, secreted by the small tubular glands lining the small intestine, the pancreatic juice, formed by a special organ lying at the back of the abdomen known as the pancreas, and the bile, a product of secretion of the liver. The secretion of all these juices is effected by a chemical mechanism. The acid of the gastric contents acts upon the cells of the intestine, producing in them a substance known as *secretin*. This secretin is absorbed by the blood vessels, carried all round the body, and finally reaches the pancreas, the liver, and the glands of the small intestine. On all these it has a drug-like action, causing secretion, so that the entry of gastric juice automatically excites in the next segment of the alimentary canal the formation of the juices necessary for completing the act of digestion. All these juices are alkaline. Since they are produced only so long as the action of the acid in producing secretin persists, the quantity formed just suffices to neutralise the fluid which has entered the small intestine, and all the rest of the digestive processes which occur in the twenty or thirty feet of small intestine take place in a neutral medium. These three juices act on all classes of foodstuffs, the bile being especially important for the digestion and absorption of fats. The proteins are finally completely broken down into their constituent amino-acids; the starches are converted into grape sugar, and the fats are split up into fatty acid and glycerine, the fatty acids being dissolved in the bile or combining with the alkalies of the juice to form soaps, which are then dissolved by the bile. Thus the whole bulk of the food eaten is transformed into soluble products.

Since the secretion of the three juices, pancreatic juice, intestinal juice and bile, is excited by the entry of the acid stomach contents into the small intestines, it is evident that the efficacy of intestinal digestion depends on that of the gastric digestion. If the stomach reacts normally and produces gastric juice appropriate in amount, acidity, and digestive strength to the food that has been taken, the rest of the processes of digestion will follow automatically. The food passes down the gut under the influence of the intestinal movements, carried out by the muscular wall of the tube. The soluble products of digestion are absorbed as fast as they are formed into the blood vessels lying just under the mucous membrane. The processes of digestion and absorption thus go on contemporaneously, and are practically complete by the time that the intestinal contents arrive at the lower end of the small intestine. A small amount of fluid material, consisting chiefly of insoluble constituents of the food, e.g. the cellulose of vegetables and fruits, passes on into the large intestine. Here it becomes inspissated, and is gradually passed on along the large gut, finally leaving the body as fæces. On an ordinary civilised diet 90 per cent to 93 per cent of the constituents of the food are absorbed, so that there is very little waste occurring by loss in the fæces.

We must now consider the influence of the presence of alcohol, in proper dilution, on the various events in the long series of processes which make up the act of digestion.

A number of researches have been carried out, especially by Roberts and by Chittenden, on the influence of alcohol and alcoholic beverages on the action of the digestive juices when investigated outside the body. We can collect saliva and let it act upon boiled starch in a test-tube. Similarly from an animal we can collect pure gastric juice, or pure pancreatic juice, or bile, and investigate the digestive action of these juices when mixed with proteins, fats or carbohydrates in a glass vessel and kept in the laboratory at body temperature. In fact, these experiments are carried out by medical students in order to study the action of the various juices.

Such experiments may however be misleading if we attempt, without further consideration, to draw conclusions from them as to the influence of alcoholic drinks on digestion as a whole. For this, as we have seen, is not a single chemical reaction carried out in a glass vessel, but it is a whole series of co-ordinated processes, each of which depends on the one which has preceded it and is subject to continual regulation according to the nature and reaction of the contents still remaining in the alimentary canal. These contents are subjected themselves to constant modification; the soluble products are being continually absorbed and removed from the reaction, and any production, e.g. of acid, evokes a reaction in the shape of increased secretion of the intestinal digestive juices. In the same way the nature and reaction of the contents will affect the movements of the muscular walls of the canal, producing increased or decreased rate of passage through the pylorus or along the intestine, as may be appropriate for the success of the whole process and for the well-being of the animal. Moreover, although no water or any of the ordinary constituents of food, sugar, fats, or proteins, are absorbed from the stomach, this does not apply to alcohol which, as we have seen, is absorbed from the stomach itself fairly rapidly. Thus in one experiment by Chittenden, 50 cc. of 20 per cent alcohol were introduced into the stomach of a dog, and on withdrawal of the stomach contents half an hour later no alcohol was found in the 40 cc. of fluid obtained. In another animal in which the pylorus was closed, 200 cc. of 37 per cent alcohol were completely absorbed in three hours. In this case, the animal being under an anæsthetic, the processes of absorption would be much slower than under normal conditions. It is evident therefore that, even if we start with as much as 10 per cent of alcohol in the stomach, the amount of this substance will diminish rapidly and steadily, and if any is carried on with the food into the small intestine it will very quickly disappear as the result of absorption from the walls of this tube. It is necessary to bear these facts in mind when attempting to evaluate the results of the experiments on the influence of alcohol on digestion, as carried on outside the body.

When dilute alcohol or alcoholic beverages are taken into the mouth they cause an increased flow of saliva, in this respect resembling any other sapid substances, and especially weak acids such as vinegar. The acceleration of secretion only lasts a short time after the fluid has left the mouth. Not only is the amount of saliva increased, but there is an increase also in its solid contents and its starch digesting powers. When alcohol is added to a mixture of boiled starch and saliva in a test-tube, its presence has very little action on the rate of digestion ; with 5 per cent of alcohol there may be a slight increase, and even with 10 per cent there is only a slight retardation in the solution of the starch. If instead of using alcohol we use beverages such as spirits or wines, a marked retarding influence may be observed, but this is due solely to their acid properties and may be abolished by neutralising the fluids before adding them to the salivary digest. We are here concerned, not with any specific action of alcohol, but with the fact that salivary digestion must occur in a neutral or faintly alkaline medium. Lemon juice or vinegar would have a greater retarding effect than wine or spirits. Tea also is observed to have a strong retarding effect, presumably on account of its content in tannin.

So far as salivary digestion is concerned the influence of alcohol may be said to be negligible, any effect of wines and spirits depending not on their alcoholic content, but on their other constituents, many of which are common to them and the non-alcoholic drinks such as lemonade or tea.

The Effect of Alcohol on Gastric Digestion

It has been shown by many observers that alcohol acts as a direct stimulant of gastric secretion. If alcoholic fluids are introduced into the stomach there is a rapid secretion of an active gastric juice rich in hydrochloric acid. This effect is not entirely due to the direct stimulation of the mucous membrane of the stomach, since a similar increase of secretion has been observed to follow introduction of dilute alcohol directly into the small intestine or into the rectum. The repeated introduction of strong alcohol into the stomach may cause, as we shall see later, damage to the mucous membrane and diminished secretion of gastric juice accompanied with increased formation of mucus. But there is no question that in moderate concentrations, and it is only these with which we are now concerned, alcohol acts as a direct stimulant to gastric secretion.

When we investigate the influence of alcohol on a digestive mixture outside the body, we find that pure alcohol has practically no influence up to a content of

5 per cent. With 5 to 10 per cent of absolute alcohol, which is equivalent to 10 to 20 per cent of proof spirit, there is a distinct retardation of the rate of digestion, which with a 15 per cent alcohol content may be depressed to a quarter or even a third of the normal rate. The weaker the gastric juice the more noticeable is the inhibitory effect of a given amount of alcohol. Normally we may say that there is no appreciable retardation of the solvent action of the gastric juice until the stomach contents contain 10 per cent of proof spirit. The ordinary spirits, whisky, rum, brandy, and gin, have practically no more action than corresponds to their content in alcohol. With certain wines both Roberts and Chittenden have found that the retardation is greater than can be accounted for by the action of alcohol. Thus 5 per cent of sherry has a greater retarding effect than 5 per cent absolute alcohol. The same effect, though less marked, is observed with claret. The retarding effect seems to be due to the solids contained in the wines and is comparable with that which is produced by the addition of such beverages as tea or coffee. It is possible that the tannin content of the wines is largely responsible for the retardation which has been observed. These wines will therefore have a double action on gastric digestion—a stimulating action on the secretion of gastric juice, due to their alcoholic content, and a slight retarding effect on the process of solution, due to their solid constituents. Roberts observes: "If we consider the copious proportions in which hock and claret are used dietetically it becomes evident that their retarding effect on peptic digestion is often brought into play. A pint of claret or hock is a common allowance, and such a proportion would not be without considerable effect. On the other hand, the more sparing use of these wines, a glass or two with dinner or luncheon, would not produce any appreciable retarda-

tion of peptic digestion, but would, like corresponding doses of sherry, act as pure stimulants." Chittenden, in quoting this passage, expresses his entire agreement with the conclusions therein contained.

Any serious alteration in the movements of the stomach might cause a considerable effect on the processes of gastric digestion. There is no evidence however that in moderate doses alcohol affects the intestinal movements. Carlson has found that the hunger contractions of the stomach may be checked by taking a small dose of dilute alcohol. The same effect would however be produced by any other kind of food. It may be that the so-called carminative effect of alcohol, i.e. the relief of gastric pain and cramp as a result of the ingestion of a small dose of brandy or whisky, may be brought about in a similar way.

When we take the processes of digestion as a whole we must remember that alcohol is very rapidly removed from the stomach by absorption, so that it would seem possible that the stimulating effect of alcoholic fluids upon the secretion of gastric juice would be more lasting than any inhibiting action on the chemical processes of digestion. Chittenden, in a number of experiments on dogs with gastric fistulæ, compared the rate of digestion of a given test meal, to which water had been added, with the rate of digestion of a corresponding meal containing alcohol or some alcoholic beverage. The results as a whole showed that the period of gastric digestion is not appreciably altered under the influence of alcohol or alcoholic beverages, and he concludes that such beverages do not as a rule greatly modify the ultimate result of gastric digestion.

These results are however drawn from animal experiment and might be equally applicable to a field labourer in whom work, rest, hunger and satiety follow one another in the regular sequence of a healthy animal existence. It must be remembered that in the dog, as in man, the secretion of gastric juice inaugurates the whole sequence of processes which are required for the proper digestion and assimilation of a meal. This secretion is dependent on appetite in its widest sense and is inhibited by unpleasant emotions. Anything which adds to the enjoyment, or to the anticipated enjoyment, of a meal or to the removal of disturbing states of mind, which in man will include worry, anxiety, intellectual over-activity, anything, in short, which promotes a sense of ease and well-being, will increase the appetite and promote the normal physiological processes of digestion. This is probably the great value of alcohol in civilised life. It is part of the action on the central nervous system which we studied in a previous chapter. It cannot therefore be investigated on lower animals, but can be deduced only from the results of human experience. Wine with the chief meal at the end of the day's work is part of the amenities of civilisation, like the clean cloth, flowers on the table, a warm room, and a congenial companion; it is part of the comfort devised by civilised man for the promotion of repose and repair after the day's work. Animal experiment has sufficed to show that the deleterious effects of alcohol on the chemical processes of digestion are so small and transitory that they may be far more than counterbalanced by the advantages of its effect, when used in moderate quantities, on the central nervous system in the promotion of appetite and the production of the sense of well-being.

In view of the rapid absorption of alcohol from the alimentary canal—an absorption which would be still more rapid from the intestine than from the stomach—the chemical investigation of the influence of this substance on intestinal digestion seems of less importance. As we have seen, anything which increases the flow of gastric juice will indirectly evoke an increased production of pancreatic juice, bile, and intestinal juice. If we investigate the action of pure pancreatic juice on foods with and without the admixture of alcohol, we find that the interference with digestion is more profound in this case, even 2 to 3 per cent of absolute alcohol being sufficient to produce a distinct retardation of the processes of solution. The addition of wines is more effective in retarding pancreatic digestion than that of alcohol, but in this ease the effect is due almost entirely to the acidity of the fluid and would be produced equally by the addition of lemonade. Under normal circumstances the acidity of the products of digestion which pass from the stomach into the intestine is itself the cause of an increased secretion of the intestinal and pancreatic juices which are produced in quantities just sufficient to neutralise the acid of the stomach contents.

We may conclude therefore that, taking into account the very small percentage of alcohol which is ever likely to reach the intestine and the rapidity of absorption of this substance from the intestine, it is extremely improbable that alcohol, in proper dilution and in moderate doses, can ever be credited with a retarding action on intestinal digestion.

The effect of alcohol on the central nervous system thus remains as the most important criterion of its use or abuse. Provided that alcoholic beverages are used in such moderation that their action on the central nervous system can only be regarded as beneficial to the man as a whole in fitting him for his daily work, its action on digestion will probably also be beneficial. It is the influence of alcohol on the nervous system which must determine for each man the amount of this substance which he can take regularly or occasionally with benefit to himself and the society in which he lives.

CHAPTER VIII

THE EFFECTS OF ALCOHOL ON THE CIRCULATION OF THE BLOOD

THE popular idea, which credits alcohol with stimulant properties, is very largely based on the commonly observed effects of alcohol on the circulation in moderate intoxication, where the flushed face and the rapid full pulse are prominent features of the condition. There is no doubt that this common experience was in the first place responsible for the use of alcohol as a cardiac stimulant in cases of faintness, or in disease where there is enfeebled action of the heart. Let us inquire what scientific grounds there are for this use of alcohol in medicine.

In discussing the question we must begin with precise ideas as to what is meant by a circulatory stimulant. The value of the circulation of the blood to the organism is that by its means all parts of the body are brought into material connection, so that all the organs become members of one household. Food material—fats, carbohydrates, or proteins—are absorbed from the alimentary canal or taken from their store depots in the body and carried to the tissues, where they are required for the replacement of waste or for the furnishing of energy. Every cell in the body is supplied with oxygen absorbed in the first place by the lungs, and the blood in exchange takes back to the lungs for excretion into the surrounding atmosphere the carbonic acid produced in the cells. In the same way the soluble waste products of the activity of the different organs are poured into the blood to be transported to the kidney, where they are excreted in the urine.

The circulation of this common fluid is maintained by means of a central muscular pump, the heart, situated in the chest. At each contraction this organ expels the blood it has received from the veins into the great arteries, namely, the *pulmonary* artery which takes the blood to the lungs, and the *aorta* which supplies branches to all parts of the body. From the main branches of the aorta the blood passes through fine tubes with muscular walls, known as the arterioles, and these then break up into meshworks of capillaries which pervade every organ of the body. From the capillaries the blood is returned by veins which join finally to form two great trunks, the *venæ cavæ*, which pass into the right auricle of the heart.

In order that blood may be supplied to the different tissues according to their needs, it is necessary to maintain a certain head of pressure in the large arteries. In man we find that in these vessels the blood pressure varies at each heart beat between 80 to 120 millimetres of mercury, i.e. we have a head of pressure of about one-seventh of an atmosphere. In order to maintain this pressure there must be a resistance to the free outflow of blood from the great arteries, and to this end the muscular walls of the arterioles are kept by the central nervous system in a constant state of partial contraction, so that they only allow the escape of blood with difficulty. The arterial blood pressure, on which the circulation to the tissues depends, is therefore determined by two factors: (1) the amount of blood pumped out into the arteries, and (2) the resistance to the escape of blood afforded by the contraction of the small arterioles. With this head of pressure in the arteries, the central nervous system,

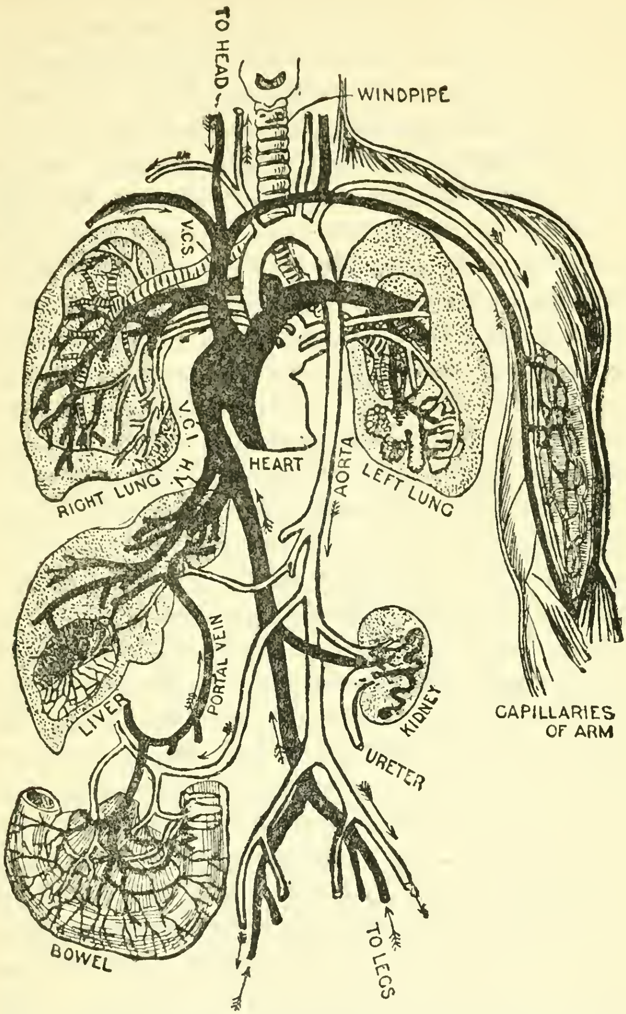

FIG. 12. Diagram of the circulation. The venous blood *black* in the vena cava superior and inferior and their branches, in the portal vein, and in the pulmonary artery. Arterial blood *white* in the aorta and its branches. In the left lung some air sacs are shown and the blood changing from *venous to arterial.* In the capillaries of the arm-muscles, bowel, and kidney the blood is shown changing from *arterial to venous.* In the kidney two tubules are shown. The kidney tubules purify the blood from urea, and pass the urine into the ureter. In the bowel three villi are indicated. These absorb the food. The food passes by the portal vein to the liver. A lobule of the liver is shown. The liver-cells prepare the portal blood. The blood passes from the liver into the vena cava inferior. The renal tubules, the air sacs, the liver lobule, and the villi are *really* of microscopic size. (L. E. Hill.)

the master tissue of the body, can always receive a sufficient supply of blood with its contained oxygen. If by any means there is a diminution of the arterial pressure, the central nervous system at once takes measures to raise the pressure again by constricting the arterioles of all other parts of the body, so as to maintain the pressure and therewith the circulation through the brain. The central nervous system controls not only the condition of the arterioles, but also the rate and force of contraction of the muscle which forms the heart pump. This control may be exercised reflexly or directly by the lower centres of the brain, those for instance contained in the *medulla oblongata*. But, as we have seen, every level of the central nervous system is subject to control or to reinforcement of its activities by the higher levels of the brain. Thus the heart may be quickened or slowed as a result of emotions. In the same way the blood vessels may be constricted or dilated—the pallor or flushing produced by different emotions is familiar to everyone. To produce these effects on the heart or blood vessels, the parts of the brain, whose activity is responsible for the production of emotions, act through the lower medullary centres. The higher parts of the brain may also affect the circulation indirectly. One of the main factors in increasing the return of blood to the heart is the contraction of the voluntary muscles, which press on the blood in the veins and send it on towards the heart. In this way, by increasing the inflow into the heart, muscular exercise increases the output from the heart and therefore tends to cause a rise of blood pressure; the increased inflow of blood may also reflexly affect the heart centres and cause a quickening of the pulse. The mere act of attention or volition, such as the preparation for running a race or for carrying out any willed movement, brings about a quickening of the pulse and respiration and a rise of blood pressure, even before any of the mechanical results of exercise on the circulation have come into play.

In view of the many and complex ways in which the circulation may be affected in the intact man, it is necessary to proceed with considerable caution in our endeavours to analyse the effects which may be produced by alcohol on the circulation.

There can be no question that the increased warmth of the skin and quickened pulse, which may be the earliest objective signs of the action of alcohol, are largely secondary to the effects of this substance on the general behaviour and mentality of the subject. Both these phenomena are the frequent concomitants of any state of excitement, especially if it be of a pleasurable character. As we have seen, alcohol produces a susceptibility to the excitatory effects of the environment, so that in congenial company the man who has taken alcohol may become more talkative, more pleased with himself, and freer in his movements. It must not be forgotten that some dilatation of skin vessels is a frequent result of taking any form of food. We must exclude so far as possible these indirect effects on the circulation before we can judge of the direct effect of alcohol on the circulatory mechanism. If a man sits perfectly still after a moderate dose of alcohol these effects become much less marked and less regular in their incidence. Even under these conditions some degree of flushing or dilatation of the superficial blood vessels occurs in the majority of cases. It is this dilatation which is responsible for the feeling of warmth in the skin after taking alcohol. In itself this dilatation would cause a lowering of the general blood pressure, which, however, could be compensated by contraction of the arteries of the internal organs or by increased rapidity of the heart beat. It is possible that the slight feeling of dizziness often experienced a few minutes after taking a small dose of alcohol on an empty stomach may be brought about by a fall of blood pressure. The feeling is as a rule transient, and disappears as the superficial dilatation is compensated for by the means just mentioned. The dilatation is not however constant and does not occur in all individuals, if the mental stimulation and excitement be avoided. In the same way the quickening of the pulse is itself inconstant, and in one series of careful experiments was observed to occur only in 45 per cent of the cases.

The healthy condition of an organ is shown, not so much by its ability to carry its resting load, i.e. to discharge its functions when reduced to a minimum, as by its power to adjust its work to the needs of the body as a whole. For this purpose every organ has a large margin within which it can carry out increased or diminished work. The heart for instance can increase eight or ten times the amount of work it carries out in the minute, according as the circulation has to be rapid or slow. The respiratory mechanism during violent muscular activity causes a ventilation of the lungs ten times as great as that occurring during repose. It is not sufficient then to investigate the action of a drug such as alcohol on a subject at rest. We must determine whether, under the influence of alcohol, the heart, or other organ of the body, has the same power of adapting its work to increased demands as in the absence of the drug. Does alcohol increase or diminish the power of the heart to expel its contents when these are increased, or when the resistance against which they have to be expelled is augmented by a rise of general blood pressure ?

We have as yet no sufficient answer to this question, though it is evident that it is on the answer that depends very largely the question of the employment of alcohol as a heart stimulant in disease. A number of experiments have been carried out on the isolated hearts of animals under more or less abnormal conditions. It is possible to maintain a rabbit's or a cat's heart beating for many hours simply by passing through its blood vessels a warm oxygenated salt solution. Dixon has found that in such a preparation the addition of up to ·1 per cent of alcohol to the circulating fluid may cause a distinct improvement in the condition of the heart and increase the strength of contraction. When the concentration of alcohol was increased above this amount, the effect tended to become depressant. These results have been confirmed by other observers, but it has been stated that when the alcohol is given dissolved not in salt solution but in blood, that is to say, under more normal conditions, no effect at all is observable with a concentration of ·1 per cent, and the only definite results obtained have been of diminished activity when the alcohol was raised to a concentration of over ·5 per cent. If the alcoholic concentration attains ·5 per cent in the blood of man, the individual is not only dead drunk, but is dangerously near death from acute alcoholic poisoning, so the obvious conclusion from these experiments would seem to be that alcohol in all ordinary doses has no direct effect on the heart.

Dixon ascribes the results he obtained with the salt solution to the fact that the hearts were being starved under the conditions of his experiment, and suggests that the alcohol acted in the same way as a similar dose of grape sugar in providing an easily combustible material, which could serve as a source of muscular energy. There is no question that the subject requires further investigation. It has not yet been proved that there is an actual oxidation of alcohol in the heart muscle, such as occurs in the body as a whole, and no proper tests have yet been made as to the influence of alcohol on the power of the heart to react to different conditions of filling and pressure. In man large doses of strong alcohol bring about a condition of collapse in which the heart beats very feebly, but this may be due to the direct irritant effects of the strong alcohol on the stomach and alimentary canal affecting the action of the heart reflexly. With sufficiently large doses one would expect alcohol to act on the heart somewhat like chloroform, but it is doubtful whether the necessary concentration in the blood is ever attained when alcohol is taken by the mouth.

We see that the experimental evidence with regard to the influence of alcohol on the heart is more or less negative. This is in marked contrast to the popular experience that alcohol may act as a cardiac stimulant and revive a feebly acting heart. Thus, if a patient faints as the result of a shock or a sudden injury, it is very usual to give him or her a dose of strong brandy with, as a rule, beneficial results. These are, however, probably not due to any direct stimulant action of the alcohol on the heart muscle but are brought about indirectly in one of two ways. In the first place strong alcohol could act by its directly irritant effect on the mucous membrane of the mouth and perhaps of the stomach, thus having an influence similar to that of ammonia or burnt feathers. It has been observed that taking strong brandy into the mouth may in some cases cause a quickening of the pulse which passes off when the brandy is ejected, but which may last twenty minutes if the brandy is swallowed and taken into the stomach.

The other factor involves the direct action of alcohol on the central nervous system. Thus, if a man is 'knocked out' at football, a dose of brandy is frequently administered to hasten his revival so that after a few minutes he may take up the game again. In this case he has probably received a severe blow on the abdomen or lower ribs, causing a reflex inhibition not only of the heart but of all the functions of the body. This reflex inhibition can be diminished by lowering the activity of the nerve centres. After the alcohol the individual does not feel any pain so acutely as before, but the same insensibility applies to the lower centres, so that they no longer interfere with the activities of the body as a whole by imposing on them an enforced rest, which is the result of the reflex inhibition and is part of the protective mechanisms of the body.

We need hardly describe here the effects of injecting alcohol directly into the blood stream in an anæsthetised animal, since the conditions are too abnormal and complicated to allow of deductions being drawn as to the influence of alcohol on the intact man.

The question of the use of alcohol as a stimulant in cases of disease is dealt with by Dr. Hutchison in the Appendix to this book. It seems possible that several factors may be involved in the undoubtedly beneficial results of the administration of alcohol in some cases of disease, where moderate doses of alcohol may produce a slowing and strengthening of the pulse with an improvement in the general condition of the patient. In the first place, an important action of alcohol in such cases is as a food. In febrile disorders as a rule the secretion of gastric juice is diminished or abolished, there is entire absence of appetite, and we must assume that all the processes of digestion as well as of absorption are retarded. In such cases alcohol, which is absorbed with great ease even from the stomach and which requires no digestion, is the most easily administered of any foodstuff. We have seen reason to believe that the starved heart-muscle may make use of alcohol as a food, though this fact has not been established beyond doubt, and we know that the body as a whole can deal with alcohol and oxidise it and make use of the energy so obtained in exactly the same way as it does with sugar. Moreover, alcohol is not subject to fermentative changes in the intestine, which may militate against the use of carbohydrates such as sugar, while the functions of the alimentary canal are at a low ebb. There is no need in such cases to give so much alcohol as to raise its percentage in the blood to the intoxication level. The healthy man can oxidise 7 to 10 cc. of alcohol per hour, so it is in small repeated doses that this substance should be given in order to produce its optimum results.

The value of alcohol as a food in diabetes has already been dealt with. Here the reasons for its employment are specific and the arguments we have brought forward for its use would not apply to other diseases.

In the second place, the dilatation of peripheral vessels, which is the usual effect of small doses of alcohol, may in certain cases cause a fall of blood pressure and relieve strain on the heart. It may also relieve fever by increasing the loss of heat from the body and so assist in the lowering of temperature. These results are however problematic.

In the third place, there can be no doubt that what we have called the narcotic action of alcohol in small doses may be of value to the sick man. Anything which relieves the sense of discomfort—the hundred and one trifles which make the sick man's life a burden—will tend to ameliorate his condition, to diminish the inhibitory effects of malaise on circulation and digestion, to relieve restlessness, and to promote repose and sleep. The sum of these results may bulk largely in determining a more rapid recovery from disease and the restoration to the body of its normal functions.

CHAPTER IX

THE INFLUENCE OF ALCOHOL ON RESPIRATION

THE maintenance of the life of a warm-blooded animal depends on a continuous series of oxidative changes occurring in its tissues. These oxidative changes are the source of all the energy involved in the activities which we denote as vital, and are utilised for the greater part in maintaining the temperature of the body at its normal level, which is usually higher than that of the surrounding atmosphere. A smaller fraction of energy appears in the more important form, from the human standpoint, of mechanical work. According to the activity of the animal, so the rapidity of the oxidative changes varies. Thus, a man at rest takes into his tissues about 350 cc. of oxygen per minute, but during violent exercise this may go up to 3000 cc. per minute. In sleep the intake of oxygen may drop to 250 cc. The oxygen absorbed is used immediately for the oxidation of the tissues and ultimately of the foodstuffs, with the production therefrom of carbon dioxide and water. Thus, if a man be in a confined space, the atmosphere around him becomes gradually poorer in oxygen and richer in carbon dioxide, and continual ventilation of our rooms is necessary in order that life may be maintained.

We may use either the consumption of oxygen or the production of carbon dioxide as a measure of the oxidative changes occurring in man or animals.

The exchange of carbonic acid for oxygen is carried out in the lungs, and the movements of respiration are adapted to maintain such a ventilation of the air cells of the lungs as to provide the blood circulating round them with sufficient oxygen for the needs of the body and to remove the carbonic acid as it is produced in the tissues. The activity of the respiratory movements, which produce the ventilation of the lungs, must vary according to the rapidity of the oxidative changes occurring in the body and must be accurately adapted to these changes. The extent and rhythm of the respiratory movements are regulated by the central nervous system, and especially by a limited portion of the brain situated in the *medulla oblongata* but extending upwards to the upper border of the *pons Varolii*. From this centre rhythmical impulses pass down to the motor centres of the spinal cord and determine just such movements of the respiratory muscles as are necessary for the adequate ventilation of the lungs. In order that these movements may be adequate, i.e. fitly adapted to the needs of the body, there must be some means by which the respiratory centre is informed of these needs, i.e. some factor which will vary according to the respiratory needs and which will affect the respiratory centre in proportion to its extent. We find that this factor or governing mechanism of respiration is represented by the pressure of the carbon dioxide in solution in the blood. Owing to the enormous area of the blood capillaries in the lungs (about two thousand square feet !), interchange of gases between blood and air, as the blood courses through the lungs, is practically complete, so that the pressure of carbon dioxide in the arterial blood is identical with the pressure of this gas in the air cells. We find by experiment that in the normal individual living at sea-level the respiratory centre is, so to speak, 'set' at a pressure of carbon dioxide amounting to 5·5 per cent of an atmosphere. Thus, if we analyse the air from the air cells of a man (known as the 'alveolar air'), we find that this contains 5·5 per cent of carbon dioxide when measured at atmospheric pressure. If the carbon dioxide percentage be increased in the alveoli, breathing increases first in depth and then in rate, with increased ventilation of the lungs as a result. If we pump the carbon dioxide out of the lungs by rapid forced breathing, the pressure of this gas is lowered also in the arterial blood, and the period of forced breathing is followed by a period in which there is no desire or need to breathe at all, a condition known as *apnoea*. The first breath is taken after this respiratory pause, when the pressure of carbon dioxide in the arterial blood rises once again to 5·5 per cent of an atmosphere. If any change occurs in the centre, rendering it more sensitive than normal, it will react to a smaller pressure of carbon dioxide. This occurs during residence at high altitudes, and we find in such cases that the alveolar air contains a diminished percentage of carbon dioxide when measured at atmospheric pressure. On the other hand, diminished sensitivity of the centre, such as may be produced under the influence of anæsthetics, will make it necessary to raise the pressure of carbon dioxide in the blood to a higher level before the centre is stimulated, so that the alveolar carbon dioxide content is increased.

In addition to this chemical control of the respiratory centre the movements of respiration can be altered by the will and are, as we know, affected by almost any emotion. For the lungs are not only the means of oxygenating the blood, they are essential organs for the production of voice and speech. There is hardly any emotional expression in which they are not involved by alterations in the rhythm of the respiratory movements. In fact, the description of any strong emotion would be incomplete if it failed to mention the effects on respiratory movements: holding the breath, deep breathing, rapid breathing, sobbing, laughter—all these modifications of the normal movements of breathing may play their part in revealing the emotional states of an individual.

It is evident that alcohol might affect the activity of respiration, i.e. the rhythm and amplitude of the respiratory movements, in one of two ways.

(*a*) It might alter the rate of oxidation in the body either by a direct stimulating effect on metabolism, or by producing increased muscular or glandular activity. In such a case the needs of the body for oxygen and the production of carbon dioxide would be raised, and the respiratory movements would be proportionately increased in virtue of the mechanisms normally acting in the body, the increased carbon dioxide production raising the pressure of this gas in the blood to a slight extent and so heightening the activity of the respiratory centre.

(*b*) In the second place, alcohol might affect the sensitivity of the respiratory centre, either directly by action on the centre itself, or indirectly by action on some other part of the central nervous system. In such a case an increased sensitivity of the centre would be shown by a lowering of the alveolar content of carbon dioxide, while diminished activity would be evidenced by a rise in the percentage of this gas in the alveolar air.

The experimental investigation of the influence of alcohol on the respiratory movements must therefore be subject to many fallacies. We must for instance exclude the effects of movements, which are more easily aroused under the influence of alcohol in response to changes in the environment. If the person becomes more talkative, he will tend to breathe more rapidly, and even the taste of strong alcohol may cause reflexly a change in the movements of breathing, just as respiration may be affected by the smell of ammonia or burnt feathers.

We have therefore to discount a considerable number of the older experiments on the subject, and we need deal only with a few in which the necessary precautions have been taken to avoid so far as possible these disturbing influences.

In some experiments by Higgins on seven subjects the effect of considerable doses of alcohol, namely, 30 cc. and 45 cc., diluted with water so as to form solutions of 15 to 22 per cent, taken in the morning on an empty stomach, was noted. This amount would be equivalent to two and three ounces respectively of whisky at proof. Under these conditions of administration, i.e. on an empty stomach and in fairly strong solution, the doses were large enough to produce a feeling of warmth and drowsiness, and in some cases talkativeness and mental excitement. The subjects were kept carefully at rest either in the sitting or recumbent position, and each alcohol experiment was controlled by one in which the subject took the same amount of water with a flavouring agent without alcohol.

In the first place the influence of alcohol on the total oxidative changes of the body was measured by determining the total heat production during the period of the experiment. In most of the cases no effect at all was observed—the heat production remained unchanged. In this respect alcohol differed from ordinary foods, such as sugar or protein, each of which would have caused some definite rise of heat production by its stimulant action on the chemical changes of the body. In one-fifth of the observations a rise of 5 to 7 per cent in the heat production was observed. In some cases this was due to restlessness of the individual, but in other cases no specific reason could be detected for the rise. Such a small and inconstant rise, produced only by doses large enough to evoke the first signs of intoxication, would not justify us in assuming that the taking of alcohol causes in the normal individual any increase in the oxygen consumption or in the rate of oxidation.

Corresponding to this absence of definite effect on the oxidative changes of the body it was found that alcohol exerted no constant influence on either the rate or the depth of the respiratory movements.

It is evident that if precautions had not been maintained to restrict the movements of the individuals under observation, those who were restless would have manifested an increased activity, which would necessarily have been associated with increased oxidation and augmented respiratory movements. On the other hand, if larger doses of alcohol had been given, so as to produce a definite narcosis, there would have been a slowing of the rate of oxidation and, therefore, a diminished ventilation of the lungs.

The next point to investigate was the effect on the excitability of the respiratory centre. To do this analyses were made of the alveolar air. It was found that alcohol sometimes increased the sensitivity of the respiratory centre, as shown by a drop in the alveolar carbon dioxide content. In other cases alcohol had no action on the respiratory centre.

In view of the marked susceptibility of the respiratory centre to volitional and emotional events occurring in the higher levels of the brain, it seems doubtful whether we should be justified in assuming from these results any direct action of alcohol in moderate doses on the respiratory centre. An increased excitability would be found for instance in any act of attention, such as preparation for active movement, and in all the related emotional states, and the small results obtained in these controlled experiments can probably be ascribed to the influence of alcohol on the higher levels of the brain.

It is possible that some of the results obtained by earlier observers, which seem to point to a stimulant effect of alcoholic drinks on the respiratory centre, may have been due to the ethereal and allied substances which determine the bouquet of wines and spirits. We have no sufficient experimental evidence to come to a conclusion on this point, and we are probably justified in concluding that alcohol in moderate doses has no effect on the respiration of practical importance either for its use by normal persons or for its medicinal use. The only important effect of alcohol on respiration is the paralysis of the respiratory centre by large doses which, as we shall see, is the cause of death in alcoholic poisoning.

CHAPTER X

THE INFLUENCE OF ALCOHOL ON THE REGULATION OF BODY TEMPERATURE

WE have seen that all the oxidative changes in the body produce heat, so that during activity at any rate the temperature of any animal must be higher than its surroundings. But, since these oxidative changes are chemical in nature they must themselves be dependent on the temperature at which they are carried out—the higher the temperature the more rapid the chemical changes will be. A cold-blooded animal is therefore more or less active according to the temperature of the external medium in which it is placed. Such a dependence of activity on the temperature of the environment cannot be regarded as of advantage under most conditions of animal existence, and in the evolutionary changes leading to the appearance of warm-blooded animals this slavery to external conditions is abolished. The animal becomes independent of external temperature and maintains a temperature of the working parts of its body which is approximately constant throughout life. In man the tissues of the body are set to work at 37° C., i.e. 98·4° F. There is a slight diurnal variation, amounting in most cases to less than a degree, a man's temperature being higher in the evening and lower in the early morning. There may be a temporary rise of a few degrees in the temperature as the result of severe exercise or after immersion in a hot bath. But the body temperature very rapidly returns to normal after the conditions causing the rise have passed away.

When we speak of the temperature of the body, we allude to that of the internal parts and of the circulating blood. To determine the temperature a thermometer is placed in some cavity of the body, e.g. in the mouth or rectum, or it may be held in the stream of urine which issues at the temperature of the bladder in which it has been accumulating. The surface of the body, on the other hand, varies considerably in temperature, and it is an ordinary experience that our skin may be hot or cold, our sensations of temperature depending very largely on the temperature of the skin.

In order to maintain this constancy of the internal temperature of the body, there must be a continual regulation of the balance between the production of heat in the body and the loss of heat from the body. The amount of heat produced varies with the rate of oxidative changes occurring in the body. It is increased considerably after a meal of proteins and to a less extent after the ingestion of carbohydrates and fats ; it is largely increased by muscular activity. Since the ordinary mechanical efficiency of the body only amounts to about 25 per cent, it follows that for every twenty-five units of energy produced in the form of work, seventy-five units will be produced as heat and will have their effect in warming up the body tissues.

The increased production of heat accompanying muscular work is a familiar experience to every one and is associated with a greater need for food to restore the large amounts of body tissues consumed in the increased oxidation. Heat is lost to the body in various ways, e.g. in warming the food and drink, some of which will leave the body as fæces and urine, and in warming the air we breathe, the inspired air being taken in at the ordinary temperature and the expired air discharged at the temperature of the body. The chief channel of heat loss is, however, the skin. So long as there is a circulation of warm blood through the skin, the temperature of the surface is kept at a temperature approximating that of the underlying parts and therefore at a higher level in temperate climates than that of the surrounding air. There will thus be a loss of heat to surrounding objects by radiation and to the air by convection, and this loss of heat will be greater the larger the difference between the temperature of the skin and the temperature of the man's surroundings. While the external temperature remains constant, loss of heat will be increased by anything which brings more warm blood to the skin. If the temperature of the skin is constant, the heat loss will be increased by a lowering of the temperature either of the surrounding air or of external objects. If the surrounding temperature is nearly equal to or above that of the body, the loss of heat by radiation, conduction, and convection may not be sufficient to balance the heat production of the body. In this case there is a second mechanism which can be brought into play. The skin of man is beset with *sweat glands* which, when the temperature of the body rises, begin to secrete, so that the whole surface of the body is kept moist. This moisture evaporates rapidly, abstracting heat from the body. It is by the secretion and evaporation of the sweat that the temperature of the body is kept within moderate limits when a man enters a Turkish bath. If he could not sweat, the effect of radiation, conduction, and convection would be to raise the temperature of the whole body, so that he would rapidly die of heat stroke, when his temperature rose to 110° to 112° F.

The maintenance of a constant temperature in man necessitates, therefore, a very fine adjustment between the conditions of heat production and heat loss in accordance with the activity of the organism and with the changes in the environment. Like all other fine adaptations, it is carried out through the intermediation of the central nervous system, and is the special office of a limited part of the fore-brain situated in what is known as the *corpus striatum*. This heat centre regulates the temperature by controlling both heat production and heat loss in varying degrees according to the requirements of the animal.

The regulation of heat production is partly involuntary or reflex, partly conscious and voluntary. Thus, exposure of the body to cold increases the tone of the muscles, and this may result in actual rhythmic movements which we know as shivering, and which, though often controllable, are quite involuntary. If we measure the respiratory exchanges of a man exposed to cold, we find that he takes in more oxygen and puts out more carbon dioxide, i.e. there is a quickening of the oxidative changes and therefore increased heat production accompanying the augmented muscular activity. In the conscious individual even a minute lowering of the body temperature or a chilliness of the surface causes feelings of discomfort, and we consciously seek to relieve these feelings by taking exercise, by quickening our pace if walking, or by moving the arms about. On the other hand, a rise of external temperature brings about a general slackness of the muscles and a voluntary avoidance of effort, so as to diminish the heat production in the body as much as possible.

In the same way the regulation of heat loss is partly involuntary, partly voluntary. Exposure to cold causes reflexly a constriction of the blood vessels supplying the skin, so that less of the warm blood is brought to the surface and exposed to its cooling effects. The skin therefore becomes colder and the difference of temperature between it and the surrounding temperature is less than if it were warm. On exposure to a warm atmosphere or under conditions when there is a large increase in heat production, as during muscular work, we find the skin hot from the dilatation of the vessels bringing the blood to it from the deeper parts, and a hot skin means a greater loss of heat to the surroundings.

These changes in the calibre of the blood vessels supplying the skin are carried out by the vaso-motor nerves, which are under the control of the central nervous system. In the same way the sweat glands, which are called into play in cases of excessive heat production or greater restriction of heat loss, are controlled by the so-called sudo-motor nerves. Stimulation of these nerves brings about secretion of sweat in the parts they supply.

Besides this involuntary regulation of heat loss, the conscious individual takes a large share in aiding the involuntary mechanisms of the body. In cold weather his heat loss is diminished by putting on more clothes, by taking refuge in houses where he is less exposed to the cooling effect of the wind and which he can warm up either by the heat given off from his own body or by the use of fires or other means.

In fever it seems that the temperature-regulating centre becomes ' set ' to a higher point. The temperature is found to be perhaps 39° C. Any lowering of the temperature below this point causes shivering and a feeling of discomfort.

We are now in a position to discuss the action of alcohol on this complex process of heat regulation. We can determine the influence of alcohol on the production of heat in the body either by direct calorimetric measurements, as in Atwater's experiments, or by observation of its effect on the respiratory exchanges and on the consumption of oxygen. Atwater found that the heat production was unaffected by the replacement of part of the food by a corresponding (iso-dynamic) quantity of alcohol, provided the alcohol were given in moderate doses. In Higgins' experiments the taking in of moderate doses of alcohol raised by a moderate amount the heat production in one-fifth of the cases investigated. This, as we saw, might have been due to a slight increase in the activities of the body. Alcohol, however, has no specific dynamic action ; though it can be used as a food and so give rise to the production of heat, its ingestion does not stimulate metabolism as may happen with the other foodstuffs, especially proteins. We may conclude that moderate doses of alcohol cause no increase in the production of heat. On the other hand, large doses have a narcotic influence, not only on the highest controlling centres, but on the lower levels of the brain, so that we get somnolence or sleep, lowered tone of the muscles, and diminished muscular activity generally. Every state of narcosis is associated with a lessened heat production. Moreover, in the normal individual the application of cold to the surface of the body calls forth reflexly increased muscular tone and therefore increased heat production, or by arousing disagreeable sensations acts as an incentive to the individual to button his coat more tightly round him and to take more violent exercise. In narcosis all these reflexes are lost, and a lowering of the surface temperature will be followed by a lowering of the internal temperature, with a consequent diminution in all the chemical processes of the body, without arousing the reflex protective mechanisms which, in the normal individual, prevent the application of external cold from influencing the temperature of the deeper parts of the body.

Even moderate doses of alcohol will tend to increase the loss of heat from the body in consequence of dilatation of the blood vessels of the skin. The feeling of warmth induced by moderate doses is thus evidence, not of the body being warmer, i.e. of increased heat production, but of the skin being warmer, and therefore of increased heat loss. If, under these conditions, a man is exposed to severe cold, the surface vessels being dilated he will tend to lose heat more rapidly than in the absence of alcohol. He may not feel the cold so much, owing to the dilatation of the superficial vessels and to the blunting of his sensibilities. The reaction which normally follows exposure to cold, namely, contraction of the surface vessels, will also be retarded or absent, so that there will be an unchecked loss of heat from the body, without any corresponding increase in heat production, and the temperature of the body will fall. Alcohol is therefore extremely dangerous if taken before prolonged exposure to severe cold and is rightly avoided on Arctic and Antarctic expeditions.

The case is different when it is a question of the administration of alcohol to persons suffering from the *effects* of exposure to cold. When such a man is brought into a warm room, and wrapped in hot blankets with hot bottles applied to his extremities, alcohol may be very useful in quickening reaction and recovery. The dilatation of the peripheral vessels in this case can only be of value in facilitating the taking up of heat from the surrounding objects and may at the same time diminish the strain on the heart and allow a more rapid flow of blood through the whole body. Indeed, alcohol may occasionally have some use, even before or during a brief exposure to cold. A man, before he has 'got up his circulation' as the phrase is, may be feeling miserably cold and depressed in consequence of the contracted condition of all his skin vessels, and resulting chilliness of the body surface, even though he is well clothed. A small dose of alcohol may in such case relieve the spasm of the peripheral vessels, and produce a temporary feeling of comfort and cheerfulness, which in its turn may bring about increased desire for activity and movement, and thus result in an actual increase in heat production sufficient to maintain the skin temperature at a comfortable level.

Alcohol has occasionally been recommended as an anti-pyretic, i.e. as an appropriate remedy for diminishing the temperature in cases of fever. It is difficult to see any justification for this opinion, which probably had its origin in the subjective feeling of greater comfort in cases such as malaria, where the onset of the fever is preceded by a cold stage accompanied by shivering and a cold skin during the time that the internal temperature is rising rapidly. In such a case it is possible that alcohol may hasten the dilatation of the skin vessels which occurs when the temperature has reached its maximum, and in any case the patient, after alcohol, will be less sensitive than before to the misery and disagreeable sensations aroused by his state.

We may conclude that in temperate climates the action of alcohol in moderate doses under the ordinary conditions of life within doors has no effect of importance on the body temperature, but that this substance should be avoided by persons who are about to expose themselves to severe and prolonged cold. The sensation of warmth produced by the alcohol is in the latter circumstances a dangerous illusion which, by rendering the person indifferent to the chilling effects of the outside cold, increases the chance of a definite lowering of the internal temperature of the body with all the resulting evils that such a chill may entail.

CHAPTER XI

THE EFFECTS OF IMMODERATE USE OF ALCOHOL

THE facts that alcohol undergoes no changes under the influence of the digestive fluids, and is absorbed rapidly both from the stomach and from the intestine, render it easy to raise the concentration of this substance in the blood to almost any extent compatible with the life of the animal. It must be remembered that the concentration of alcohol in the blood is merely an index of its concentration throughout the tissues of the body, since it passes with as much ease through the capillary walls and into the tissues cells as through the wall of the alimentary canal. Nicloux, indeed, has shown that after the ingestion of alcohol its concentration in the tissues and in the fluids of the body, such as the lymph, the cerebro-spinal fluid, saliva, the milk, and the urine, is almost identical with that found at the same time in the blood. Moreover, in pregnant animals it passes through the placenta to the fœtus, and is found in the amniotic fluid as well as in the tissues and blood of the fœtus.

In previous pages we have restricted our study to the influence of "moderate" doses, and we have seen reason to believe that, although any effect of such doses was in the direction of a diminution of the highest activities and functions of the brain, their effect on the whole is often of indirect advantage to a man in contributing to a happy and healthy existence. But there are no physiological mechanisms, such as exist for the ordinary foodstuffs, for the protection of the normal individual against an excessive concentration of alcohol in his blood and tissues. The regulation of the concentration of alcohol in the blood and its maintenance below the minimum at which it begins to become deleterious is entirely dependent on the voluntary control of the individual. When such voluntary control is deficient or not exercised, alcohol may be consumed in such quantities or under such conditions as to cause the concentration of alcohol in the blood and tissues to rise to the level at which this substance becomes distinctly harmful and poisonous. Such poisonous effects may be acute or chronic. The effects of acute alcoholic poisoning may be described as a continuous and progressive impairment and abolition of the functions of the brain, starting at the highest evolutionary level and progressing downwards. The stage in which there is lessened self-criticism, greater freedom of utterance, and diminished self-control is succeeded by a phase in which there is interference with the social habits of the individual, while the co-ordination of muscular movements becomes more and more imperfect. This gives place to a condition of stupor or drunken sleep in which the individual may persist for many hours until the greater part of the alcohol has been oxidised in the tissues and its concentration sinks once more below the poisonous level. In the drunken sleep the noisy, laboured breathing often shows the beginning of interference with the innervation of the respiratory muscles, and if the dose has been sufficiently large this may lead to death from paralysis of respiration. This dangerous stage of intoxication corresponds to a concentration of alcohol in the blood of about ·6 per cent.

In some cases, as, e.g., after the drinking of a bottle of whisky for a wager, the result may be a condition of profound shock from the direct irritant effects of the strong alcohol on the stomach, and heart failure may be associated with the gradual failure of respiration.

The amount of alcohol sufficient to evoke poisonous symptoms, including those of intoxication, varies in different individuals. A certain degree of tolerance may be acquired in habitual and heavy drinkers, so that they may consume with very little apparent immediate effects quantities of alcohol which in other persons would produce severe intoxication. It may be that the immunity is inherent in the man's nervous system and has been a contributory cause of his drinking habits. On the other hand the dose necessary to produce evil effects is much lower in persons of nervous inheritance and temperament, and those who have suffered from head injuries. In such an individual there is an inborn or acquired lack of nervous stability. He finds it difficult enough at any time to maintain his balance and to control and modify his behaviour in accordance with his environment. He cannot therefore afford to diminish in the slightest degree the functional efficiency of the highest levels of his central nervous system, and a very small dose of alcohol may suffice to upset his exiguous powers of control and to produce evident intoxication and unsocial behaviour. This susceptibility of psychopaths, i.e. persons of weak nervous inheritance, is probably responsible for the comparatively large number of cases in which insanity has been put down to alcoholic excess, whereas the excess was simply the earliest symptom of the failing control.

A similar increased susceptibility to the action of alcohol is sometimes observed in persons who have suffered from delirium tremens brought on by excessive drinking. The alcohol has apparently produced permanent damage in the nervous tissues and left them more susceptible to the action of small doses of this substance.

In animals—dogs and horses—signs of intoxication have been noted with an alcoholic concentration in the blood of ·12 per cent, while as much as ·72 per cent has been found when so much alcohol has been given as to produce a condition of stupor which in most cases terminated fatally. In man, in a state of moderate intoxication, a percentage of ·153 has been found in the blood, while in a more advanced case the concentration found was ·227 per cent. ·15 per cent is the concentration that would be produced by taking either at one dose or in doses repeated within a couple of hours, 3½ ounces of absolute alcohol; this is equivalent to 7 or 8 ounces of pure whisky, or four pints of beer, taken on an empty stomach. If the same amount were taken with a meal, absorption would be so retarded that the concentration in the blood would probably not reach this amount, and would perhaps not rise above ·12 per cent.

A concentration of 0·6 per cent of alcohol in the blood, which represents the level at which life is endangered, would be produced by the taking of one and a half pints of proof spirit, i.e. more than one bottle of whisky, or two gallons of beer, supposing that the beer were drunk within a short time, and that it was absorbed from the stomach as quickly as strong spirits. But we have already seen that alcohol when diluted to 5 or 10 per cent is absorbed much more slowly than when drunk in a concentrated form. So that apart from the difficulty of drinking two gallons of beer, or one gallon of wine within a short space of time, the absorption of the alcohol would be so retarded that the portion first absorbed would be oxidised before the rest had found its way into the blood, and the percentage of alcohol in the blood would never rise to the dangerous limit. The man would probably be too drunk to drink any more, before he had taken enough to endanger his life. This is why spirits are more dangerous as intoxicants than beer or wine.

Another frequent result of immoderate doses of alcoholic drinks is gastro-intestinal disturbances. This is especially marked in the stomach, which is the first organ exposed to the action of the alcohol. As we have seen, the strong alcohol acts as a direct irritant; by its attraction for water it tends to coagulate animal tissues. When it falls on a wounded surface it causes acute pain. Although pain may be absent when it is applied to the mucous surfaces of the mouth and stomach, it may still produce injury. The stomach reacts and protects itself by the secretion of mucus, but this in itself is a sign of over-stimulation. Moreover, the diminished sensibility induced by the action of alcohol on the central nervous system will lessen any feelings of discomfort and render it easy to overload the stomach. In many cases this over-loading of the stomach may relieve itself by the production of vomiting, which is the best thing that can occur to the individual who has transgressed the bounds of moderation. Indeed, a 'drunk,' when brought into the hospital, is always treated by emptying and washing out his stomach with a stomach pump. If vomiting does not occur, all the alcohol which has been drunk undergoes gradual absorption and oxidation in the tissues, and the patient sleeps heavily until the percentage of alcohol in the tissues and blood has been reduced once again to a low level.

In most cases it is during recovery from the poisonous effects of alcohol that its harmful influence on the digestive tract makes itself felt. The day after a drinking bout there is generally tenderness of the stomach, loss of appetite, foul breath, and furred tongue, and in many cases headache.

The Effects of Chronic Poisoning by Alcohol

Except in the rare cases when a fatal dose has been taken, an individual recovers completely even from a severe condition of intoxication. The alcohol in the blood and tissues undergoes gradual oxidation, so that after twenty-four to thirty-six hours the whole of it has disappeared from the blood and the man may be feeling little or none the worse for his excess. Indeed, it is astounding how relatively small are the results of drinking bouts on the health of normal individuals provided that the excess is only occasional. Under these conditions the effects, though minimal on the permanent health of the individual, may be disastrous for the happiness of his belongings or for his own economic and social advantage.

The relative innocuousness to the individual of fairly frequent but temporary bursts of drinking is seen if we compare the mortality of coal-miners (who however, it must be remembered, are a picked population) with that of certain other classes of the community. Coal-miners cannot be regarded as a class as particularly averse to alcoholic excess, and yet their comparative mortality figure for alcoholism and liver diseases is only 13 as compared with 23 for the total male population of the country, 22 in commercial clerks, 43 in dock labourers, and 152 in publicans. This is evidence that the nervous and other tissues of the body, though deeply poisoned by alcohol, recover completely provided they are given a sufficient period of total immunity from its effects. It is the chronic soaker who betrays most frequently the effects of alcohol in causing disease. In such cases the blood and tissues are never free from the action of alcohol, and are not allowed an opportunity for the self-repair which occurs in the man who indulges simply in an occasional spree. Nor is it necessary that alcohol should be taken to the extent of producing intoxication. The chief point is that it should be taken continually, so that the individual at all hours of the day and night is slightly under its influence.

The effects of this continuous or repeated and excessive drinking of alcoholic liquors are most marked, as we should expect, on the central nervous system, though there is hardly a tissue in the body which may not feel its influence and suffer accordingly. Among the nervous disorders resulting from the immoderate use of alcohol the most striking is that known as delirium tremens. This is generally seen in persons who habitually drink freely, and who have been taking unusual quantities, especially of strong spirits, continuously for several days. The onset of the disease is sometimes determined by a severe shock, such as a broken limb, or by an acute febrile condition such as pneumonia or erysipelas. A graphic description of the symptoms and course of this disorder will be found in Sir F. Mott's essay, as also of the other nervous disorders related to alcoholic excess, such as alcoholic neuritis, and certain types of insanity.

In the chronic alcoholic the nervous symptoms are generally associated with those due to a disordered digestion. Muscular tremor is one of the distinguishing features—the hands are unsteady, the lips tremulous. The patient is restless and irritable, sleeps badly, and in the morning has sensations of prostration, for the cure of which he has recourse to more of the poison from which he is suffering. There is mental weakness, shown by inability for sustained intellectual work. Judgment and will power are weakened and there is generally failure of memory. These symptoms are almost always associated with signs of gastric disturbance; there is often vomiting in the morning and lack of any appetite for breakfast, the tongue is furred and the breath unpleasant, the whites of the eyes are often slightly jaundiced. The disorders of the alimentary canal reflexly bring about familiar vaso-motor changes in the vessels of the face, the minute venules of the cheeks and nose become dilated and the complexion blotchy. The continuous engorgement of the nose often leads to over-growth of connective tissue with the production of the huge bulbous nose so often seen in the chronic drunkard.

Cirrhosis of the liver is so frequently associated with the immoderate use of ardent spirits that it has been designated, the 'gin-drinker's liver.' It has not been possible to reproduce with any certainty this condition by the experimental administration of alcohol to animals, and it may occur in rare cases in men who have not indulged in any alcoholic excess. It seems that its true cause is to be sought in the primary disorder and destruction of the lining membrane of the alimentary canal, rendering this less efficient in the absorption of food and more prone to admit the passage of toxins produced in the process of digestion, or of the micro-organisms which abound in the contents of the gut. Cirrhosis of the liver is a chronic inflammation of the tissues around the branches of the veins which run from the intestines to the liver. It is probably caused by the action of toxins or allied irritant substances absorbed from the alimentary canal, and is only indirectly due to the action of alcohol. The fact that it occurs generally in spirit drinkers is due to the irritant and destructive effects of strong solutions of alcohol on the mucous membrane of the stomach and intestines. It rarely or never occurs in wine or beer drinkers.

On the other hand, a large number of diseased con ditions occur in persons who indulge immoderately in wine and beer. In these cases however the immoderate indulgence is often or generally part of a general condition of gluttony. The man or woman is said to "do themselves too well," and we have a condition which is therefore not peculiar to the alcoholic but may occur in patients, even total abstainers, who are too fond of the good things of the table, which they consume to excess. In some cases the wine or beer is used as an addition to a food supply which is already more than ample for the individual's requirements. Deprivation of alcohol in such patients will do them good, not only by removing the action of a substance which, if constantly present in the blood and tissues above a very low level, acts as a poison, but also by diminishing the superfluous amount of energy which the man is taking in as food. A course of dieting is often as important as deprivation of alcoholic drinks.

Among these diseases we have those affecting the circulatory organs—high blood pressure associated with thickening of the arteries and degeneration of the arterial wall, which often terminates in apoplexy. The heart may be weak, fatty, and dilated. In Germany such a heart is called either the 'glutton's heart' or the 'beer heart,' and was not infrequent in Munich in individuals who took enormous quantities of beer. The factors co-operating in the production of such a condition are the water-logging of the body as the result of the huge quantities of fluid taken, the excessive amount of food, leading to deposition of fat and a hampering of the action of the vital organs, and the constant presence of alcohol in the blood which diminishes the tendency to exercise and activity while depreciating the physiological resistance of the tissues to injury.

In the same way the intemperate use of alcoholic drinks may be a contributory factor in the production of Bright's disease and diabetes, especially in fat subjects.

It must be remembered that in all these cases the alcoholic intemperance is only part of the general intemperance, and treatment involves not only a cutting down of the alcoholic intake, but also an ordered manner of living in which diminution of the total fluid and total food is associated with graduated exercises.

Alcohol has often been endowed in popular opinion with the property of increasing the resistance to infection. The free use of alcohol has also been credited with virtue against tuberculous infection. It cannot be said that there is any foundation for either of these beliefs. The chronic drunkard is especially prone to the infections of pneumonia and of erysipelas, and although there is a striking contrast between the rubicund individual with gross appetites and the pale emaciated sufferer from tuberculosis, it is a fact that a large number of the chronic alcoholics die finally of tuberculous infection.

The impairment of vitality caused by constant exposure to small percentages of alcohol in the tissues, such as is produced by its continued immoderate use, is shown especially in the reproductive organs. Thus, in habitual drunkards there is often wasting of the testicles and an almost complete absence of the germ cells or spermatozoa, though the individuals are in the prime of life. Similar changes have been found in the ovaries of female alcoholics, and the same effect may be produced experimentally in animals, such as rabbits, by their prolonged exposure to alcohol given by the mouth or administered in the form of vapour. It seems a pity that this action does not occur more rapidly, since it is evident that its tendency will be, by diminishing the fertility of the chronic alcoholic, to eliminate gradually from the race the stock which has shown itself unfit to support the temptations and trials of civilised life. Unfortunately the drunkard at the beginning of his or her downward career is said to be more prolific than the ordinary individual, though the resulting effect on the population is probably more than neutralised by the high infant mortality among the offspring—due partly to the direct injurious effect of the alcohol taken by the parents, partly to carelessness and accidents such as overlaying, and very largely to the prevalence of syphilis among these degenerates.

It is probable that many of the morbid changes found in the bodies of patients who have been immoderate drinkers are not themselves directly due to the action of alcohol. The intemperate drinker, with lessening self-control, becomes more and more careless and indifferent to the measures which must be taken by everyone for the preservation of health and avoidance of infection. He becomes indifferent about his food or his surroundings, and is prone to infection by syphilis as well as by tubercle. Many of the pathological changes—degeneration of the arteries, overgrowth of fibrous tissues, changes in the brain—which have been ascribed to alcohol, are probably syphilitic in origin. This increased exposure to infection and accident can hardly be regretted, since it is one more means by which nature tends to eliminate the unfit from among its societies.

Susceptibility and Tolerance

It has been already mentioned that individuals with weak nervous inheritance, or who have suffered from concussion or sunstroke, are extremely susceptible to the action of even small doses of alcohol, so that they may show signs of loss of control or even of intoxication after quantities of alcoholic beverages which would leave a normal individual unaffected. But there are many degrees in the extent to which even normal individuals are affected by alcohol, some showing signs of its action after small doses, while others, who are generally spoken of as having 'strong heads,' can take large quantities without showing any evidence of intoxication. If the individual is normal he very soon finds out for himself the limits of his tolerance, and if this is small, either abjures the use of alcoholic drinks altogether or limits it to the smallest possible amount. With continued use of alcohol there is some increase in the tolerance, and habitual drinkers are often found who can consume quantities which would be regarded as enormous by the ordinary man, without being particularly affected or losing their power of control or muscular co-ordination. Cases have been recorded in which a man took a bottle of spirits—gin or whisky—every day, a dose which might be fatal to one unaccustomed to its use.

We know as yet very little as to the physiological basis of this tolerance to alcohol. There may be an increasing power of the tissues to oxidise alcohol, so that it disappears from the body more rapidly than in the ordinary individual, or there may be constitutional insensibility of the nerve tissues to the action of the drug. But such a tolerance of the brain is a doubtful advantage, since it does not seem to be shared by the other tissues of the body, and it is just in these strong-headed persons, who can afford to drink large quantities of alcohol without forfeiting their place in society, that we see most markedly the injurious effects of excess of alcohol on the alimentary organs, the liver, kidney, heart, and arteries.

Every action which is sufficiently often repeated tends to become a habit, and in habitually intemperate drinkers there is thus a craving for alcohol, i.e. an overbearing desire to take another dose as soon as the effects of the last begin to pass off. But this craving or habit is not as marked as in the case of other drugs. Thus, in prisons it is found that the habitual drinker feels more his deprivation of tobacco than his inability to obtain alcohol. Nor is the tolerance for alcohol, which is established by repeated over-indulgence, to be compared with that for drugs such as morphia or cocaine. In the case of morphia the ordinary doses very rapidly cease to have any effect, and the victim to the morphia or cocaine habit has to increase the dose continually in order to arrive at the desired effects, so that he very soon begins to take regularly quantities which would be fatal to the normal individual. And the craving for these drugs is a much more real thing than in the case of alcohol, in that their sudden complete removal may have severe or fatal results. In a home for inebriates the best treatment is to remove alcohol entirely from the reach of the patients. When, however, the attempt is made to cure a morphia taker, it is usual and safer to diminish the drug by degrees, giving smaller and smaller doses daily until its use can be entirely discontinued.

CHAPTER XII

THE INFLUENCE OF ALCOHOL ON THE COMMUNITY

SO far we have discussed chiefly the influence of alcohol on the individual, as if he were an isolated unit. But for long ages man has existed only as a member of some society or other, and his survival is bound up with that of the community of which he is a part. Although the effects of alcohol on the individual are of interest to himself and to his family, the benefits and disadvantages of alcohol must be finally judged by its significance for the welfare of the community as a whole. It is precisely from this standpoint that alcohol parts company with other drugs, in the strict sense of the term, which, like alcohol, act on the central nervous system. Alcohol is not only a food capable of being entirely oxidised inside the body and utilised for the production of heat and work, but it also, when taken in anything above minimal doses, acts as a narcotic, in that it diminishes the activity of the highest levels of the brain. But whereas other narcotic drugs, such as morphia and Indian hemp, are distinctly anti-social and remove the man from communion with his fellows and from the influence of the common desires and impulses which determine corporate action, the effect of alcohol, at any rate in moderate doses, is to strengthen the man's sense of membership of the society in which he is for the time being, and to make him more subject to the influence of his human environment. Each of us tends to live too much apart from his fellows; the more arduous the daily toil, the more absorbing the professional occupation, the greater is the estrangement of the individual from his fellow-creatures, who become objects of indifference or merely instruments for his personal advancement or for the success of his projects. Alcohol in small doses diminishes, as we have seen, control in the nervous system from above downwards, so that the first things to go are those habits of behaviour and thought which are the instruments of his personal success among and against the rest of the community, habits and reactions which he has acquired as the crown of his education and which have absorbed his greatest efforts. With this lessening of the shackles of self-interest and self-criticism, the instincts of the herd become predominant and the individual feels himself more kin with his fellow-men and quickened with their common life. It is no slur on the action of alcohol that a man under its influence or inspiration becomes more susceptible to the operation of the spirit of charity, with its fruits of love, joy or pity, nor is it a misfortune to the community if, under similar conditions, a man gives half a crown to a beggar or promises a hundred pounds to a hospital at the cost of some carefully planned selfish pleasure or some pet scheme, for the realisation of which he was making prudent preparations. It may be true, as Helmholtz has said, that the great generalisations of science are not to be attained by good living nor do they owe their inspiration to the action of alcohol. But under its effects the shy worker may be emboldened to unburden himself and to interest others in his work, and thus gain not only helpful criticism but, what is still more important, a renewed zest in his labours through the interest and sympathy he has experienced from workers in other fields. A certain degree of self-satisfaction is a necessary element for successful activity, and a life that is not joyous is one that can never attain its full powers of accomplishment.

So far as the moderate use of alcoholic drinks serves to further either of these ends it must be regarded as a distinct advantage to the community as a whole.

It is often argued that since large doses of alcohol act as a poison, paralysing the brain and diminishing the vitality of all the other tissues of the body, small doses must, by repetition, have the same harmful effect, so that in the long run even the moderate use of alcohol must be regarded as detrimental to the individual and therefore to the community. Such reasoning is entirely unwarranted. Physiology furnishes us with numerous examples in which a substance, which is beneficial or even necessary in small amounts, becomes harmful when present in the tissues and fluids of the body in excess. The thyroid gland produces a substance which has been called iodothyrin, the constant presence of which in the body is necessary for the mental functions and for the normal growth and nutrition of most of the body tissues. Its absence in the young child gives rise to cretinism, in the adult to the disease known as myxoedema. Under certain conditions the thyroid gland hypertrophies and produces too much of this substance, and then we get once more a condition of disease, a disease due to excess of iodothyrin circulating through the body. This disease is spoken of as *exophthalmic goitre* or Graves' disease. The symptoms of this disease can be imitated by the administration to a normal individual of large doses of thyroid gland.

In the same way the utilisation of sugar in the body depends on the constant production of a substance, which has been called *insulin*, and which is manufactured in a special tissue forming part of the pancreas. If this substance is not produced or if the pancreas of an animal is extirpated, the man or animal becomes diabetic and dies of the disease. It has been shown lately that if this substance be extracted from the gland and injected into an animal which has been rendered diabetic, the diabetes may be cured so long as the injections are continued. If too large doses of the substance be given, the animal suffers ill effects and may die in convulsions.

We see therefore that the body may actually require substances acting as drugs in moderate quantities and must be supplied with these substances during the whole of its life, and yet the same substance when present in too large a quantity acts as a definite poison. The normal healthy individual possesses physiological checks on the formation of substances such as iodothyrin and insulin so that these are never manufactured in too large a quantity. The healthy, civilised man, trained in control from his youth up, has also the checks to the immoderate consumption of alcohol furnished by the racial experience of centuries, by his own proper experience, and by the constraint of the society in which he exists. Common experience teaches us that where these checks exist the moderate use of alcoholic drinks has no such effects that would justify the consideration of this substance as a poison. The work of the community is carried out almost entirely by men with whom the moderate use of alcohol is habitual. We have only to look at the leaders in every walk of life—members of the Government and of the Civil Service, judges, leaders of the Bar and of the medical profession, Fellows of the Royal Society, heads of our big industrial and commercial concerns. In each group we find a small handful who are total abstainers, but a census would give probably over 90 per cent who habitually partake of small doses of alcohol. In these cases there is no question of a craving for alcohol or a feeling of mal-adaptation to the environment, to be drowned in forgetfulness. The use of alcoholic drinks among such men is as an addition to the amenities of existence and as a means of increasing the pleasure, joy, and profit in life. It is probable that in these cases the use of alcohol has a real physiological value, in relieving the strain on the human machine, in promoting a forgetfulness of the cares of the day's work, and in assisting repose and the reintegration of the forces of the body. Health is in most people a necessary condition of success, and most of the members of the leading groups of society we have enumerated are distinguished not only by their good general health, but also by the fact that they live to a ripe old age.

But in citing such instances it might be objected that we are dealing with chosen lives, and indeed certain statistics gathered by life insurance companies have often been represented as proving that even the moderate use of alcohol has a deleterious effect on health and tends to shorten life.

In this book we have the advantage of a re-examination of the whole question by Professor Raymond Pearl, who has collected a mass of new material bearing on the influence of the moderate use of alcohol on the duration of life. I must refer to Professor Pearl's essay for the detailed discussion of the results and the methods by which they were obtained, but it is interesting here to note that any advantage as regards increased expectation of life in his tables lies with the moderate and occasional drinkers rather than with the total abstainers. Nor do we find in our daily experience a marked superiority in health among the total abstainers, whom we meet, above that of the rest of the community. Indeed, if we were to argue from the statistics in certain cases of heart and nervous disorders, we might be tempted to conclude that total abstinence was actually bad for the individual in predisposing to these disorders. I allude to the cases among soldiers, known as 'disordered action of the heart' and 'shell shock,' described by Sir F. Mott in his essay

(p. 206). In both these groups it was found that a large proportion were teetotallers. But, of course, it would be absurd to argue that total abstinence was the cause of the morbid conditions in these men. It is more probable that they were weaklings from their birth up, deficient in vigour of body and mind, and refraining from the use of alcohol by an instinct of self-protection. We find indeed that the psycho-neurotics were of the same stuff as drunkards are made, since in 50 per cent of them there had been alcoholic excess among their parents and grandparents. In 30 per cent the parents and grandparents had been total abstainers, so that here, as in so many cases, a given temperament unbalanced may result in the production of either extreme. As regards alcohol it may produce a drunkard or a fanatic teetotaller, just as in religion it may produce religious intolerance or blatant atheism.

The life and health of men living in communities are seriously affected by the two chronic infections of tuberculosis and syphilis. Alcoholic excess is often charged with furthering both these infections. We have seen that a chronic soaking of the tissues with alcohol diminishes their resistance to infection. Moreover, even a moderate condition of inebriety, by rendering the reactions, both volitional and automatic, more sluggish, depreciates the subject's powers of self-protection. The drunken subject takes no care to ward off the cold, and the chills that may ensue may cause greater proneness to infection of the respiratory organs, and under conditions of severe external cold may lead to death from exposure. In the same way a man who exposes himself to infection by syphilis when he is in drink is equally careless in guarding against the effects of such exposure. So that we are not surprised to find that a man, who has depreciated his manhood by constant excessive indulgence in alcohol, should be a prey to all sorts of infections and especially those which are most widely disseminated among the community. But it is often said that even the temperate use of alcohol, by lessening self-control, leads to immorality in the limited sense of the term, i.e. to sexual intercourse outside marriage, and in this way tends to the spread of diseases such as syphilis. It is very difficult to find evidence for this view, especially as there is a certain degree of antagonism between sexual and alcoholic indulgence.

Certain incomplete statistics were collected by Colonel Harrison, bearing on the question of the relation of alcoholism to venereal infection. The data were collected from the Rochester Row Military Hospital and the Lichfield Military (V.D.) Hospital, and inquiries were made of the patients presenting themselves for treatment for venereal disease as to their condition at the time when they contracted the disease. Out of 1256 patients 10 per cent were drunk at the time of infection, 17 per cent had had some alcohol, but were not drunk, 47 per cent were perfectly sober, and 24 per cent were total abstainers. Two points are of interest in these figures. The first is that only 27 per cent of the patients were under the influence of alcohol at the time they contracted the infection, while 24 per cent were total abstainers. If we allow that the abuse of alcohol would tend to the neglect of all common precautions for the avoidance of infection, it seems probable that the percentage of sober persons and of total abstainers who actually exposed themselves to infection was much greater than that given in these figures, which refer only to those who, in spite of all precautions, became infected. The 24 per cent of total abstainers represents a considerably higher proportion than is found in the Army generally, a fact which bears out the relative antagonism between alcoholic and sexual indulgence. Each of these tends to allay restlessness and irritability, to produce a condition of contentment and self-satisfaction, and to promote repose, and figures such as those just quoted seem to point to a craving for one or other kind of indulgence, and do not further the hopes that have been expressed that a complete absence from alcohol, voluntary or enforced, would be in the interests of sexual morality.

Although we have been unable to find any evidence for the view so often expressed that the moderate use of alcoholic beverages is in itself harmful and leads in the long run to the deterioration of health and of morality, there is no question that its excessive use is the cause of a large amount of disease, crime, misery, and inefficiency. In Sir F. Mott's essay he quotes Sullivan to the effect that chronic alcoholism is responsible for a considerable proportion of the suicides in this country, for about three-fifths of the homicidal crime and for rather less than one-half of the sexual crime—though apparently playing no part in the crime of acquisitiveness. It is possible that we have here to a certain extent concomitant signs of degeneracy, the vicious circle described by McCurdie, and that total abolition of alcohol would not lead to such a diminution of these crimes as the above figures would lead us to hope. At any rate, that seems to be the experience in the United States. The effect on health and on the duration of life is obvious from the study of the tables of comparative mortality, such as those published in the Report of the Advisory Committee and from which the following examples are taken.

What is especially apparent from this table is the relative innocuousness of bouts of drunkenness as compared with a chronic soaking. The trades and occupations which show the biggest mortality from alcoholic disease are those in which, owing to the nature of the work,

	Alcoholism.	Alcoholism and Liver Diseases.	All Causes.
All males	7	23	790
Railway engine driver, guard, porter, etc.	2	11	586
Platelayer, railway labourer	2	11	623
Agriculturist	3	11	474
Coal miner	3	13	727
Shipbuilding	5	12	633
Printer	5	14	773
Building Trade	5	17	726
Metal worker	5	19	804
Shoemaker	6	17	820
Textile manufacturer	6	19	799
Commercial clerk, Insurance agent	6	22	802
Tailor	6	22	799
Baker	7	19	664
Carman, Carrier	7	21	900
Shopkeeper	8	27	683
Commercial traveller	9	32	724
Coach, Cab, Bus	12	29	921
Messenger, Porter	13	33	1137
Seaman and Merchant Service	18	34	1485
Butcher	18	56	885
General labourer	20	50	2301
Dock labourer	26	43	1127
Coster, Hawker	30	52	1507
Publican, Innkeeper, etc.	50	152	1265

Comparative Mortality of Males aged 25–65 years in the Chief Occupational Groups (England and Wales) (a) *from Alcoholism* (b) *from Alcoholism and Liver Diseases taken together, and* (c) *from all causes, in the period* 1910–1912.[1]

Note.—The "comparative mortality" figure from any given disease in any given occupation indicates the number of deaths from that disease which would occur in a population corresponding in numbers and in age constitution with the standard population, but composed solely of persons engaged in the particular occupation in question. In this table the "standard population" is the population of males, aged from 25 to 65 years, which *in the period 1900–1902* furnished 1000 deaths from all causes.

[1] From a table by Dr. T. H. C. Stevensen in the Report of the Advisory Committee.

alcohol can be taken many times in the course of the day, so that the tissues are never free from the poisonous effects of this substance. In what is called industrial drinking the constant soaking must lead to gradual inefficiency as well as damage to the health of the individual. It would seem therefore that any measure that would diminish such industrial drinking would add to the happiness and efficiency of the community. In devising such measures we must have a clear idea of why men drink to excess. The causes of drunkenness or of the immoderate use of alcoholic liquors can be divided into four classes. In the first place we have fashion—a perverted herd instinct, a man drinks because his fellows do likewise. A century ago in the upper classes a man was looked down upon unless he could carry his bottle of port like a gentleman, i.e. could attain a certain degree of inebriety without offending the more obvious canons of society. This foolish and pernicious fashion is now extinct in English society, and at the present time no credit or discredit attaches to any one who prefers to abstain altogether from alcohol, and a state of inebriety with its attendant lack of control arouses only contempt in a man's fellows and a sense of shame in the individual himself. Like every other change in manners, this mode of regarding drunkenness is spreading downwards and soon we may expect it to be general among all classes of society.

A second cause of drunkenness is ignorance. The pleasant subjective effects of alcohol have caused it to be endowed, in popular tradition, with all sorts of beneficial qualities which it does not possess. Chief among these is its supposed property of aiding heavy muscular work, so that we find among men carrying out heavy tasks, such as that of dock labourers, a firm faith that they can do their work better by continually taking fresh draughts of beer or other alcoholic drink. In both these cases men will learn that the game is not worth the candle, that they will attain more happiness, comfort and health by total abstinence or a very moderate use of alcohol than by continually seeking an illusory strength and satisfaction in the use of alcohol.

In the third group of causes alcoholism must be put down to economic conditions. If a man or woman in virtue of his or her environment is forced to lead the life of a beast, he may seek to avoid the horrible reality of everyday existence by recourse to the numbing effects of alcohol. The number of such individuals is probably only small, but it is the duty of the community to see that no human being is condemned to such an environment. Here the problem of the prevention of drunkenness is one that involves questions of housing, sanitation, education, and the provision of proper means of recreation.

All these three causes of alcoholism are thus capable of removal by an improvement in the education and social conditions of the people. The fourth group is, however, not susceptible to such treatment. It includes those individuals with an inherent nervous defect, who are out of tune with their surroundings and are, therefore, anti-social, and have constant difficulty in behaving in accordance with the requirements of the community in which they live. The condition of such an individual has been described by Dr. MacCurdie as follows. After pointing out that these individuals suffer from mal-adaptation, he says, " Adaptation means contact with reality. When this is difficult to maintain one instinctively yearns to abolish reality or blot it out of sight. Any drug which stupefies will do this. Hence the man who wants to forget the world, drinks. He gains the desired release. If this were all, alcohol might be an unmixed blessing as an emergency measure. But unfortunately this release is purchased by impairing those very faculties that are needed to attain success, and, to make matters worse anti-social tendencies are liberated at the same time, and these increase the maladaptation. The alcoholic drinks to forget and thereby increases that which he would forget. This is the vicious circle."

We may say of this fourth class that they are people who are born drunkards. Continuous imprisonment or total abolition of alcohol would not cure their inherent nervous defect. They might end up as inmates of a lunatic asylum, or they might without alcohol just keep their head above water and their place in society and by propagating transmit their weakness to the individuals of the next generation. As things are at present, this class, unless it is perpetuated by unwise legislation, tends gradually to eradicate itself. We have seen that chronic alcoholism causes atrophy of the reproductive cells so that the individual becomes sterile. The same effect is produced as a result of the infections, especially syphilis, which the chronic alcoholic tends to gather in his course downwards through life.

Moreover, the deleterious effects of alcohol extend to the individual's offspring. A long series of interesting experiments has been made by Stockard on the influence of alcohol on the offspring in guinea-pigs, and with some reserve we may draw useful lessons as to the action of alcohol on the human race. The experiments were begun twelve years ago, and now cover several thousand animals of pedigree stock. The experimental method employed was to submit the guinea-pigs to a daily inhalation of alcoholic fumes up to the point of intoxication. Three groups of experiments were carried out. Males alcoholised in this way were mated with normal animals. In the second series normal males were mated with alcoholic females, and in the third series both parents were alcoholic.

It was found in all three series that the treatment of the parent with alcohol modified the germ cells, with the result of injuriously affecting the offspring. Not only was the mortality of the young in these three series higher than in the control experiments on normal animals, but some of them were defective. The breeding of the offspring from alcoholic parents was continued for four generations. Some of the offspring in the first generation were defective and many were sterile, but in spite of the elimination of the defectives the grandchildren also showed an unfavourable record with increased pre-natal as well as post-natal mortality among the offspring. As a final result, however, the constant elimination of defective individuals through three generations gave animals descended from alcoholised great-great-grandparents who were superior in their records to other normal control animals. They were born in smaller litters than the controls, but their mortality was only 64 per cent of that of the control, so that the selection resulting from the action of alcohol finally brought out a group of unusually strong specimens from which all the weaklings had been eliminated. Stockard concludes that if one should desire to apply these experimental results to the human alcoholic problem, it might be claimed that such elimination of unfit individuals had benefited the races of Europe, since all the dominant races have a definitely alcoholic history, and the excessive use of alcohol used to be decidedly more general than it is to-day, that is, certain families that were alcoholic three generations ago have not been excessively so in the more recent generations.

Certainly one cannot say that the races which have been excluded by religion or circumstances from all use of alcoholic beverages are at the present time either more moral or more efficient than nations such as the Western European who have grown up under the influence of the widespread use of alcoholic drinks. And it would seem that total withdrawal of alcohol from a civilised community would help to perpetuate the existence of an inherently unstable stock which would tend to degenerate still further in subsequent generations.

The economic results of the use of alcohol by the community hardly fall within the scope of this book except so far as they depend on the physiological efficiency of the individual. In a recent paper by Professor Collis it is pointed out that in the United Kingdom the expenditure per head on food comes to sixteen guineas and on alcoholic drinks to eight guineas. In itself this amount spent by the whole country on alcohol does not seem disproportionate, if we consider that half of the total sum spent on alcohol reverts to the State and is used for carrying on the business of the nation. Moreover, alcoholic drinks supply the most widespread and easily obtainable means of increasing the pleasure of life and of diminishing the frets and worries of daily existence. When alcohol is taken in moderation the money spent on it must be compared with that spent on cinemas, theatres, music halls, or in another class of society, on novels and concerts. All these are means which the individual employs to lessen the maladaptations of existence, to procure himself a respite from reality, and to allow him to live for a time in a land of dreams. If this expenditure were spread equally over the whole population in accordance with their means, there would be little need of temperance propaganda and the drink problem would be one of interest only to psychopaths and fanatics. The trouble is that in many cases the proportion of income spent on alcohol is greater as the social status of the spender is lower, in other words, manual labourers who expend energy and need more food supply, spend proportionately more than do non-manual workers, and efficiency suffers. There is no doubt that if we could abolish 'industrial drinking' the efficiency and health of much of the labouring part of the community would be improved. In this respect an enormous amelioration has been effected in the course of the last fifty years, and there is reason to believe that the improvement is a steadily progressive one. It is doubtful however whether a compulsory withdrawal of all alcoholic drinks would effect the desired change. Such a measure might be successful with a low type of servile population and is indeed employed in many cases where indentured native labour is made use of for manual tasks.

But for the highest efficiency a man must be contented and happy in his work, and we could hardly expect to attain these conditions by a forcible withdrawal of the privileges to which our manual workers have been accustomed. Industrial drinking will be cured by education and improvement in social conditions of the worker. There is no reason to apprehend that the growth of control and temperance which has been continuous during the last generation will now come to an end—rather may we expect it to proceed at an accelerating pace.

CHAPTER XIII

CONCLUSIONS

WE have now considered in brief survey the action of alcohol in various doses on the functions of the body, as well as its influence on the individual in his relation to the community. It remains to us to summarise in this chapter the main facts at which we have arrived and to consider what conclusions are to be drawn as to the value of alcohol to the individual and to the community as a whole. Does an unbiassed study of the facts revealed by scientific investigation confirm us in the view held for so many ages, that alcoholic drinks are a divine gift to mankind, which properly used tends to increase the sum total of human welfare and happiness ; or are we to condemn the discovery of the process of fermentation as a retrograde step in civilisation, which we should attempt to nullify by the total abolition of all alcoholic drinks from our midst ?

I think any one who carefully considers the evidence that has been brought forward will conclude that the answer to this question depends upon the distinction between the use and the abuse of alcohol. In moderation it is difficult to appreciate any harmful effects from its use, whereas when temperance is abandoned and alcohol is used immoderately, its effects are evil and fraught with disaster to the individual and damage to the community.

Our review of the effects of alcohol has established the following facts.

In the first place alcohol is without doubt a food. It is absorbed readily and rapidly both from the stomach and from the intestines. It passes into the blood and thence into all the tissues and fluids of the body. In the tissues it undergoes oxidation in the same way as sugar or fat. As a result of this oxidation energy is set free which may be utilised for the production of muscular work or as heat to maintain the temperature of the body. It differs however from other kinds of food in that there are no means, after it has been taken into the body, for preventing the occurrence of a large concentration of alcohol in the blood and tissues. However large a diet of starch or sugar a healthy man takes in, the amount of sugar in the blood does not rise above ·08 to ·12 per cent, whereas we need only take sufficient alcohol into the stomach to raise its percentage in the blood to ·1, ·2, or even to the fatal concentration of ·6 or ·7 per cent. The normal man in fact behaves towards alcohol in somewhat the same way as the diabetic does towards sugar. A man with deficient sugar tolerance, i.e. in the early stages of diabetes, cannot take a dose of sugar without immediately producing such a rise of the concentration of this substance in the blood that it escapes by the kidneys, giving rise to the *glycosuria* (sugar in the urine) typical of diabetes. This analogy must not be pressed too far, because the diabetic very soon loses the power of oxidising the sugar which is taken in, whereas the normal individual can always oxidise the alcohol in the blood. Indeed, the recovery from the effects of alcohol is brought about by its steady diminution in the blood in consequence of oxidation. The concentration of alcohol in the blood and tissues can therefore be controlled only by regulation of the amount which is drunk, i.e. by the voluntary self-control of the individual. If this is not exercised, any beneficial effect of alcohol as a food is more than compensated for by its deleterious effects as a drug. It is therefore necessary in most cases to limit the intake of alcohol to such a small amount that as a food it can only form a small proportion of the total diet. The idea that a plentiful use of alcoholic drinks is beneficial for heavy workers is misleading and mischievous. Although we often find powerful men doing large amounts of work and taking considerable quantities of alcohol, this work is done in spite of and not by aid of the alcohol. We have seen that a trained mountaineer may, after taking a moderate dose of alcohol, make a severe ascent in a shorter time than the ordinary untrained individual. Compared against his own record without alcohol however it was easy to see that the alcohol had a deleterious effect in slowing his pace and in increasing the energy which he had to put out for a given piece of work. Wherever it has been possible to make a comparison between gangs of men doing heavy work, one allowed the free use of alcoholic drinks during the work and the other debarred from such drinks, it has always been found that the performance of the abstinent gang was superior and attended with less fatigue. Industrial drinking is thus founded on a pernicious illusion, and any measure which would diminish its extent can result only in greater efficiency and in improved health of the workmen.

On the other hand there are certain cases where the action of alcohol as a food is especially sought. An example is found in diabetes, where it is desirable to use alcohol, which the patient can oxidise, in place of the sugar which the patient is unable to oxidise. Under these conditions we must take measures to diminish the toxic action of alcohol as much as possible by preventing its concentration in the blood from rising at any time to a toxic level. For this purpose alcohol is given diluted in repeated small doses from hour to hour during the waking hours.

The ease of absorption of alcohol and the fact that it does not require digestion also makes it useful even as a food in the weakness of old age and in some cases of disease. Here the drug-like action of moderate doses may be of actual value to the patient in allaying restlessness and producing sleep. But for the normal individual, the food value of alcohol is not of importance. In most cases it is not as a food that alcohol is consumed, but in order to add to the pleasant taste and enjoyment of food and so to promote digestion and assimilation. The justification of wine has always been that it makes glad the heart of man. No one has considered it as replacing the flesh, corn and oil which are the traditional necessary elements of a dietary.

In considering the drug-like effects of alcohol we have seen that, apart from the results of chronic over-indulgence in strong alcoholic fluids, the only action which is significant is its action on the central nervous system. In popular opinion alcohol is regarded and spoken of as a stimulant, on account of its effect of producing greater freedom of movement and speech, quickening of the pulse and circulation, and often a condition of excitement. These phenomena do not however, as we have seen, depend on stimulation by the alcohol itself, but are the indirect results of its narcotic influence on the highest and last developed functions of the cerebral cortex. The action of alcohol from beginning to end is essentially depressant. Its first effect is to dull the perception of unpleasant feelings and surroundings, to diminish self-criticism and the fear of undertaking any action which may excite remark or be regarded by other people as inappropriate to the situation. Civilised man, like the ancient Japanese, is constantly striving to avoid any action which is "other-than-to-be-expected," though among us the penalty of social ostracism or loss of respect from one's fellows has taken the place of the more drastic methods of the times of the Shoguns. Thus, under the influence of alcohol an individual becomes more communicative, losing his suspicion, he is more receptive and interested in the conversation and affairs of his fellows, his emotions are more easily aroused ; the shy and diffident person becomes less fearful of revealing what is passing in his mind and may display himself as a brilliant conversationalist or witty speaker. It is not surprising therefore that alcohol is commonly regarded as a stimulant. But the same action continued further so as to affect the next lower levels of the nervous machine causes interference with the processes of co-ordination and deterioration of the intelligence, so that it is only necessary to increase the dose for the witty conversation of a man to degenerate into the tiresome loquaciousness and blurred speech of intoxication.

There is nothing inherently good about a stimulant and nothing inherently bad about a narcotic. Each may have its value in the proper dose and under appropriate conditions, and our study of the effects of alcohol enables us to judge what are the proper conditions for its employment. In the first place we can say that it is unsuitable for the highest mental efforts, or during the performance of prolonged muscular feats. But in many individuals the control by the highest centres is developed to an excessive degree so that it may actually interfere with the carrying out of complicated acts acquired by constant practice. To such individuals it is relaxation rather than increase of tension or of nervous excitement which is required, if they are to attain their optimum performance, and a small dose of alcohol may result in an improvement of efficiency. It is in this category that we can include the instances already adduced in which a man's play at golf is improved by a glass of whisky, or the shy man is emboldened to make a speech or to comport himself naturally or with less constraint in society.

This relaxation of tension resulting from the narcotic action of alcohol on the highest centres of the brain may also be of value in promoting repose after toil, in freeing a man from the cares and worries of the day's business and enabling him to digest and assimilate his food and restore his powers by sleep better than he would have done in the absence of such aid.

The action of alcohol as a restorative in conditions of 'faintness,' induced by sudden shock or injury, is also dependent on its narcotic action in diminishing the susceptibility of the patient to painful impulses, physical or mental, and in lowering the excitability of the centres, by the intermediation of which the action of the heart is being reflexly affected.

We have seen that alcohol is injurious in its effects either when taken in immoderate doses or when taken repeatedly in excess over a long period of time. The constant exposure of the tissues to the action of alcohol in the body fluids leads to a general impairment of their vitality. This effect is exacerbated if the alcohol is taken in strong concentration, so as to damage the lining membrane of the alimentary canal, and thus set up all kinds of secondary disorders depending on the absorption of the toxic products of digestion. Chronic alcoholic excess produces not only specific nervous disorders, such as delirium tremens and others which have been mentioned, but also a progressive deterioration of the mental and moral qualities of the individual, while the effect of alcohol on the tissues diminishes his powers of resistance to infection, his reactions of self-protection, and by its action on the reproductive cells tends to the elimination of the stock from among the community.

Throughout this book we have spoken repeatedly of and drawn a contrast between the effects of the moderate and the immoderate use of alcohol, and an inquiry seems justified as to the quantitative definition of these terms, moderation and immoderation.

The safest general statement would be that any dose is immoderate which diminishes a man's efficiency and powers of performing his normal avocations. For the psychopath, for the man of weak nervous inheritance or who has suffered from head injury, this statement implies that *any* use of alcohol would be immoderate, and the same rule should apply to children, and young people during the period of growth, while their processes of control are being perfected by education and discipline. For the normal healthy individual, the experiments which have been cited in the previous chapters, especially in Chapter V, show that 12 cc. of alcohol, when given on an empty stomach, occasionally produce an effect in diminishing powers of muscular co-ordination and other complex neural processes, but that in nearly all cases the effects of such a dose are unappreciable when taken with a meal. 12 cc. correspond to a glass of beer or a wine-glass of claret, so that our conclusion must be that any alcohol taken on an empty stomach will tend, if only slightly, to depreciate an individual's powers of performance, but that a glass of wine or beer taken with his lunch will not interfere with the carrying out of his afternoon's work. When the work of the day is finished a greater freedom in the use of alcohol is permissible. We have seen that 35 cc. of alcohol produces in nearly all cases effects on muscular co-ordination and performance which can be measured, but would not influence a man's behaviour or his powers of comporting himself with propriety as a member of society. 35 cc. of absolute alcohol are contained in half a bottle of light wine—claret or hock—in a pint and a half of ale, 3 ounces of whisky (30 under proof) or in a quarter of a bottle of port. Moreover, 35 cc. of alcohol will undergo complete oxidation in the body within 3½ to 5 hours, so that if this amount is taken with the evening meal the alcohol will have disappeared from the blood and the body tissues many hours before it is necessary to get up in the morning and commence the work of the day. Such quantities might be taken throughout adult existence without interfering with bodily health or efficiency and are sufficient to attain the beneficial results and to produce the increased pleasure in living which are the objects of the employment of alcoholic beverages. It is probable that the amounts given might be doubled on occasions, but it must be remembered that 70 cc. of alcohol will take at least seven hours for its complete oxidation in the body, and during sleep may require ten or twelve, so that in all probability the man who has thus indulged will not be at his best when he rises the following morning.

An occasional debauch is not so harmful as the continual soaking of quantities of alcohol just short of the degree necessary to produce evident intoxication. But such a proceeding involves the loss of a man's self-respect and the regard of his fellows. In the normally constituted individual it is succeeded by a sense of shame which should be a sufficient deterrent from its repetition. The function of control in the individual is trained in the young animal by the painful results of wrong action, and, with advancing age, by the herd instinct which makes a man seek the approval of his fellows and fear their contempt. It is by a change in popular opinion that drunkenness has been eliminated from the higher and middle classes, and the process is rapidly extending to the lower grades of the population. Except therefore in the case of persons of weak nervous inheritance, we may hope that in time, by education, by instillation of proper ideals, and by providing such conditions of life as are compatible with self-respect, drunkenness with all its attendant and consequent evils, may be entirely abolished.

ALCOHOL AS A MEDICINE

By Robert Hutchinson, M.D., F.R.C.P.

ALTHOUGH there can be no doubt that our forefathers used alcohol as a medicine too often and in too large doses, yet there are few medical men to-day who would not agree that it is a most valuable drug and one which we could ill do without in practice. It is often a difficult matter in any case of illness to be sure whether a medicine that was given has contributed to the patient's recovery or not, and this is specially so in the case of an agent such as alcohol, where a good effect in one direction is often balanced by an unfavourable influence in another. None the less, there are many morbid conditions in which the benefit derived from the administration of alcohol seems so clear and is so much in harmony with what one would expect from its physiological action that there can be no reasonable doubt of its curative effect. It is proposed in what follows to confine attention to these instances and to leave out of consideration possible therapeutic uses of alcohol which are open to reasonable dispute.

Alcohol as a Food in Disease

It has been shown elsewhere in this book (p. 67) that alcohol is a real food in the physiological sense, and that it undergoes complete combustion in the body with the liberation of energy in the proportion of seven Calories per gramme. In addition to this it shields the proteins and the fats of the body to some extent from oxidation. These properties make alcohol of considerable use in some cases of disease. In prolonged fevers, for instance, such as typhoid fever, when the patient has difficulty in taking food and nutrition becomes impaired, the administration of alcohol checks tissue waste and helps to supply energy to the body. It has also the advantage that it is easily taken and makes no demands on the enfeebled digestive powers. The form in which the alcohol is administered in these circumstances varies in different countries. Here we are accustomed to give it in the form of whisky or brandy, but on the Continent a light wine is usually employed. There is a good deal to be said for using beer as a suitable vehicle. It has the advantage of containing alcohol in a dilute and agreeable form, whilst the dextrins which it also contains enhance the nutritive value of the beverage. A similar use of alcohol may be made in all chronic wasting diseases although unaccompanied by fever, and in cases in which it is desired to make a patient gain weight. Stout has attained a high degree of popularity when the latter object is aimed at. In severe cases of diabetes in young subjects, especially when treated by the modern method of underfeeding, alcohol is often of help, as it to some extent takes the place of carbohydrates without being itself a source of sugar, whilst at the same time its use adds to the patient's feeling of well-being.

Alcohol as an Aid to Digestion

The effect of alcohol on the processes of digestion has been the subject of much experimental investigation. The results of such work, however, must be interpreted with great caution. The action of alcohol on the process of artificial digestion in a test-tube cannot fairly be compared with the very different conditions which obtain in the living stomach. Nor can deductions from its effects in health, especially in healthy animals, be safely applied to the action it is likely to have on the human digestion in cases of disease or disorder.

Bearing these cautions in mind we may yet safely agree that experiment shows that on the whole alcohol tends to increase the secretion of gastric juice and to stimulate the activity of the stomach movements, and that relatively large quantities must be present in the gastric contents before the action of the gastric ferments is seriously interfered with. It follows from this—and experience at the bed-side concurs—that alcohol will be harmful in cases of digestive disorder which are accompanied by an increase of secretion or acidity, but that it is likely to be beneficial where secretion is diminished and motor power impaired. In cases of so-called 'atonic' dyspepsia, therefore, alcohol may be administered with advantage. Such a form of indigestion, attended by diminution in the gastric secretion and by feebleness of the muscular tone of the stomach wall, is met with commonly in old people, and manifests itself by delayed and difficult digestion with much distressing flatulence. In these circumstances the administration of alcohol with meals is often a great aid. In healthy people, too, there is no doubt that the digestion of a cold meal, especially if taken late in the day, is often greatly helped if some form of alcohol is taken with it. There are, again, many otherwise normal people who suffer at times from what may be called a 'tired stomach.' If such an one sits down after an exhausting and harassing day to partake of an evening meal, it often proves that the stomach is unequal to the task of dealing with it satisfactorily. In these circumstances an alcoholic beverage may make all the difference. Alcohol, through its action on the nervous system, soothes the irritated higher centres, thus removing checks and interferences; whilst at the same time it stimulates the functions of the stomach. By its aid food may be taken with relish and digested with comfort, which would otherwise either be refused or lie upon the patient with a load "heavy as frost." The 'tired' stomach is of common occurrence in modern civilised life with its incessant demands on nervous energy, even in healthy people; but it is also met with during convalescence from serious disease, and here again alcohol is often of the greatest help in improving appetite and digestive power, and so bringing the patient back to normal health.

Lastly, alcohol has a valuable carminative effect in cases of flatulence. Some of the benefit which follows its use in atonic indigestion is due to this property, but it is particularly serviceable in cases of sudden flatulent distension of the stomach from any cause which may, especially in the aged, seriously hamper the action of the heart and even threaten life itself. In such a state of affairs a mouthful of old brandy, taken neat, is a sovereign expeller of wind, brandy being superior in this power to any other form of alcohol, probably in virtue of the ethers which it contains. It exerts a similar beneficial effect to some degree in all forms of colic, probably in virtue of its 'antispasmodic' action. In the other forms of digestive disorder spoken of above, the form in which the alcohol is taken may to a large extent be left to the patient's choice, but it should not be too dilute, for the introduction of a large quantity of fluid into a toneless stomach is harmful. There is much to be said for a glass or two of good wine, the æsthetic properties of which tend to promote appetite and gustation more than a spirit; whilst for the reason already given beers are too dilute and bulky to be employed with safety, except in those cases in which appetite alone is impaired.

Alcohol as a Tonic

A tonic may be defined as anything which makes a patient feel better, and there can be no doubt that alcohol is a tonic in this sense for those who are unaccustomed to its use. In order to obtain its tonic effects it should be given with meals, for it acts mainly by increasing the patient's appetite and power of digestion. The red wines, such as Burgundy and Port, are believed to be specially possessed of 'tonic' properties. There are also several 'medicinal' wines on the market in which the tonic effect of alcohol is increased by the addition of bitters, meat extracts, malt, etc., and there can be no doubt that when administered under medical supervision these have a legitimate place in treatment. It is in the building up of patients who are simply 'run down,' who are neuralgic, or who are convalescing from acute disease that the tonic effects of alcohol are of special value.

Alcohol in Disorders of the Circulation and Heart

Alcohol dilates the superficial blood vessels and 'determines' blood to the surface of the body, and these actions are sometimes taken advantage of by the physician. After exposure to cold, for example, when the superficial vessels are contracted and the blood has been largely driven into the deeper organs, alcohol may save the situation and prevent the onset of visceral congestion or even inflammation by bringing about a fresh distribution of the circulating fluid. During the temporary 'chill' or rigor, which may occur in such a disease as malaria, to mention one example, it has a similar effect, whilst in patients who have an habitually 'poor circulation' its regular use helps to keep the surface vessels and extremities better filled. In aged persons especially this action is often very beneficial and may even counteract a tendency to senile gangrene. Another consequence of its influence on the peripheral vessels is that alcohol tends to lower blood pressure, and although it is not wise to use it for this purpose in cases of habitual high tension, it is often of service in emergencies such as an anginal seizure. For all these purposes the alcohol should be administered "hot and strong," as, for example, in some form of grog.

The action of alcohol upon the heart has been much disputed and has been the subject of an immense amount of physiological investigation, the outcome of which has been to show that it has no *direct* 'stimulating' effect upon the heart as was so long supposed, but that here as elsewhere its main action is sedative. It must, therefore, be admitted that the practice of administering alcohol regularly throughout an acute illness with the object of stimulating the heart is not justifiable on physiological grounds, and it has fallen more and more into disuse for this purpose by clinicians. Here again, however, one must not lay too much stress upon the results of experiments on animals, for although alcohol has no directly stimulating effect on the heart in health, it may still improve its action in disease by removing nervous inhibitions or by controlling an exaggerated reflex excitability. If, then, its use is really beneficial in acute disease as the older practitioners universally believed and as many of their successors of to-day still hold as the result of observation at the bed-side, it is in some such indirect ways as these that it must be supposed to act.

On the other hand, there is no doubt that alcohol *temporarily* increases the force and frequency of the heart's contractions by acting reflexly through the stomach, and in transient heart failure, such as is met with in syncope, shock and faintness, the administration of a concentrated form of alcohol is undoubtedly of immediate benefit. It is true that the effect does not last long, but in the conditions indicated a prolonged effect is not required.

Alcohol as a Sedative and Hypnotic

All physiologists are agreed that the action of alcohol on the nervous system is essentially a depressant or sedative one, and that its supposed stimulating effect on the brain is really illusory and due simply to inhibition of the higher controlling centres. In conditions of abnormal cerebral excitability this sedative action of the drug can be turned to good account by the doctor, the best example of this perhaps being the employment of alcohol as an hypnotic in cases of mild insomnia. It is especially in old and weakly persons that alcohol, preferably in the form of a night-cap of toddy, is indicated, and in such subjects it exerts its best effects.[1] In the cerebral excitation which results in delirium, its quietening effect is also of value, and the appearance of any cerebral symptoms in the course of an acute fever always calls for its administration.

Apart from this direct sedative or hypnotic action there is little doubt that what may be called the 'physiological' effects of alcohol are often of service to the patient in acute illness. By calming the higher centres it helps to remove the factors of worry and anxiety which militate against recovery, and gives the patient courage, even if it be but Dutch courage, to fight his disease. It must never be forgotten that the object of the physician should be not only to cure his patient, but to do so, to use the expression of the old writers, "tuto, cito, et jucunde," and it is in lessening the inevitable discomforts of illness that alcohol is often a potent help.

[1] It is the combined efforts of alcohol in aiding digestion, improving the peripheral circulation, and promoting sleep that make its regular use often so helpful in maintaining life in the aged. "Wine is the milk of old age."

ALCOHOL AND ITS RELATIONS TO PROBLEMS IN MENTAL DISORDERS

By Sir Frederick W. Mott, K.B.E.,

LL.D., M.D., F.R.S., F.R.C.P.

IN 1897 I was appointed Pathologist to the London County Asylums for the purpose of investigating the causes of insanity. At that time I was Physician at Charing Cross Hospital. My attention was immediately attracted to the assigned causes of mental disease in the reports of the L.C.C. Asylums and of the Commissioners in Lunacy, and the great difference they showed to my experience of such as Hospital Physician. Whereas in the hospital I saw large numbers of cases of acute and chronic alcoholism which showed either no symptoms of insanity, or only transient symptoms, and large numbers of cases of organic disease of the nervous system which were due to syphilis, I found, in the statistics of assigned causes of admissions to the London Asylums, alcohol as a cause in a very considerable proportion of cases, while syphilis as a cause was hardly recognised. I therefore determined to see how far these statistics were reliable. I was able to show that the reverse was the case, for all the cases of general paralysis, a large proportion of the cases of organic brain disease, and numbers of cases of congenital imbecility were due to syphilis; but the cases in which alcohol was *per se* the cause of insanity were to the total population of the asylums relatively few. This article will be based largely upon investigations which have been published in full in the "Archives of Neurology," Vol. III, 1907, and in the Report of the International Congress of Psychiatry held in Amsterdam in 1907. Subsequent experience has confirmed these results. As Neurological Expert for the Neurological Clearing Hospital of London during the war, I had the opportunity of investigating the relation of alcohol to war neuroses and psychoses.

With this preamble I will discuss first briefly the physiological action of alcohol on the nervous system.

The Physiological Action of Alcohol on the Nervous System

The main effects of alcohol that have any real significance are upon the nervous system. The action of alcohol on the nervous system is essentially sedative, and, with the possible exception of its direct influence on the respiratory centre, is not truly stimulant. The apparent stimulant effects are due to the narcotic effects of alcohol on the highest controlling centres of the organ of mind, leading to a release from control of the evolutionally lower centres.

Proportional to the degree of concentration of alcohol in the blood, and thereby in the cerebro-spinal fluid, is the effect in depression or suspension of the functions of the various evolutional levels in the inverse order of their phylogenetic and ontogenetic development. The last to come evolutionally, therefore the least stable and firmly organised, is the first to go. This highest functional psychic level, which is so varied in capacity in different individuals, has developed *pari passu* with progressive evolution of the social instinct. The feelings of a civilised human being are largely dominated and his behaviour determined by the customs, traditions, religion, and social usages of the community and race. Experience shows that disorders of conduct arising from the effects of alcohol—and in speaking of disorders of conduct I refer to all forms of anti-social conduct, whether it be crime or insanity—are dependent not only upon the quantity of alcohol consumed, and the period over which inebriety extends, but even more upon the inborn degree of organisation and stability of this highest psychic level.

Evolutional Levels of Hughlings Jackson in Relation to the Effects of Alcohol

Hughlings Jackson, in his philosophic paper on the factors of insanities, pointed out that the different depths of dissolution of the evolutional levels, and the positive and negative phases of symptoms arising as a result of successive dissolution of these levels, constituted a basis for the study of insanities. Maudsley has stated, " A drunken man notably exhibits the abstract and brief chronicle of insanity, going through its successive phases in a short space of time." Let us see how far these views accord with the facts.

Alcohol affects as a narcotic the synaptic junctions of all the neurones, but it affects first the synapses of this highest evolutional level, causing at first lessened function, and later loss of function. The effects are not stimulant on this level, but sedative and narcotic ; alcohol thus releases from control the lower levels, thereby permitting a positive phase in the lower levels—for example, a brisk flow of ideas translated into speech and action associated with self-confidence. There is, however, a diminution of self-criticism, deliberation, and judgment when this level is narcotised by alcohol ; and this psychic level being inherently of a deficient organisation and stability a small quantity is sufficient to produce this effect. Experiments show that alcohol taken under conditions of restful environment and mental placidity—that is, where there is no external or internal exciting cause—has a sedative effect, and leads to drowsiness and sleep. Consequently, the apparent stimulating effects are due to the narcotic action on the highest psychic level and release of control over the lower levels, which are thereby much more easily roused by internal or external stimulation to activity.

As alcohol concentrates in the blood the second depth of dissolution occurs. This is a progressive falling off of awareness and self-criticism, which is manifested by excited talk, aggressiveness, and inflamed emotions, accompanied by fine sensory-motor disturbances as exhibited in difficulties of articulate speech, diminished acuity of æsthetic sense perceptions, and more or less clumsiness in the execution of fine skilled movements.

In the third stage of dissolution the negative condition of the higher functions of the organ of mind is very great. There is manifest evidence now of affection of lower levels by coarse sensory-motor disorders—for example, double vision, motor inco-ordination, instability of gait and station. The reeling gait is doubtless due to affection of the cerebellum ; for a similar condition occurs in cerebellar disease. Speech is slurred, indistinct, incoherent, and confused. On the emotional side the individual is either expansive and quarrelsome, or melancholic and maudlin, the *vin gai* and *vin triste* of the French, and the drunk and disorderly of our police courts.

In the fourth stage of dissolution there is a total dementia and stupor with stertorous breathing, and often incontinence of urine and fæces. Gradually these conditions pass over into a state of deep sleep, after which the patient usually returns to the normal condition. In some cases, however, when the quantity of alcohol taken is very large, the vital centres are so greatly affected that the drunkard may become comatose and die of failure of respiration. It is generally estimated that when the blood content is 0·6 per cent of alcohol, which corresponds to a dose of about fourteen ounces of absolute alcohol, or nearly a pint and a half of proof spirit, there is a considerable likelihood of death ensuing. The quantity of beer which would contain this amount of alcohol would be over two gallons, so that it is easy to understand that a concentration in the blood sufficient to kill is not so likely to occur with beer as with spirits.

Tolerance to Alcohol of the Habitual Drunkard

As a result of continued use, tolerance can be acquired, so that the habitual drunkard may consume, without becoming intoxicated, quantities of alcoholic beverages which would cause well-marked signs of drunkenness, or even prove fatal to the person not accustomed to it. The acquisition of tolerance, however, implies a removal of a protective mechanism, for it allows the drunkard to imbibe daily quantities of alcohol which he could not have taken if his brain had retained its normal power of reacting to it; eventually he becomes a chronic inebriate, and develops sooner or later pathological conditions.

I will first relate my experiences as Physician to Charing Cross Hospital. Cases in which intemperance was the main cause of the disease, which came under observation at this hospital, were especially numerous on account of the situation of the hospital and the class and occupation of the patients who sought relief there for various diseases. Located amongst the theatres, music-halls, restaurants, and places of refreshment, it was the receiving place for those who were intemperate in the pursuit of pleasure, also for a number of people engaged directly or indirectly in the liquor traffic, or whose occupations led to prolonged intemperance. Among such were potmen, barmen, barmaids, publicans, prostitutes, waiters, cooks, and kitchen servants from hotels, stage carpenters, scene shifters, cabmen, bus drivers and conductors, and particularly numerous were the Covent Garden porters who were addicted to drink large quantities of beer. The majority of these people were, at the time that they came or were brought to the hospital, in employment. I regard this as an important point in connection with nervous symptoms which may be manifested as the result of prolonged intemperance, because to the casual observer certainly, and even to the skilled observer not infrequently, no marked mental symptoms were discoverable in a very large proportion of these acute and chronic inebriates. Occasionally, head or other injury slight or severe, the onset of disease (especially pneumonia or other infection) or an extra bout of drinking resulted in delirium tremens, or it developed after the patient had been admitted in some cases, because alcohol was withheld. A few cases proportionally of true alcoholic psychosis with multiple neuritis occurred, affecting especially women.

During the year 1905 there were 781 cases admitted to the medical wards of Charing Cross Hospital. The notes of these 781 cases were examined in respect to the direct or contributory effects of alcohol. In 111 males and 17 females alcohol was noted in the history either as a direct, or more often a possible contributory cause. Among these were 21 cases of liver affection, 5 cases of delirium tremens, and 8 cases of alcoholic psychosis with multiple neuritis.

Dr. Ascherson, in a valuable monograph "On Some Aspects of the Mental State in Alcoholism, with especial reference to Korsakoff's Disease" (alcoholic psychosis with multiple neuritis), see "Archives of Neurology," Volume III, states that among 245 cases of disease due directly to alcoholism admitted to St. George's Hospital during the years 1900 to 1904 inclusive, there were 38 cases of Korsakoff's disease. I mention this because I have compared the postmortem results of St. George's and Charing Cross Hospitals. I have no doubt that far fewer instances of alcohol as a direct or contributory cause of admission to these hospitals would be found now than in the first five years after 1900 when these statistics were taken. This is of importance, because the admissions to asylums have increased while drunkenness and chronic inebriety have decreased (*vide* p. 198).

Chronic Alcoholism in Hospital Practice

Although mental symptoms were not noted in the chronic alcoholics attending Charing Cross Hospital, doubtless, could their conduct have been ascertained in their home and daily life, a mental deterioration would have been discovered. Although their faculties of intelligence and memory might have been intact, their moral sense and self-criticism would have in most cases deteriorated.

Generally speaking the chronic alcoholic becomes indifferent to responsibilities, loses ambition, and his affection wanes. Thus he is content to see his home ruined, and his wife and children reduced to poverty and misery. He is either boastful and loquacious, or taciturn and ill-tempered. At one time he may be amiable and sociable, at another peevish and irritable, constantly grumbling and finding fault, if not actually rude and insulting. He may exhibit in his conversation wit and humour, but not infrequently the mental association is rather by rhyme and repetition of well-worn jokes, abusive epithets, and coarse vulgar stories, but occasionally he exhibits keen repartee. He is warm-hearted and generous when, having regard to the poverty in his home, he should be careful with his money. Untruthfulness, loss of power of attention, and a tendency to invent fictitious stories are common symptoms of mental deterioration in the chronic alcoholic. But although he may be at any time a danger to society, he generally manages to escape the lunatic asylum.

Many of these chronic alcoholics, in all stations of life, are successful in their profession and are good skilled workmen and artists. Is it not because the master intellectual feeling—that with which the whole nature is imbued, and the actions of which by constant repetition become subconscious and habitual—persists when other states of feeling have become perverted and gone? Even the æsthetic feelings, which are the last to come evolutionally, and therefore normally the first to go, may, owing to an inherent tendency and constant habitual and subconscious activity in associative memory, tolerate better the deteriorating effects on the mind produced by chronic alcoholism, and resist longer the work of destruction than the moral sense. The æsthetic sense may thus remain when the elementary feelings of right and wrong may be lost or perverted. Thus a chronic alcoholic artist may by his conduct be anti-social, and yet still delight the public, whether it be in painting, sculpture, music, poetry, or the drama. We see in such cases the most fragile state of feeling which goes to make up character, and especially individualism, persist in the moral degenerate because it has become a passion dominating the whole of the man's nature, and the main object of the habitual routine of life. It is sometimes brought forward as an argument in favour of the use of alcohol that some of the greatest artistic geniuses have used it to excess, and it has been assumed that it stimulated their emotions and imaginative faculties, even if it weakened their will-power, and having made them indifferent to social customs and anxieties, their æsthetic feelings and passions were enabled to have full play. But "poets are born not made," and their imagination persists *in spite of* the effects of alcoholism.

A considerable proportion of the chronic alcoholics drift into the vagrant class or help to swell the floating population of prisons and workhouses. Many of them are more anti-social in their conduct than the certified lunatic.

Chronic Alcoholism, Suicide, and Crime

Dr. Sullivan, in his work on alcoholism, 1906, comes to the following conclusions regarding disorders of conduct and insanity. The statistical and other evidence concerning suicide, crime, and lunacy, offers the material from which he forms at least a rough numerical estimate of the absolute and relative importance of the alcoholic influence in the production of these social evils. From this evidence he has been led to the view that chronic alcoholism is the cause of a considerable proportion of the suicide in this country, probably of as much as a fifth of the total amount; and that it has had a large part in the upward movement of suicide which has been observed during the last few decades. Similarly he has concluded that chronic intoxication is responsible for about three-fifths of the homicidal crime in England, and that in rather less than half the cases of sexual crime the causal condition is either chronic alcoholism or simple drunkenness, the latter being more usual in rape on adults, while the violation of children is more often an offence of the chronic drunkard. In crimes of acquisitiveness, on the other hand, alcoholism seems to be a practically negligible quantity. My own experience tends to confirm Sullivan's view regarding the part played by drunkenness in respect to suicide and crimes of violence.

Unreliability of Asylum Statistics in Relation to the Influence of Alcohol in the Production of Insanity

The statistics relating to alcohol and insanity in the London County Asylums (for thirteen years) show that the percentages of admissions in which alcohol was the asserted cause of insanity varied considerably in different asylums in the same years and in the same asylum for different years, and the differences were so great that the collected statistics derived from this source are not reliable. The personal equation of the medical officers who obtained the information and of the friends who gave it, as to what constitutes alcoholic excess, and as to how far alcohol is an efficient cause, or merely a co-efficient in the production of insanity, was variable. Thus in one year, 1902, from the same class of people, alcohol is the assigned cause of 25·6 per cent of the admissions to Hanwell, and to Claybury 11·2 per cent; but in 1906, in 28 per cent of the admissions to Claybury intemperance is the assigned cause, while at Colney Hatch it is only 14 per cent (*vide* table). At Bexley, where the statistics appeared to be fairly uniform since its opening, intemperance as an assigned cause was high, the average being 22·8 per cent for the seven years; but an analysis of the cases admitted during 1905 to this asylum, in which intemperance was the assigned cause in 25·7 per cent of the total admissions, shows that there were many in which other causes were associated. Thus, out of 248 male admissions, alcoholic excess was the assigned cause in 46, or 18·5 per cent, and out of 246 female admissions alcoholic excess was the principal cause in 38, or 15·4 per cent —a total percentage on the whole admissions of 17 per cent. But when we inquire into these cases, we find that 13 were imbeciles, 5 were cases of chronic delusional insanity, 5 were epileptic, 5 had organic dementia, and no less than 20 were cases of primary dementia. In fact, out of the 84 cases quite

Table showing the Percentage of Total Admissions to the various London County Council Asylums of Cases in which "Intemperance" was regarded as a Causative Factor.

Year	Hanwell	Colney Hatch	Banstead	Cane Hill	Claybury	Bexley	Manor	Horton
1893	18·4	11·8	5·3	11·0	—	—	—	—
1894	18·1	16·5	13·5	16·6	9·5	Not opened.	Not opened.	Not opened.
1895	18·5	11·5	13·5	16·2	17·6			
1896	14·0	14·3	13·8	15·0	20·6			
1897	15·4	13·0	16·9	17·1	22·6			
1898	20·7	10·9	20·7	18·6	27·5			
1899	10·4	12·2	17·9	19·1	17·8			
1900	15·8	18·8	17·0	14·1	12·9	23·8	8·7	—
1901	18·8	15·0	15·0	16·8	13·2	23·2	6·5	—
1902	25·6	12·8	17·8	20·0	11·2	15·4	15·7	—
1903	14·0	13·2	16·5	24·7	19·1	20·6	15·9	—
1904	17·4	17·8	17·4	22·2	29·3	24·2	21·8	12·2
1905	15·9	13·2	19·2	20·2	26·9	25·7	11·6	14·2
1906	19·6	14·4	15·7	18·2	28·8	27·6	14·0	17·0

one-half were lunatics or potential lunatics and the subjects of an inborn tendency to mental disease. My experience at Hanwell, Claybury, and the other asylums I visited corroborated this statement.

It would have been interesting to have ascertained what was the percentage of total abstainers admitted to the asylums. Without being able at present to produce any precise data, I think the percentage would come out considerably larger than many people think. Of course, it would be necessary to take adults only. In this connection it is interesting to note that Sullivan,[1] in his valuable work on Alcoholism, after analysing the causes of intemperance and its relation to insanity, concludes "that in this country the proportion of cases of certified insanity in which alcoholism is the essèntial cause of disease falls a good deal short of the 16 per cent at which it is rated in the official statistics, and may possibly be something under 10 per cent." He refers to "the enquiry conducted by the American Committee of Fifty, which showed that insanity was attributed to drink in 24·22 per cent of the patients observed, but that only a little over half that number (viz. 12·22 per cent) were genuine alcoholics," and to a similar investigation carried out by the Massachusetts Labour Bureau, in which 20·86 per cent of cases were supposed to be due to alcohol, but only 16·9 per cent were excessive drinkers. It may perhaps be worth mentioning as an interesting illustration of the danger of *post hoc ergo propter hoc* reasoning in regard to pseudo-alcoholic cases, that in both these enquiries total abstinence was found to be much more frequent than intemperance as an antecedent of insanity."

Regional Dissociation between Alcoholism and Insanity

Alcohol as an *efficient* cause of insanity is not so great as the published reports of the Lunacy Commissioners indicate. In support of this I will briefly indicate some further arguments. Dr. Bevan Lewis has shown a regional dissociation between alcoholism and insanity. Thus, inland and agricultural communities were the least inebriate, but had the highest ratio of pauperism and insanity; while maritime, mining, and manufacturing communities above all others were the most intemperate, and revealed the lowest ratios of pauperism and insanity.[2] Dr. Sullivan, by careful analysis and tables, shows conclusively that in the regional distribution of insanity it is difficult to trace any evidence of alcoholic influence such as might be expected if alcoholism really accounted for a sixth of the total number of cases. Thus Lancashire, Warwick,

[1] "Alcoholism: a Chapter in Social Pathology," 1906, by W. C. Sullivan, M.D., Medical Officer in H.M. Prison Service.

[2] "Alcohol: Crime and Insanity." *Journal of Mental Science*, 1906.

and Cheshire, which rank very high in the scale of alcoholism, and the mining counties, where drunkenness is very rife, are alike in showing very low rates of insanity.

These valuable observations of Dr. Bevan Lewis and Dr. Sullivan present points in similarity with the observations of Sir Hugh Beevor on tuberculosis, who showed that an industrial population often exhibited a lower death-rate from tuberculosis than the surrounding agricultural population. He attributed this, in a measure, to deficient nutrition on account of wage-earning capacity. There is another, and still more important factor, and that is the poor mental and physical state of the agricultural population near to large industrial centres. The mentally and physically capable migrate to the large towns for higher wages, leaving the physically and mentally feeble and unfit behind. Dr. John Macpherson,[1] "Morison Lecture," 1904, showed that in Scotland generally the ratio of insanity to population tended to be low in those communities with a rising population, and high in those with a falling population. This was confirmed by Dr. Easterbrook. It is a well-known fact that the feeble-minded are especially prone to tuberculosis, which is a fortunate circumstance, for it tends to rid the race of poor types. Imbeciles and idiots and sufferers with primary dementia of adolescence are often unfertile, which is another reason for the dying out of a degenerate stock; but a degenerate stock frequently contains feeble-minded in all grades, some of which will not die out, but propagate in considerable numbers, and it is probable that no class of the community produces insanity to such a degree as the high-grade imbecile. The progeny begotten of a feeble-minded mother by a drunken father, according to my experience, is much more likely to be born mentally defective or become insane in later life, than when both parents are intemperate but neither of inherent mental deficiency.

Statistics of Post-mortem Examinations in Hospitals and Asylums Compared

If we compare the statistics of hospital and asylum post-mortem examinations we are struck with the fact that in the former there are a large number of cases of advanced cirrhosis

[1] "Journal of Mental Science, 1904."

of the liver, whereas in the latter there are relatively few, and many of those only recognisable with difficulty. A statistical analysis of the results obtained in 1099 autopsies on adults at Charing Cross Hospital, compared with 1271 post-mortem examinations at Claybury, was made. An analysis of the results obtained by Sir Humphry Rolleston and Dr. Fenton on post-mortem records extending over ten years at St. George's Hospital in the main supports the opinion, that the statistics derived from Charing Cross Hospital agree with those which could be obtained at other London hospitals.

The principal points of interest, which this tabular synopsis (p. 196) of a comparative inquiry into the post-mortem incidence of cirrhosis of the liver at Charing Cross Hospital and Claybury Asylum afford in relation to the subject of alcohol and insanity, may be thus summarized :

> At Charing Cross Hospital the notes of the autopsies upon 1099 adult cases were examined—735 males and 364 females. Of this number there were 85, or 7·7 per cent, cases of cirrhosis of the liver, which accords closely with the 8 per cent in which alcohol was the immediate and direct cause of the disease for which patients were admitted to the hospital. The percentage of males was 9·1, and of females 4·9.
>
> At Claybury Asylum the notes of 1271 autopsies were investigated (627 males and 644 females). Of this number only 23 cases of hepatic cirrhosis were found (14 males and 9 females). The total percentage of cirrhosis of the liver works out at 1·8 per cent (males 2·2 per cent, and females 1·3 per cent).

There are a number of points of interest to which the synopsis refers, but I will limit my remarks thereon to the following more important facts which have been elucidated —namely, that no case of cirrhosis *with dropsy* occurred at Claybury Asylum, whereas of the cases of cirrhosis at Charing Cross Hospital 66·6 per cent had dropsy, 22·2 per cent with a history of operation to drain off the fluid. At Claybury, in only one instance of the 23 cases was cirrhosis of the liver mentioned as the assigned cause of death, whereas, at the hospital in 72·2 per cent of the 85 cases of cirrhosis of the liver, this disease was assigned as the cause of death. The cases of cirrhosis of the liver met with on the post-mortem table at the asylum were mostly cases of alcoholic psychosis with multiple neuritis and alcoholic dementia, but there were also a few cases of general paralysis. The single case in which cirrhosis of the liver was the cause of death occurred in a chronic alcoholic billiard-marker, who was admitted to the asylum because he had attempted suicide. This man had previously given himself up to the police as having murdered a woman, which was a delusion. When in the asylum he knew that he suffered with cirrhosis of the liver, and he stated that he felt so miserable on this account that he had attempted suicide. The liver weighed over 2000 grams. The relatively greater frequency, with which acute and chronic gastritis and other inflammatory lesions of the stomach are met with in cases of alcoholic affections of the liver among the insane, is shown.

There is a greater frequency of arterio-sclerotic changes associated with cirrhosis of the liver in the case of the insane, especially among the males. Atheroma and pearly fibrosis of the aorta is common on the post-mortem table (even in comparatively young people) in asylums. This is explained by the fact that a large proportion of the deaths occur in the subjects of general paralysis, which is without exception of syphilitic origin, acquired or congenital.

It may be remarked that in only four of the fatal cases occurring at the hospital were there nervous symptoms associated. In fact, it is noteworthy that alcoholic cirrhosis of the liver, with pronounced dropsy and a history of prolonged intemperance, even excessive intemperance, frequently occurs in individuals who show absolutely no mental symptoms beyond a weakened will and loss of moral sense.

The following letter from Dr. Sullivan so strongly supports the foregoing pathological evidence which I have brought forward regarding the relation of alcohol and insanity, that I publish the letter in full as it appeared in the "Lancet," 14th September, 1922.

"The Causal Relation of Alcoholism to Insanity

To the Editor of 'The Lancet'

"Sir,—In view of the frequent repetition, even in quite reputable text-books of psychological medicine, of the statement that alcohol is one of the chief factors in the causation

Comparative Incidence of Cirrhosis of the Liver at Charing Cross Hospital, St. George's Hospital, and Claybury Asylum.

	Charing Cross Hospital.				St. George's Hospital.				Claybury Asylum.			
	Males.	Per cent.	Females.	Per cent.	Males.	Per cent.	Females.	Per cent.	Males.	Per cent.	Females.	Per cent.
al number of post-mortem xaminations . . .	735	—	364	—	*	—	*	—	627	—	644	—
al number of cases with epatic cirrhosis . .	67	—	18	—	82	—	32	—	14	—	9	—
nber of cases with ascites .	25	37·3	12	66·6	27	32·9	9	28·1	—‡	—	—	—
nber of cases without ascites	42	62·7	6	33·3	55	67·1	23	71·9	13	92·8	9	100
nber of cases with a history f paracentesis abdominis .	13	19·4	4	22·2	*	—	*	—	—	—	—	—
nber of cases fatal from rrhosis	24	35·8	13	72·2	29	35·3	18	56·2	1	7·2	—	—
nber of cases fatal from iseases other than cirrhosis	43	64·2	5	27·7	53	64·7	14	43·8	13	92·8	9	100
rage age at death of cases tal from cirrhosis . .	50–8 years	—	47 years	—	50–3 years	—	46–6 years	—	32 years†	—	—	—
rage age at death of cases tal from diseases other than irrhosis	46 ,,	—	48 ,,	—	48 ,,	—	45–6 ,,	—	51 ,,	—	46 years	—
rage age at death with scites	49 ,,	—	47 ,,	—	*	—	*	—	—	—	—	—
rage age at death without scites	46 ,,	—	48 ,,	—	*	—	*	—	51 years	—	46 years	—
nber of cases associated	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

clerosis	1	1·5	—	—	*	—	*	—	5	35·7	1	11·1
mber of cases with a history f alcohol	25	37·3	8	44·4	64 (male and female combined)			56	3	21·4	5	55·5
mber of cases associated vith tuberculosis . .	19 out of 85 cases§ . .			22·3	34 out of 114 cases . .			29·8	6 out of 23 cases§ .			30·4
mber of cases fatal from uberculosis . . .	4 ,, 85 ,, . .			4·7	17 ,, 114 ,, . .			14·9	—	—	—	—
erage weight of liver in all ases	67·5 oz. . . .			—	65·49 oz. . . .			—	54·3 oz. . . .			—
erage weight of the liver in ases fatal from cirrhosis .	67·4 ,, . . .			—	63·17 ,, . . .			—	—	—	—	—
erage weight of the liver in ases fatal from diseases ther than cirrhosis . .	67·4 ,, . . .			—	67·19 ,, . . .			—	54·3 oz. . . .			—
erage weight of spleen in all ases	9·5 ,, . . .			—	9·8 ,, . . .			—	9·3 ,, . . .			—
erage weight of spleen in ases fatal from cirrhosis .	11·9 ,, . . .			—	11·0 ,, . . .			—	—	—	—	—
erage weight of spleen in ases fatal from diseases ther than cirrhosis . .	8·2 ,, . . .			—	9·0 ,, . . .			—	9·3 oz. . . .			—

* Denotes that the information is wanting. † One case. ‡ In one case there was a pint of fluid noted, but there was cardiac failure in this e. It will be observed that the age of the male insane patients is higher than that of the hospital cases, the reason being that a number of old n suffering with arterio-sclerosis under the influence of drink are sent into the asylums. One striking fact was the much greater frequency of ieroma in asylum cases as compared with hospital cases. This may be explained by the fact that nearly half the total male cases in asylums general paralytics. The relation of syphilis to general paralysis is probably associable with this result. § Of the 7 female cases, only 1 showed ive tuberculosis; the remaining 6 were cases of quiescent tubercle. Of the 19 male cases, 6 were cases of quiescent tubercle.

of mental disease, it may be of interest to call attention to the statistics of insanity in this country during the recent period of decreased alcoholism. The accompanying table shows, for the years 1913 to 1918, the number of first admissions to asylums in comparison with the movement of drunkenness and of other manifestations of alcoholic excess. To avoid the obvious risk of fallacy arising from the absence of large numbers of the adult male population on military service, the figures refer to women only.

Alcoholism and Insanity (*Women only*), *England and Wales*, 1913–18.

Year.	Convictions for Drunkenness.	Deaths from		Attempted Suicide.	First Admission to Lunatic Asylum.
		Alcoholism.	Cirrhosis of Liver.		
1913	35,765	719	1665	988	9372
1914	37,311	860	1773	1049	9702
1915	33,211	584	1525	816	9078
1916	21,245	333	1163	436	8850
1917	12,307	222	808	452	8702
1918	7,222	74	579	400	9726

"The fact that, despite a reduction of alcoholism amounting to about 80 per cent, there has been no decline, but if anything, a slight upward tendency in the incidence of insanity, would be difficult to understand if it were true, as asserted by some writers on the subject, that 'alcohol stands in the first rank as a factor in the production of insanity.' It has already been shown conclusively by Sir Frederick Mott that the belief in the predominantly alcoholic ætiology of mental disease is a myth evolved by the application to unreliable data of a very crude process of inference from antecedence to causation, and these figures give further evidence of the soundness of his criticism.

"The point is of more than merely theoretical interest at the present time, because, since alcoholism is often regarded as differing from other deleterious agencies by being in some sort a manifestation of wilful vice, it may happen that an insane person, whose insanity is erroneously imputed to alcoholic excess, will on that account be debarred from financial relief to which he might otherwise be entitled. There is, therefore, some need to emphasise the fact that, when insanity is really due to alcoholism, it bears characteristic clinical marks of its origin, and that, in the absence of such marks, a history, even if authentic, of antecedent drinking in a case of paranoia, or dementia præcox, or any other psychosis, gives no sort of ground for assuming that alcohol had anything to do with the causation of the disease.

"I am, Sir, yours faithfully,

"W. C. Sullivan, M.D.,

Medical Superintendent, Broadmoor State Asylum.

Sept. 14th, 1922.

Intolerance of Alcohol in Mental Defectives

Dr. Branthwaite, in his report of 1905, concerning Certified Inebriate Reformatories established under the Inebriates Act, 1879, 1900 (p. 10), remarks :

"Upwards of 62 per cent of the persons committed to reformatories under the Act are found to be insane or defective in varying degree. I am satisfied that the majority of our insane inebriates have become alcoholic because of congenital defects or tendency to insanity, not insane as the result of alcoholism, and that the drunkenness which preceded alcoholic insanity was merely the herald—the only obvious sign—of incipient mental disorder. In relation to the final insanity, drunkenness in such cases is the intensifier perhaps, but not the cause of the disease."

Concerning the congenital defectives, which are divided into two classes—(*a*) comprising degenerates, imbeciles, and epileptics, and (*b*) moral and social defectives—he remarks :

"A marked intolerance to the action of alcohol is present in both refractory and quiet class of defectives ; very small quantities of drink, no more than is taken daily without apparent physiological effect by an ordinary individual, being sufficient to cause disorderly and violent behaviour. Our experience in this direction has led us to accept the view that intolerance to the exciting effects of small quantities of alcohol may be considered a fairly certain sign of impaired mental equilibrium."

The Different Pathological Effects of Alcohol upon Different Individuals

We are prepared now to understand how very different is the effect of alcohol on different individuals. Let us consider first the well-fed workman, business or professional man of normal mental stability, who on account of his occupation becomes the victim of a vicious habit of indulgence in alcohol to excess. The normal sense of well-being in such an individual, which comes from physiological nutritional equilibrium, is gradually perverted and replaced by an artificial sense of well-being, owing to the effect of the alcohol. Sooner or later visceral disturbances—notably gastritis—lead to loss of appetite and failing nutrition, with more or less persistent *disorder of his organic sensibility.* The craving for spirits replaces the desire for food, and the vicious habit has so altered his nervous system that it can no longer function without stimulant. For a time the symptoms of disordered organic sensibility due to chronic alcoholism—namely, pain and oppression in the region of the heart, dyspepsia, loss of appetite, nausea and morning vomiting, muscular weakness and tremors—may be relieved by alcohol, but the quantity taken has to be steadily increased to produce the desired effect. A head injury, microbial infection, an extra bout of drinking, and the sudden withdrawal of the alcohol, may lead to delirium tremens. Such subjects of chronic alcoholism may live until advanced cirrhosis of the liver with dropsy occurs, from which they eventually die after repeated operations to drain away the large quantity of serous fluid that has accumulated in the belly in consequence of obstruction to the portal circulation of the liver. It may be presumed that individuals who were able to drink continuously and to such an extent as to die eventually from this condition, were possessed of an inborn stable mental organisation, and, without having any precise statistical data to prove it, I am of opinion that they would transmit to progeny the stable mental organisation they inherited rather than the weakened will power which they had acquired by force of circumstance of environment.

Delirium Tremens

The most frequent type of alcoholic mental disturbance commonly spoken of as the ' horrors ' may be a mere episode in the life of the average chronic drinker. Many factors may conspire with the alcohol in producing this condition, such as lowered resistance of the body tissues and a tendency to accumulation of alcohol, the effects of which fall especially upon the nervous system. Other contributing factors are microbial toxins from various sources, especially pneumonia. Again head injury, mental and physical shock, may be contributory factors. "The importance of the sudden withdrawal of alcohol as a causal factor of the production of delirium is an unsettled question. The fact must be borne in mind that in some cases there is reached a point of tolerance beyond which there develops the delirium in question, which may have as one of its prodromal signs a repugnance to the taste for alcohol."

The premonitory signs of delirium tremens are disturbed sleep, restlessness, irritability, loss of desire for food, the patient eating nothing for days, only drinking. Then typical delirium develops suddenly, the motor restlessness is increased, and to this are added marked sensory disturbances. Of these hallucinations are the most characteristic, numerous, and varied. The visual hallucinations are, usually, fantastic, grotesque, or horrible, more often the latter. Rats, spiders, beetles, and creeping crawling things are seen in the imagination; these hallucinations may arise from the toxic effects upon the sensory nerves of the skin, for various disturbances of the normal sensibility occur causing formication (crawling of ants), numbness, and pins and needles. These abnormal sensations derived from the skin may also cause various delusions of electricity, of being on fire. Again there may be delusions of devils, or of detectives pursuing him, or of dead friends and coffins appearing. He hears voices accusing him, and he converses with imaginary persons, the subject of his utterances relating especially to his profession or occupation; thus the actor shouts his part, the publican is busy serving his customers, the drayman drives his horses. He is the subject of illusions, and the patient mentally transforms objects about him; figures on the wallpaper or the carpet, are converted mentally into creeping animals, or devils; specks on the bedclothes may be taken for vermin which the patient tries to remove. There is marked fine tremor of the hands and face, also general muscular weakness and tremors. Tremor of the tongue is always present. At one time he will answer questions promptly and correctly, at another he is confused or his mind is distracted by the terrifying hallucinations. His disposition is changeable, at one time friendly and amiable, and at another irritable, angry, and quarrelsome. The mood may change within a few minutes. There is little rise of temperature, and the pulse is weak and of low tension. There is usually profuse sweating as a result of the restless motor activity.

These symptoms last three or four days, then he passes into a sound sleep and recovers, or he enters into a typhoid condition with low muttering delirium and may die from exhaustion or some intercurrent disease.

It is a question whether the alcohol is the direct cause of these symptoms, for they may be a secondary manifestation due to accumulation of toxins which are developed as a result of the action of alcohol upon the cardio-vascular system, leading to passive hyperæmia in the kidneys and deficient elimination of waste products. Morbid changes in the alimentary canal leading to production and absorption of microbial toxins also play a not inconsiderable part in the toxemia.

The other form of mental disorder met with in hospital practice as well as in asylums, is one associated with inflammation of many nerves of the body; therefore it is termed polyneuritis, or multiple neuritis. In severe cases all the nerves of the body, even the nerves supplying the eye muscles, the face, and the vagus nerve may be affected. The mental symptoms are like those of delirium tremens. The disease especially affects women, and by many authorities it is considered to be a form of chronic delirium tremens associated with neuritis. The neuritis gives rise to wasting of the muscles or paralysis affecting especially the lower limbs associated with various sensory disturbances; particularly characteristic is the affection of the nerves of deep sensibility, so that if the calf muscles are squeezed the patient screams out. Cases in which the paralytic nerve symptoms predominate are treated in the general hospitals and infirmaries, while those in which the mental symptoms are the more pronounced find their way to the asylums. Severe cases occur where both the mental symptoms, and the sensory-motor paralysis are pronounced. Some of these cases which are sent to hospitals or infirmaries eventually are sent to asylums.

Both in hospital and asylum practice delirium tremens is much more frequent in males than in females ; whereas polyneurotic psychosis is much more frequently met with in females than in males. Both occur in the subjects of chronic alcoholism. Women often take to drink because of the pains experienced at the menstrual periods, and on account of disease of the reproductive organs following miscarriages, abortion, and venereal infection. I have, moreover, so often found, post-mortem, septic inflammation of the reproductive organs in women (metritis, parametritis, and salpingitis) in cases of alcoholic paraplegia, that I have thought it probable that the toxins engendered by microbic infection, carried up the lymphatics of the nerves, have exercised an important causal relationship to the multiple-neuritis.

As a rule the convolutional pattern of the brain in these cases of alcoholic psychosis denotes a fair order of intelligence, and the wasting of the convolutions and the thickening of the membranes is slight as compared with that occurring in general paralysis.

There is a form of alcoholic dementia of the expansive form that simulates general paralysis. The patient may suffer with delusions of grandeur associated with some evidence of neuritis, but a diagnosis can always be made by an examination of the cerebro-spinal fluid.

The changes in the brain in alcoholic dementia are not marked as a rule, and do not, in my opinion, account for the symptoms as they do in general paralysis, where the dementia is in great measure proportional to the cortical brain destruction.

The great proportion of cases which are statistically included under alcoholic insanity occur in persons of an inborn or acquired unstable mental organisation—epileptics, degenerates, imbeciles, potential lunatics, general paralytics, subjects of head injury, local brain disease, syphilis, and arterio-sclerosis.

If alcohol is the essential factor, however, in the production of an insanity, there will be certain specific indications in the varied forms of insanity pointing to the more or less specific action of the alcohol. Even in the absence of a history of alcoholic indulgence there are certain physical signs and symptoms which point to alcohol as the cause. The more definite these signs and symptoms are the more certain can we be that the cause is removable and the more hopeful is the prognosis. These signs and symptoms are found most pronounced in the two conditions of mental and nervous disorder which occur in hospital practice—namely, delirium tremens and polyneuritic psychosis.

Chronic Delirium Tremens with Multiple Neuritis

Although every form of mental derangement may be closely simulated by alcohol when an insane temperament is acted upon by a sufficient quantity, yet when it has been an efficient cause in the production of the insanity there are certain indications in the characters and constancy of the illusions, hallucinations, and delusions. Illusions of identification of persons are common. The hallucinations and delusions are generally of a persecutory nature, and are possibly due to a deranged and perverted organic sensibility of the body and viscera. In one case a woman with polyneuritic psychosis said her body was on fire and she tried to get out of the window. The next day blebs occurred on the body, and I found acute degeneration of the nerves going to these patches of skin. Often the woman fancies she hears the baby crying and that it is in the bed. Delusions of marital infidelity are especially common in men and may lead to homicidal assaults. Loss of orientation in time and space and of memory of recent events are usually met with, likewise a tendency to pseudo-reminiscences and mental confusion, which in some cases amounts to incoherence, and may then overshadow completely the disturbance of memory. Purposeful motor restlessness, hallucinations, and delusions are common, also tremors of the tongue and the small muscles of the face. Moreover, alteration of the deep reflexes, tenderness on deep pressure of the muscles, anæsthesia, paræsthesia, hyperæsthesia—indicative of neuritic affection—are frequently present, singly or combined.

Alcoholic Hallucinosis

The cases of alcoholic hallucinosis may, however, show very little or no mental confusion and amnesia (loss of memory), and hardly any loss of orientation. They tend to recover within one to six months after admission, but relapses are frequent. Since auditory and visual hallucinations, especially the former, frequently occur in insanity in which there is no alcoholic factor, it is often difficult to decide simply by the hallucinations and delusions alone whether alcohol is the cause. Should they persist, however, while the mind otherwise becomes clear, it is highly probable that the case is one in which alcohol has only played a subordinate part, and the outlook of recurrent or chronic insanity is probable. This is all the more likely to be so if the hallucinations and delusions become systematised and if there is a complete absence of any peripheral cause.

Another class of patient is the subject of delusions; normally sociable and good-tempered, after a drink or two he imagines slights or insults and becomes dangerously quarrelsome; this is a constitutional condition which drink reveals. These are not well-adapted people, that is to say, their adjustments to social life are not easy and automatic, and anti-social tendencies are latently strong in them.

> "It may be remarked that patients suffering with Dementia Præcox may show episodes with practically identical symptoms, although the subjects are abstainers, or the hallucinations may appear after drinking a relatively small amount of alcohol. Such facts have led some psychiatrists to think this psychosis is a psychogenic reaction liberated by alcohol; that it is so to speak an acute dementia præcox reaction essentially constitutional that appears when alcohol removes the normal acting inhibitions." (MacCurdy.)

Dipsomania

A periodic form of alcoholic insanity, akin to recurrent mania, is met with, termed 'dipsomania.' Persons who in the intervals are decent sober members of society, leading, perhaps, a blameless life with no intellectual or moral defects, are seized with a craving for drink. Often long periods of normal conduct occur between periods of debauch, in which they go drinking day after day, taking little food and getting little sleep, until exhaustion from want of food sets in, and, tremulous and miserable, the craving being at last satiated, they return to their home and occupation until another attack occurs. There is usually a morbid nervous inheritance in these cases, and it is regarded by many authorities as a form of manic-depressive insanity.

Alcohol and Syphilis

Here I would call attention to the effects of alcohol in the spread of venereal disease. Syphilis is so often acquired as a consequence of alcoholic intoxication that the effects of the contagion are frequently attributed to the alcohol.

Alcohol and War Neuroses and Psychoses

My experiences during the war, at the Neurological Clearing Hospital of London, showed that individuals with a neuropathic or psychopathic tendency displayed intolerance to alcohol, and confirmed my previous opinion with regard to the fact that individual personality plays a most important part in connection with the mental disorders and diseases attributed to alcohol. It was found that a quantity insufficient to affect a normal human being is enough to render an individual with an invalid brain anti-social; consequently cases of so-called shell-shock, mental deficiency, neurasthenia, epilepsy, and head injury, occurring in soldiers, were very susceptible to the toxic effects of alcohol.

An inquiry which I made regarding the influence of alcohol in the production of war neuroses and the value of the rum ration was of interest in relation to the inborn temperament and alcohol. By a card system I found that at least 60 per cent of 147 cases which were admitted under my care to the Maudsley Neurological Section of the Fourth London General Hospital in 1917 were total abstainers, which was double the percentage of 62 cases admitted to Ruskin Park Hospital suffering with wounds or diseases other than functional nervous conditions.

The high percentage of total abstainers among cases of war neurosis and shell shock was associated with fear of the consequences of drink, or a dislike of the taste of drink, consequently refusal to take the rum ration. Fear of the consequences, in a great number of instances, was due to the results in the home of paternal drunkenness, and in fewer instances of maternal drunkenness, or drunkenness in both parents.

It was observed that a number of total abstainers admitted that the rum ration had been beneficial, and that they had taken it when they had to 'stand to' in the trenches wet and cold in the early morning, prior to getting over the parapet for an attack.

Moreover, I questioned a number of officers of all ranks, even including advocates of temperance, and with very few exceptions they were convinced of the value of the rum ration, if it were given out by an officer who saw that no soldier obtained more than his ration. They emphasised its utility as a stimulant when the men were wet and cold and had to stand to at dawn ; it put the feeling of warmth in them, and gave them the necessary stimulus and ardour to go over the parapet for an attack. The general recommendation was to give it in the tea, and the men preferred it so ; only a few cared for it neat—it was too strong. Many officers and men were of opinion that on returning to billets, cold and wet through, a rum ration produced a comforting feeling and promoted sleep.

Captain J. M. Wolfsohn, of the American Army Medical Service, at my suggestion, investigated the personal history and the leading nervous state of 100 of my cases of soldiers suffering with shell-shock or war psycho-neuroses (neurasthenia and hysteria) and compared the same with 100 surgical cases suffering with wounds under the care of Captain Turner at the Fourth London General Hospital, and found that the vast majority of the psycho-neurotic cases studied were among soldiers who had a neuropathic soil. In 74 per cent of these cases a family history of neurotic or psychotic stigmata, including insanity, epilepsy, alcoholism, and nervousness was obtained, whilst a previous neuropathic constitution in the patient himself was present in 72 per cent—a striking contrast to the percentages obtained in the wounded cases.

The three following tables of the results are quoted from Captain Wolfsohn's paper in "The Lancet," February 3rd, 1918:

TABLE I

Family History.

Percentages of characteristics named in (A) Neurosis, (B) Wounded.

	(A)	(B)
Nervousness	64	15
Alcoholism (parents and grandparents)	50	24
Teetotaller (parents and grandparents)	30	16
Irritability of temper	36	12
Insanity	34	0
Epilepsy	30	0
Tuberculosis — immediate family	12	4
Tuberculosis — relatives	6	4
Stigmata	10	0
Positive history for one of several of above	74	38

TABLE II

Personal History.

Percentages of characteristics named in (A) Neurosis, (B) Wounded.

	(A)	(B)
Stigmata	34	4
Previous nervousness	66	12
Fears	50	8
Head injury	38	12
Epilepsy	8	0
Tobacco—excessive	8	4
Alcohol—excessive	6	16
Alcohol—teetotaller	48	20
Married	42	28
Moody	55	8
Previous breakdown	2	0
Enuresis	12	4
Frights in childhood	4	0
Excessive religion	6	0
Positive personal history	76	12
Positive family and personal history	70	6
Recurrences and relapses	14	0
Acquired neurosis	12	3

TABLE III

Present Illness.

Percentages of characteristics named in (A) Neurosis, (B) Wounded.

	(A) Service. 12 mos.	(B) Service. 10 mos.		(A) Service: 12 mos.	(B) Service: 10 mos.
Unconsciousness	55	24	Dreams	88	50
Dazed	84	24	Fatigue	94	40
Tremor	84	12	Headache	88	36
Poor memory	88	4	Moody	92	0
Poor concentration	88	4	Vertigo	74	8
Insomnia	86	0	Fits	10	0
Fears	76	0			

It was the almost unanimous opinion of the witnesses who gave evidence before the Shell Shock Commission that the rum ration given under the conditions above mentioned was most useful.

Alcoholism, Suicide, and Insanity in the Army

The percentage of cases of acute and chronic alcoholism among officers admitted under my care was higher than the percentage from the ranks.

Alcoholics were often returned as suffering with neurasthenia or their drinking propensities had been discovered, while on leave from active service, by crimes or misdemeanours; or while undergoing treatment in hospital they had absented themselves without leave, returned to hospital intoxicated, or been sent or brought to the hospital in a state of acute alcoholic intoxication, or even in a state of delirium tremens.

An inquiry into the family and past personal history of cases of acute and chronic alcoholism showed that in many cases there was an inborn mental instability which predisposed an individual to drink. It is always difficult to decide the relative importance of the predisposing cause and opportunity. In some cases the family history showed that alcoholism, suicide, neuroses and psychoses affected antecedents in varying numbers, while in others no such history was obtainable, and the habit seemed to have been acquired in early life as a result of convivial imitation or to drown dull care. Not infrequently the history showed that a brilliant career had been destroyed by the habit having become a vice over which the individual had lost complete control. Enfeebled will and power of concentration, failing memory and loss of moral sense, became manifest by carelessness, broken promises, lack of auto-critical faculty, neglect of duty, and unreliability in speech and conduct. Attacks of despondency, followed often by bouts of drinking which were attended either by boastful loquacity and quarrelsome excitement in which the individual became dangerous to others, or the reverse happened, and the patient became maudlin, sentimental, tearful, perhaps depressed and suicidal, according to the temperament of the individual.

Norman stated that the number of cases among the soldiers in which suicide occurred was disproportionately great with those observed in ordinary times. Cut throat was by far the most common method in this condition, as in suicidal attempts in general. Major Hotchkiss noted that of the forty-five cases of cut throat admitted to Dykebar Military Hospital during a year, eighteen were the subjects of alcoholism. "Many of these attempts were made during an acutely confusional stage, and later there was no recollection (or apparently none) of what had taken place. In others it was associated with intense depression, which alcoholic excess produces in certain individuals.

According to my experience, also according to the experience of most authorities, symptoms of chronic alcoholism and of alcoholic insanity were found among the older men, and especially those serving in Labour Battalions, or that were employed permanently at the base, where they had more opportunities of indulging in alcohol to excess. In the majority of cases of chronic alcoholism the symptoms were auditory hallucinations and delusions of persecution. As in civil life, delusions of conjugal infidelity were common.

One elderly officer, a chronic inebriate, came under my care, and he had delusions of conjugal infidelity and visual and auditory hallucinations of a man "he had done in" whom he imagined had been the cause of his wife's unfaithfulness. This patient also exhibited a considerable degree of mental confusion, amnesia and coarse tremor ; in addition there was muscular weakness of the legs, absent knee jerks, and tenderness on pressure of the calves. A fairly typical Korsakoff psychosis with polyneuritis.

There was no form of alcoholism or alcoholic insanity which was not met with, and the hallucinations and delusions, were, as in other forms of insanity, coloured by the conditions of warfare. If the temptation that there was to drink during periods of great stress and anxiety when opportunity occurred be considered, it is remarkable that more cases of alcoholism did not occur in the fighting line. Much more drink was, however, consumed during the suspense and inactivity in billets and camps, also during leave. It is difficult to estimate the amount of military inefficiency caused by intemperance under the stress and strain of war. It was, however, proportionally more evident among officers than in the ranks, and among those employed at the base than at the front.

Conclusions

All thinking people are agreed that the abuse of alcohol among civilised nations is directly or indirectly responsible for a large proportion of the crimes of violence, of industrial inefficiency, of poverty, and misery. Why, then, do the great majority of intellectual, sensible, and moral people, men and women of as high civic worth as total abstainers, drink alcoholic beverages ? It seems incredible that a large part of the human race, present and past, should have fallen into a gigantic error as to their use and value. It may be remarked that the causes of drinking are infinitely varied and intimately bound up in the heart of man, at once an expression of his strength and his weakness, his success and his failures. Its moderate use, in my opinion, may act beneficially by tending to remove that cautious self-criticism and selfishness which restrains the natural and spontaneous feelings of human sympathy and sociability which spring from the affective side of man's nature. We can thus understand how "Wine maketh glad the heart of man." But moderation in the normal mentally sound and stable individual may be excess in the case of the mental defective, the epileptic, the neurasthenic, the potential lunatic, and the possessor of an invalid brain as a result of organic disease or injury. A judgment, however, must not be formed against the moderate use of alcohol based upon its effects on abnormal individuals ; yet this has been done by an extreme section of the Temperance Party, who, in their zeal, for example have claimed that 20 per cent of the admissions to asylums are directly or indirectly due to alcohol. This statement, as expressed, is misleading. The facts which I have brought forward, based upon an analysis of statistics of admissions to the London Asylums for thirteen years (see p. 191); the comparative post-mortem records of hospitals and asylums regarding the relative incidence of cirrhosis of the liver (see pp. 194, 196), the experience of inebriate colonies (see p. 199), and statistics showing a slight rise in the rate of admissions to asylums, with a marked falling of convictions of drunkenness and deaths from cirrhosis of the liver (see p. 198), all bear witness to the fact that alcohol plays a relatively unimportant part in the production of certified insanity. All the evidence, however, indisputably tends to show that persons with an inborn neuropathic or psychopathic tendency, therefore having a narrow physiological margin of self-control, either due to an inborn deficiency of the highest evolutional level of the brain, or a functional instability of it, become anti-social by quantities of alcohol which would have no effect on the normal individual. If small quantities of alcohol become a test of this highest control, it follows that it serves as a means of eliminating poor types by making such persons anti-social, and thus causing their segregation in asylums, mentally defective institutions, and prisons. This view supports the following statement by Dr. Stewart Paton of Princetown University, U.S.A. : "Signs of Sanity," page 200. "Because we have stopped the use of alcohol, do not let us think we have stopped the habits that were responsible for the cravings for drink." Again he says (p. 202), "In communities where the spirit of prohibition is active there is almost always an unusual amount of nervousness, not to mention an exceedingly defective and unhealthy outlook upon human problems."

ALCOHOL AND MORTALITY

By Professor Raymond Pearl,

The Johns Hopkins University.

I. The Problem

THERE are few problems of greater significance in human affairs than the one presented by the use as a beverage of solutions of ethyl alcohol of varying degrees of concentration and flavour. Such usage is of the greatest antiquity. Evidence of its existence is to be found in the earliest historical records. Furthermore, there are but few large groups of people anywhere to be found where some form of this usage has not been in existence from time immemorial.

In the face of such antiquity and such widespread prevalence of a human habit, one is philosophically constrained to the view that there must be something socially or biologically valuable, or at least not harmful, in this habit. Otherwise it seems impossible to account for its persistence over so long a period in man's evolutionary progress, or for its widespread prevalence in the face of efforts to accomplish its abolition. In social, as in purely physical evolution, things which are positively detrimental to the continued existence of the race are automatically eliminated by a process of natural selection. Such elimination is biologically inevitable, provided time enough is given, and the matter in question is one which affects a large proportion of the population. Both of these conditions are realised in the case of the use of alcohol as a beverage.

But this usage has not been naturally eliminated. On the contrary, so far from there being any natural trend towards the elimination of any but *excessive* usage of alcohol as a beverage, reformers who believe that such elimination ought to and must be brought about, encounter the greatest difficulty in accomplishing this result. In fact, it never has been accomplished in any real sense. Prohibition at its best has never absolutely prohibited, it has merely reduced somewhat the consumption per head by the population; at its worst it has tended to increase consumption per head by reason of a well-understood trait of human psychology.

The course of events in respect of *per head* consumption and prohibitory legislation in the United States is instructive. The pertinent data are exhibited in Table I, and graphically

TABLE I

Data as to consumption per head, by the total population of the United States, of various beverages, together with data as to the population under state-wide prohibition in census years.

Year.	Consumption per head of Population of					Population living under state-wide Prohibitory Laws.
	Wines (gallons).	Malt Liquors (gallons).	Spirits (gallons).	Tea (pounds).	Coffee (pounds).	
1870	·32	5·31	2·07	1·10	6·00	1,186,306
1871	·40	6·10	1·62	1·14	7·91	——
1872	·41	6·66	1·68	1·46	7·28	——
1873	·45	7·21	1·63	1·53	6·87	——
1874	·48	7·00	1·51	1·27	6·59	——
1875	·45	6·71	1·50	1·44	7·08	——
1876	·45	6·83	1·33	1·35	7·33	——
1877	·47	6·58	1·28	1·23	6·94	——
1878	·47	6·68	1·09	1·33	6·24	——
1879	·50	7·05	1·11	1·21	7·42	——
1880	·56	8·26	1·27	1·39	8·78	679,277
1881	·47	8·65	1·38	1·54	8·25	——
1882	·49	10·03	1·40	1·47	8·30	——
1883	·48	10·27	1·46	1·30	8·91	——
1884	·37	10·74	1·48	1·09	9·26	——
1885	·39	10·62	1·27	1·18	9·60	——
1886	·45	11·21	1·28	1·37	9·36	——
1887	·55	12·24	1·21	1·49	8·53	——
1888	·61	12·78	1·26	1·49	6·81	——
1889	·56	12·73	1·32	1·25	9·16	——
1890	·46	13·67	1·40	1·33	7·83	4,901,426
1891	·46	14·84	1·43	1·29	8·00	——

Year.	Consumption per head of Population of					Population living under state-wide Prohibitory Laws.
	Wines (gallons).	Malt Liquors (gallons).	Spirits (gallons).	Tea (pounds).	Coffee (pounds).	
1892	·43	15·24	1·49	1·38	9·67	——
1893	·48	16·19	1·52	1·33	8·31	——
1894	·32	15·32	1·34	1·36	8·30	——
1895	·30	15·13	1·14	1·40	9·33	——
1896	·27	15·85	1·01	1·33	8·11	——
1897	·53	14·94	1·02	1·58	10·12	——
1898	·28	15·96	1·12	·94	11·68	——
1899	·35	15·30	1·18	·98	10·79	——
1900	·39	16·09	1·28	1·10	9·81	3,239,336
1901	·36	15·98	1·31	1·12	10·45	——
1902	·61	17·18	1·34	·92	13·34	——
1903	·47	17·67	1·43	1·27	10·62	——
1904	·52	17·91	1·45	1·31	11·68	——
1905	·41	18·02	1·42	1·19	12·00	——
1906	·53	19·54	1·47	1·06	9·74	——
1907	·65	20·50	1·58	·96	11·17	——
1908	·58	20·26	1·39	1·03	9·84	——
1909	·67	19·07	1·32	1·24	11·45	——
1910	·65	20·09	1·42	·89	9·33	15,602,935
1911	·67	20·66	1·46	1·04	9·28	——
1912	·58	19·96	1·44	1·05	9·23	——
1913	·56	20·62	1·50	·95	8·85	——
1914	·52	20·54	1·43	·90	10·06	——
1915	·32	18·24	1·25	·91	10·52	——
1916	·46	17·59	1·35	1·07	10·97	——
1917	·41	17·95	1·60	·98	12·22	——
1918	·28	14·59	1·12	1·38	10·29	45,490,169

in Fig. 1. The statistics of consumption per head in this table are derived by dividing the figures of total consumption by the population. The figures of consumption were furnished the writer by the Commissioner of Internal Revenue of the United States.[1] They are substantially accurate, for the reason that in this, as in most other countries, alcohol for beverage purposes has been relatively heavily taxed. It is

[1] They are published in convenient form in the Statistical Abstract of the United States. (Bureau of Census.)

a comparatively easy tax to collect, and has, in fact, been rather completely collected. The consumption data for alcoholic beverages are statistically more accurate than corresponding figures for any but a very few other commodities.

For comparative purposes, along lines presently to be discussed, there are inserted in the table and diagram the figures for consumption per head of tea and coffee. These data are derived from the annual volumes of the Statistical Abstract of the United States.

All the consumption data, both for alcoholic and non-alcoholic beverages, are for the United States as a whole.

Finally, there are inserted in the final column of the table the census figures for the total population, *in census years*, of those States which *in the indicated year* were under state-wide prohibitory laws, either in the constitution or the statutes of the state. These figures are arrived at by adding the populations of the several states fulfilling the stated condition. It should be clearly understood that these figures *understate* by a considerable amount the number of persons at each period living under prohibitory laws, because they do not include the dry portions of states having local option laws. The data as to the time relations of the state-wide prohibitory laws in the several states were derived from the excellent condensed history of prohibitory legislation in the United States, set forth in the Anti-Saloon League Year Book for 1919.

No attempt has been made to indicate the exact course of the population under state-wide prohibition during intercensal periods. To do so would entail a degree of refinement unnecessary for present purposes, and would not change the general trend of the line.

Fig. 1, which shows the data of Table I graphically, is plotted on an arithlog grid, which has the important property that the *slopes* of lines are directly and truly comparable, no matter what the absolute magnitudes of the variables plotted. If two lines plotted on such a grid are parallel, it means that the two compared phenomena are changing in the same sense, at *precisely the same relative rate.*

The broad fact brought out by the table and diagram is that, during a period of nearly a half-century, there has been no direct or causal relation between the consumption per head of alcoholic beverages and the existence of laws prohibiting the use of such beverages. Instead there is an

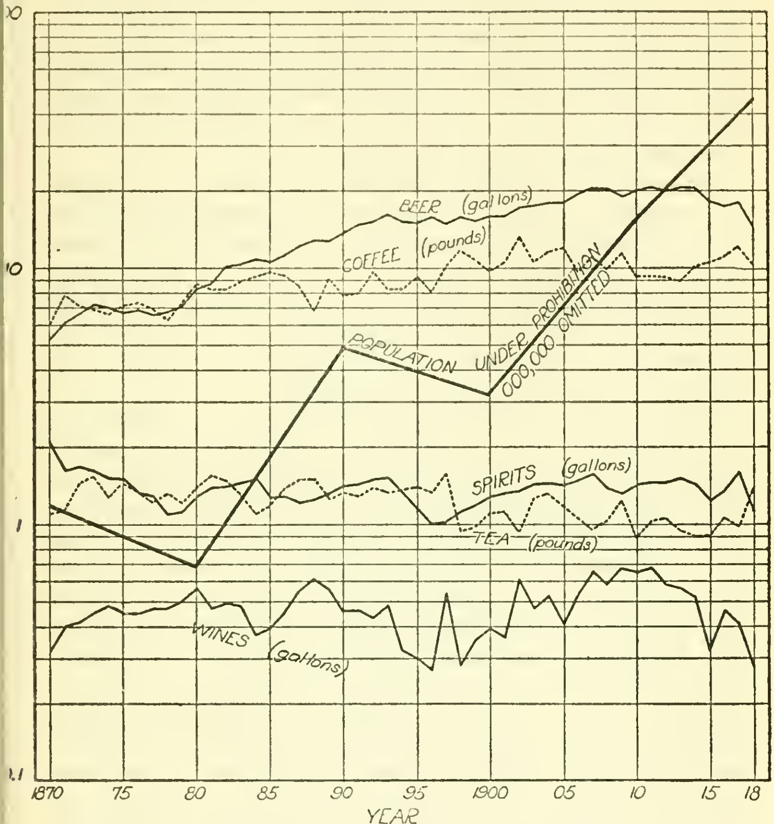

Fig. 1. Diagram showing the course from 1870 to 1918 of the consumption per head of various beverages in the United States, and the population living under state-wide prohibitory laws.

evident and considerable degree of parallelism between the consumption of two classes of alcoholic beverages, malt liquors and spirits, and two non-alcoholic, tea and coffee. Beer and coffee consumption increased in these forty-nine years; tea and spirits consumption declined somewhat. These evident facts suggest that the habits of the people in respect of drinking alcoholic beverages, have deeper biological roots than can easily or quickly be torn up by legislative action. With nearly one-half of the population of the country under state-wide prohibition in 1918, the consumption per head of beers by the *whole* population was considerably greater, and the consumption per head of spirits not greatly less, than in 1870, when roughly only one-thirty-fifth of the population lived under similar laws.

The objectivity of these curves is impressive. My purpose in presenting them is not to make any reflection whatever upon the wisdom of prohibitory legislation, but to demonstrate the broad fact that the consumption per head of the important alcoholic beverages has for a half-century in the United States followed substantially the same course as the consumption of the important non-alcoholic beverages, quite without regard to prohibitory legislation.

This fact establishes the basis for the specific problem of this discussion. Is this deeply rooted habit of the most of mankind to consume alcoholic beverages biologically harmful? Does it lower the likelihood of survival or the average duration of life of the individual? In what follows the attempt will be made to assemble and critically evaluate the significant evidence which exists upon this point. As will appear, the problem is a much more difficult one than it might at first thought be supposed to be. It is believed, however, that if the matter is approached in a purely objective, scientific manner, without prejudice or bias, but with a determination to attach value or significance only to such evidence as will withstand the most critical examination, we shall be rewarded with certain definite and reliable conclusions at the end of the inquiry. From a general biological standpoint we should discuss a further question in addition to that propounded above. Does the consumption of alcoholic beverages lower the survival value of the *race*, as well as that of the *individual?* Since, however, to go into any proper discussion of this problem would make undue demands upon the limited space available for the treatment of the special subject of this article, namely, alcohol and mortality, it will be necessary to forgo entirely any treatment here of the specifically evolutionary aspects of the alcohol problem. The reader who is interested will find detailed reports of experimental investigations in this direction in the papers of Stockard and of Pearl, listed in the bibliography.

II. Critical Standards in the Evaluation of Supposed Influences upon Duration of Life

It is undoubtedly fair to say that the most sensitive and exact single measure of the general biological fitness or soundness of the individual that is known is duration of life. But it is also a character from the behaviour of which most erroneous conclusions may be drawn unless one has a critical understanding of the effect of at least the major biological factors which may influence it. A great part of the literature on the effect of alcohol upon duration of life is essentially worthless just because of a lack of such understanding. Consequently it will be well briefly to review what is known of the biology of duration of life, as a methodological preliminary to the detailed discussion of our specific problem.

In the first place, it is well established that duration of life is a definitely inherited character of the organism. This has been shown statistically for man by the researches of Beeton and Pearson (1899 and 1901), and by those of Bell (1918). It has been demonstrated experimentally, and the mechanism of the hereditary process in part worked out, on a lower organism, by the investigations of Hyde (1913) and of Pearl and Parker (1922) on *Drosophila* (cf. also Chap. VII of Pearl, 1922a).

Beeton and Pearson (1899) in their first study, dealt with the correlation between relatives in age at death, extracting the material from Foster's "Peerage" and Burke's "Landed Gentry." The results were as shown in Table II.

It is seen at once that all of the coefficients are significant in comparison with their probable errors. The last column of the table gives the ratio of the coefficient to its probable error, and in the worst case the coefficient is 4·7 times its probable error. The odds against such a correlation having arisen from chance alone are about 655 to 1. Odds such as these may be certainly taken as demonstrating that the results represent true organic relationship and not mere chance. All of the other coefficients are certainly significant, having regard to their probable errors. Furthermore, they are all positive in sign, which implies that a variation in the direction of increased duration of life in one relative of the pair is associated with an increase in expectation of life in the other. In a later study Beeton and Pearson (1901) confirmed and extended these results.

Alexander Graham Bell (1918) has lately made a study of the inheritance of duration of life, on the basis of records extracted from the genealogy of the Hyde family. An

TABLE II

Inheritance of Duration of Life in Male Line. Data from "Peerage" *and* "Landed Gentry." (Beeton and Pearson)

Relatives.		Correlation Coefficient.	Ratio of Coefficient to its Probable Error.
x	y	r_{xy}	$r_{xy} \div E_r$
Father ("Peerage")	Son, 25 years and over . .	·115±·021	5·5
Father ("Landed Gentry")	Son, 20 years and over . .	·142±·021	6·8
Father ("Peerage")	Son, 52·5 years and over .	·116±·023	5·0
Father ("Landed Gentry")	Son, 50 years and over . .	·113±·024	4·7
Brother ("Peerage")	Brother . .	·260±·020	13·0

interesting and significant epitome of some of his findings is contained in Table III, where we have the average duration of life of individuals whose fathers and mothers died at the specified ages.

We see that the highest average age at death was in that group which had both mothers and fathers living to age 80 and over. The average age at death of these persons was 52·7 years. Contrast this with the average age at death of those whose parents both died under 60 years of age, where the figure is 32·8. In other words, it added almost exactly

20 years to the average life of the first group of people to have extremely long-lived parents, instead of parents dying under age 60. In each column of the table the average age at death advances as we proceed from top to bottom—that is, as the father's age at death increases—and in each row of the table the average age at death of the offspring increases as we pass from left to right—that is, with increasing age of the mother at death.

The bearing of these results upon our present inquiry is fundamental from a methodological standpoint. If duration

TABLE III

Showing the Influence of a considerable degree of Longevity in both Father and Mother upon the Expectation of Life of the Offspring. (After Bell.)

(In each cell of the table the open figure is the average duration of life of the offspring, and the bracketed figure is the number of cases upon which the average is based)

Father's Age at Death.	Mother's Age at Death.		
	Under 60.	60–80.	Over 80.
Under 60	32·8 years (128)	33·4 years (120)	36·3 years (74)
60–80	35·8 (251)	38·0 (328)	45·0 (172)
Over 80	42·3 (131)	45·5 (206)	52·7 (184)

of life is definitely inherited, as in fact it is, it will be necessary in order to draw correct conclusions about the effect of any external agent, such as alcohol, upon this character, to be sure that the groups compared are genetically homogeneous in a reasonable degree, at least, in respect of longevity. Otherwise quite fallacious conclusions may be reached. For example, suppose we were to compare a group of total abstainers who had, on the average, *inherited* a relatively long duration of life, with a group of drinkers, who by chance had, on the average, *inherited* a relatively short duration of life. Then, whether the alcohol consumption really had any deleterious effect upon duration of life or not, it would appear as though it had, because the non-drinking group would live longer than the drinkers. But a precisely similar difference would have appeared, because of the inheritance factor, if no alcohol at all had been taken.

It is in practice very difficult to get groups which are homogeneous among themselves in respect of hereditary longevity. This is one of the chief reasons why it has been so hard to get conclusive results on the influence of alcohol upon this measure of the general fitness of the organism.

Besides the matter of inheritance there are other critical standards which must be rigidly maintained in studies of this kind, if the results are to have any value. Groups compared in respect of death-rate should be statistically alike in regard at least to the following items :

1. Age and sex distribution.
2. Race (again because of inherited differences in longevity).
3. Occupation.
4. Social and economic position.

The mere enumeration of these critical standards will suffice to indicate how difficult it will be to get significant material for our problem from the records of life insurance companies, for example.

III. Experimental Evidence on the Influence of Alcohol upon Duration of Life in Animals

The first line of evidence which I shall discuss in relation to the general problem is that which is derived from experimental studies upon animals lower than man in the zoological scale, and on that account more easily amenable to such study. Just because this evidence is of an exact experimental character it is inherently entitled to great weight, so far as concerns the general biological principles which it brings out. Unfortunately, as will appear as we proceed, the results of the most accurate and critical experimental work on the effect of alcohol on duration of life in animals cannot be directly transferred to man, because of a presumably fundamental difference in the conditions. This fact, however, in no wise weakens the value of the evidence from a general biological standpoint, which looks at the question in a broad way, rather than solely with reference to a single organism, man.

The most extensive experiments bearing upon the influence of long-continued alcoholisation upon duration of life are those of Stockard with guinea-pigs, and those of the present writer with domestic fowls. These results, as will be shown, are in entire accord so far as the character duration of life is concerned. In both investigations fundamentally the same experimental methods were used. The alcohol was administered in the form of vapour. Stockard and Papanicolaou (1918, p. 127) described the method of administration used in their work in the following words :

> "Throughout these experiments alcohol has been administered to the guinea-pigs by a method of inhalation which was devised in the beginning. The animals to be treated are placed in fume tanks, fully described and illustrated in an earlier communication, and absorbent cotton soaked with commercial 95 per cent ethyl alcohol is placed on the floor of the tank beneath a wire screen on which the animals stand. The fumes of evaporating alcohol very soon saturate the atmosphere of the tanks, and the guinea-pigs introduced into this saturated atmosphere are allowed to remain until they show distinct signs of intoxication. During the earlier years of the experiment they remained for one hour each day in such tanks, but during the past twelve months we have increased the treatment to two hours per day for the males and three hours for the females.
>
> "This longer treatment is much better in that the animal, of course, gets a larger dose and its tissues may become more quickly influenced by the treatment. The animals may remain until they are completely intoxicated, in which case they are unable to walk, and therefore lie in a typical drunken stupor, or they may be affected to such an extent that they attempt to walk and in so doing stagger and fall in a manner characteristic of the drunken state. The amount of treatment here employed, however, does not produce complete intoxication."

Pearl's method of administration of alcohol to fowls was substantially the same, as the following account shows (1917, p. 135):

> "It is to be understood that every bird designated as a 'treated bird' has spent one hour every day in one of these tanks subjected to the fumes of the reagent specified in the particular case. At the beginning of the experiments it was thought desirable to accustom the birds gradually to the vapour treatment, and consequently in some cases the treatments for the first week were only one-half-hour in duration. It was soon found, however, that a sound healthy bird could stand the treatment for an hour, even from the first. Consequently in all later work it has been the rule to make the treatment extend over one hour each day from the very beginning."

Stockard and Papanicolaou (1918) state the following results regarding mortality:

> "A number of the guinea-pigs have now been treated with alcohol fumes almost to a state of intoxication six days per week for from five to six years. Few guinea-pigs in captivity live so long a time. There were two males treated for over six years, one of which lived to be more than seven years old. So far as we know this is the longest life reported for a guinea-pig. The treatment was continued with these very old animals, but they were not used for breeding. In no case when the treatment was begun on an animal over three months old could any injurious effects on its general welfare or length of life be discovered" (p. 133).
>
> "A number of the treated animals have died and many others have been killed at various times during the progress of the experiment. Their organs and tissues have been carefully examined at autopsy and later studied microscopically. All tissues have appeared practically normal, and none of the various well-recognized pathological conditions occurring in human alcoholism have been discovered. Tissues from animals treated as long as three years have been carefully studied, and the heart, stomach, liver, lungs, kidney, and other organs present no noticeable

conditions that might not be found in normal individuals. Alcoholised animals are usually fat, but no fatty accumulation has been noted in the parenchyma of any organ" (p. 134).

"Our card catalogue contains the record of every death that has occurred among the guinea-pigs since the beginning of the experiments, and we may state in a general way that the mortality statistics for the treated animals is certainly as good and perhaps slightly better than those of the control" (p. 137).

In my own experiments with fowls the mortality results unfortunately have to be reported in two parts. Up to the end of fifteen months of the experimental treatment the mortality per cent exposed to risk had been 0 for the alcoholists and 41·0 for their control sisters. In commenting upon this heavy mortality among the controls (more than half of which was due to roup) I said, in 1917 (1917a, pp. 167–169):

"Roup has existed in endemic form on the Maine Station Poultry plant for many years, as on most other plants where for experimental, or any other purpose, birds are brought in from outside fairly frequently. Ordinarily it gives very little trouble. Occasionally it will break out into an epidemic of greater or less violence, always as a result of a relaxation of some routine sanitary or hygienic measure. During the course of this alcohol experiment we have passed through a particularly violent epidemic of the sort mentioned. This fact is reflected in the large proportion of the deaths due to diphtheritic roup or some of its complications. On account of this epidemic the total mortality in the experiment must be regarded as abnormally high. The remarkable thing is that during the fifteen months covered in this report, i.e. to February 1, 1916, not a single one of the treated birds succumbed to this disease, though they were exactly as much exposed to contagion as the controls. This is a surprising result. It seems impossible that it can be due to any real increase in resisting power in the alcoholic birds. A possible explanation is that the daily inhalation treatment acts as a disinfectant of the air passages, and the treated birds do not take the disease because its germs are killed or greatly weakened before they have an opportunity to get an effective foothold. It would be altogether premature to draw any conclusion in regard to the matter until more extended data are at hand. At present, I desire merely to put on record the facts now available."

At the time the first report was published (January, 1917) the experiment had gone forward eleven months beyond the period covered in that report. It was then intended to publish soon a further progress report covering the additional data. But early in 1917 the United States entered the World War, and I was drawn from experimental work into war service. The records were continued by assistants till June, 1917, and for the progeny through the next year. A second misfortune in 1919 led to the destruction of all the records by fire. So the net result is that I can only give an incomplete account, from memory, of what happened in respect of mortality after February 1, 1916, the end of the period covered in the published report. The findings were, however, so striking that, so far as mortality is concerned, the essential facts can be stated with absolute definiteness. The alcoholised birds continued to live under the daily treatment, and finally in June, 1917, when the experiment was closed because of the war, the survivors, which included all but one of those which had started in the experiment with ethyl alcohol, were killed in order that autopsy records of the organs might be obtained. Meantime, all of their control brothers and sisters had long since died.

The general result was perfectly clear. The animals alcoholised daily over a long period far outlived their untreated brothers and sisters. Their mortality rate was lower than the normal at every stage of life. Incidentally the same thing was true of their progeny, both in respect of prenatal and postnatal chick mortality, as the following figures show :

Percentage mortality in first year of progeny of

(*a*) Alcoholised parents.	Prenatal mortality ..	26·9
	Postnatal mortality	10·6
(*b*) Untreated controls.	Prenatal mortality ..	42·2
	Postnatal mortality	36·9

Neither Stockard's results nor mine, which agree in showing either a reduced, or at least no higher, mortality in alcoholised animals than in those not given alcohol, can be directly transferred to human conditions. The reason is that the guinea-pig and fowls were given alcohol by the method of inhalation, while man drinks alcohol and does not inhale it. There can be no question that both the immediate and remote physiological effects of alcohol are quite different according as it enters the body through the walls of the stomach or of the lungs. Alcohol taken by the stomach tends to upset the processes of digestion, and if continued over a long period of time in any large amount, tends to derange all the metabolic processes of the body. No such deleterious effects follow upon its inhalation. It is probably much more completely and quickly absorbed when taken by the lungs.

Stockard and Papanicolaou (1918) believe that the slowness of absorption from the stomach is the factor of greatest inportance in producing the difference in the two methods. They say (pp. 132–133):

> "It seems to us, therefore, that the chief difference between inhaling alcohol and drinking it into the stomach is that in the first case the action of the substance on the animal system is of shorter duration, lasting but little longer than the length of the sojourn in the fume tanks—a short acute effect—while alcohol in the stomach is gradually and continuously absorbed for a considerable length of time, so that the animal's tissues are acted upon for hours after receiving the dose. Another very serious phase of the stomach alcohol, aside from the typical intoxication effects, is its tendency to derange the animal's powers of digestion and thus to cause very injurious results. The inhalation method is accompanied by no such complications."

While the experimental results which have been cited clearly cannot be transferred directly to man, they are, nevertheless, not without indirect value in the discussion of the human problem. They indicate, as far as they go, that there is no inherently necessary, biologically deleterious effect of ethyl alcohol in moderate doses upon duration of life, however long continued and frequently taken, provided it is administered in a manner which is not immediately and directly harmful physiologically. Or, put the other way about, *the experimental results show that ethyl alcohol can be so administered to the living organism as not to affect harmfully the expectation of life.* This is a biological result of great importance, even though it has no immediate social application.

Brief mention should perhaps be made here of some of the more important of the experimental investigations which have been made regarding the influence of alcoholism upon infection, and resistance thereto. I refer to such researches as those of Abbott (1896), Deléarde (1897), Laitinin (1900, 1908), etc. None of these studies had any direct relation to the effect of alcohol upon the normal duration of life, and in many respects the experiments were so conducted that they could not possibly give valid evidence upon this problem. Either the alcohol was directly introduced into the stomach in relatively high concentrations by tube, a process highly deleterious in itself, or the infecting doses of bacteria were far more massive than would ever be encountered in normal life, or in other respects the experimental procedure failed of critical pertinency to the problem here under discussion. Furthermore, as Hunt (1907) points out, the results are by no means concordant. This whole body of work may fairly be said to be of no help or significance in the solution of our present problem, whatever its significance in other directions may be thought to be.

IV. Investigations of the Effect of Alcohol upon the Duration of Human Life, made from Data Collected 'Ad Hoc'

It will be seen as we proceed that attempts have been made at various times and by various persons to get evidence as to how alcohol affects human longevity. All sorts of sources have been most ingeniously tapped for this evidence. Mostly, however, it has been indirect and inferential evidence, derived from the manipulation of statistical data originally collected for quite other purposes. It would naturally be expected that evidence of this sort could never have the critical value for the solution of the alcohol problem, that would go with material carefully collected solely, or primarily, for the elucidation of this specific problem. This expectation is borne out by the facts. Consequently I shall take up for discussion here first those researches which have been based upon *ad hoc* material. They furnish the best of the evidence concerning man. Further on the less direct and significant sorts of evidence will be discussed.

A. *Neison's Investigations*

The first person to attack the problem of "the rate of mortality which prevails among persons addicted to the immoderate use of intoxicating drinks" was the distinguished actuary, F. G. P. Neison (1851). He says, in introducing his classic paper, which in addition to being the first remains to this day in some respects one of the best ever produced upon the subject (*loc. cit.*, p. 200): "Assurance companies have generally declined to assure such lives, from the supposed greater mortality to which they were believed to be subject; but no attempt has been previously made to test this opinion by properly authenticated facts."

The material for Neison's investigation was drawn from schedules, sent presumably to medical men exclusively, to be filled out on the basis of personal knowledge and observation of individual cases. Neison was concerned to get data only on heavy drinkers. He emphasises that it was not intended to include "mere occasional drinkers" or "generous or free livers." Instead he wanted, and got, data for excessive drinkers—drunkards, as he comes to call them in later parts of the paper.

He was, of course, confronted with the difficulty which always appears in any attempt to classify drinking habits. His remarks on the subject seem to me to show great good sense, and, indeed, to cover the case adequately. He says (p. 201–202):

> "It is obvious that it would be very difficult, if not impossible, to give a definition of what constitutes intemperate habits that would be satisfactory to every one; almost every person would have a standard of his own by

which to determine the fact of temperance or intemperance, and therefore in the preceding circular no attempt has been made to define the particular character of habits on which information is sought; all that has been urged on the attention of those filling up the schedules is to give only well-marked cases, and to include only persons who were decidedly addicted to drinking habits. The consequence of following this course is, that the objections which might be urged against the adoption of any individual or peculiar test are avoided, for, by leaving it to each contributor of data to determine for himself what constitutes decidedly intemperate habits, the whole data taken collectively, from all the various contributors, will show very precisely the result of those habits which the public, by common consent, admit to be intemperate; so that, however any individual reasoner on the results may argue, and whatever peculiar construction he may choose to put upon them, it will be impossible to avoid the conclusion, that the data really relate to what the public generally regard as persons of intemperate habits. If the testimony of those more advanced in life is to be fairly trusted on this subject, it must be admitted that during the last quarter of a century the drinking practices of society have much altered, and what is now commonly regarded as free living would have some years since been looked upon as only moderation; so, in like manner, may it be hoped that the usages of society will continue to improve, and, at no distant date, the habits now considered not to exceed the bounds of moderation be altogether unknown in polite and refined society. It is, therefore, possible that what has hitherto been regarded as intemperate habits, may differ very widely from that which may be looked upon as intemperance some years hence."

The extent of Neison's data, and the broad results which they show, are indicated in Table IV, which is his "Abstract A" (p. 203).

It is at once evident from these figures that the mortality is extremely high, as compared with the general population. In the 6111·5 life-years exposed to risk, 357 deaths occurred. This is 3·25 times as many (110) as would have been expected had the rate of mortality for the inebriates been the same as that for the general population. Neison says (p. 204): "If there be anything . . . in the usages of society calculated to destroy life, the most powerful is certainly the inordinate use of strong drink."

TABLE IV

Neison's Data on Mortality of Intemperate.

Ages.	Number Exposed to Risk.	Died.	Mortality per cent.	Number Exposed to Risk.	Died.	Mortality per cent.	England and Wales Mortality per cent.	Intemperate Mortality ÷ England and Wales Mortality.	Number which ought to have died according to England and Wales.
16–20	74·5	1	1·342	74·5	1	1·342	·730	1·8	·5
21–25	352·5	16	4·539	949·0	47	4·953	·974	5·1	9·2
26–30	596·5	31	5·197						
31–35	877·5	32	3·647	1861·0	86	4·620	1·110	4·2	20·7
36–40	983·5	54	5·491						
41–45	897·5	51	5·682	1635·5	98	5·992	1·452	4·1	23·7
46–50	738·0	47	6·369						
51–55	539·0	27	5·009	966·0	62	6·418	2·254	2·9	21·8
56–60	427·0	35	8·197						
61–65	300·5	16	5·324	500·5	40	7·992	4·259	1·9	21·3
66–70	200·0	24	12·000						
71–75	87·0	18	20·690	110·0	20	18·182	9·097	2·0	10·0
76–80	23·0	2	8·696						
81–85	10·0	2	20·000	15·0	3	20·000	19·904	1·0	3·0
86–90	5·0	1	20·000						
Total	6111·5	357	5·841		357				110·2

From the raw data Neison calculated a life table. The expectations of life drawn from this table are summarised in Table V.

The survivorship or l_x line of Neison's life table for persons of intemperate habits, in comparison with the same line for males from the Registrar-General's English life table based on the mortality experience of 1850–1854 is shown graphically in Fig. 2.

The only comparison Neison is able to make, for want of data, is with the general population. He clearly perceives the desirability of a comparison with a group of total abstainers, and contributes the following highly significant statement (p. 209):

"It would be curious to contrast with the above results the rate of mortality among persons who have been for a considerable period of years, or for the whole of life, abstainers from intoxicating drinks; but, unfortunately, there are no available data connected with this class of lives, and it seems there will long be considerable difficulty in procuring such information. A few years ago Mr. Munro, of Enfield, at much trouble and expense, procured

TABLE V

Neison's "Equation of Life," *being the period of years of which there is an equal chance of living, among the—*

Ages.	General Population England and Wales.	Persons of Intemperate Habits.	
20	44·212	15·557, being 35 per cent	Of the duration of life in the general population.
30	36·482	13·800 ,, 38 ,,	
40	28·790	11·627 ,, 40 ,,	
50	21·255	10·860 ,, 51 ,,	
60	14·285	8·947 ,, 63 ,,	

returns from Rechabite societies, showing the rate of mortality and sickness experienced by the members, and the results, although not published, are known to exhibit as high a rate of mortality and sickness as is found to prevail among the members of other friendly societies. The facts collected by Mr. Munro are of great value, and it is to be regretted that the societies furnishing them should, on account of the unfavourable nature of the results arrived at, object to their publication."

This passage indicates that three-quarters of a century ago it was apparently established that the total abstainer had, on the average, no better expectation of life than that of the population at large, the great majority of whose individuals fell into what we should call the moderate drinking class. But the facts were suppressed by the propagandists !

Neison makes a number of other interesting calculations from his material. Thus, for example, he inquires more

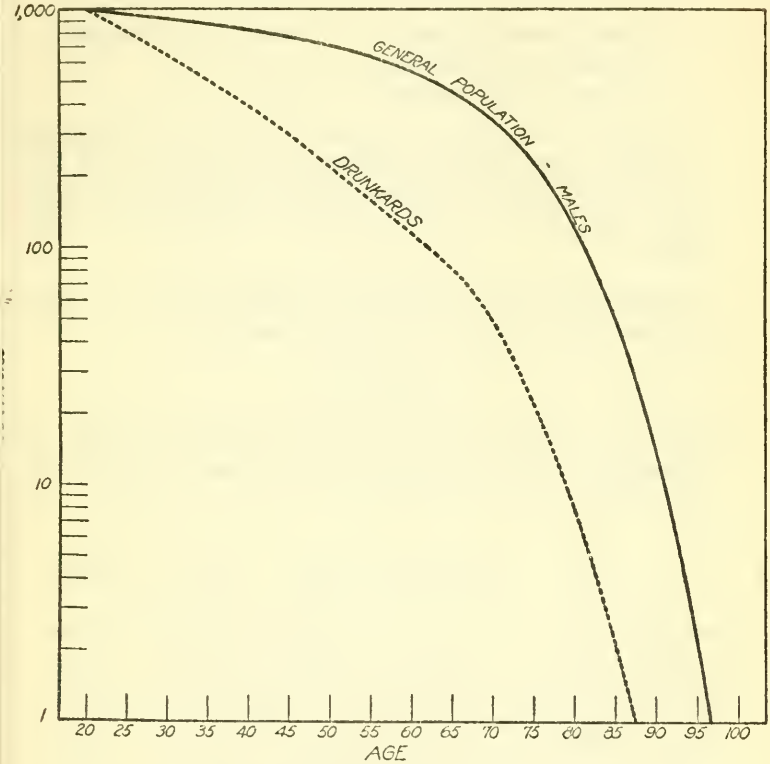

Fig. 2. l_x frequencies plotted from Neison's Table III (pp. 207, 208) plotted as a broken line, against the l_x frequencies from English life table males, 1838-1854 (solid line).

particularly into the nature of the drinking habits, with the following results (p. 209) :

"The duration of life, after the commencement of the intemperate habits, is,

Among beer drinkers . . .	21·7 years
Among spirit drinkers . .	16·7 ,,
And among those who drink both spirits and beer indiscriminately	16·1 ,,

and, consequently, the rate of mortality will be,

Among beer drinkers . .	4·597 per cent yearly
Among spirit drinkers .	5·996 ,, ,,
Among mixed drinkers .	6·194 ,, ,,

"Intemperate indulgence in the use of distilled liquors is, hence, more hurtful to health than the like use of fermented liquors, but the immoderate use of both combined is more injurious than the exclusive use of the one kind only."

In regard to particular causes of death, grouped in broad categories, the results are as shown in Table VI.

TABLE VI

Ratio per cent of Deaths, at ages twenty and upwards, from different Causes, to the Total Deaths, from all Causes, at the corresponding ages, in—

Cause of Death.	England and Wales, 1847.	Gotha Life Office.	Scottish Widows' Fund.	Intemperate Lives.
Head diseases .	9·710	15·176	20·720	27·10
Digestive organs .	6·240	8·377	11·994	23·30
Respiratory organs	33·150	27·843	23·676	22·98
Total of the above three classes .	49·100	51·396	56·390	73·38

In this compilation "Head diseases" means, generally speaking, diseases of the nervous system. It will be seen that an unduly high proportion of the intemperate die from diseases of the nervous and digestive systems. It is not clear, however, to what extent the differences exhibited by the percentages are due to differences in the age constitutions of the several populations at risk. This factor must, from the general appearance of the figures, be playing a considerable role. It is of interest to note that, contrary to expectation, the percentage of deaths due to the respiratory organs is lower in the intemperate than in any other group. Again, however, the age distribution of the population at risk may be sufficiently different to explain the result.

The final calculation which Neison gives is of the probable number of drunkards in England and Wales in 1847. This computation is based upon the following reasoning. In his own material, exclusively composed of drunkards, the number of deaths attributed to "Delirium tremens" and to "Intemperance" are known, as well as those attributed to each other specified cause. Now in the Registrar-General's returns at that time the only two rubrics attributing death directly to alcoholism were delirium tremens and intemperance. Neison argues that it is fair to assume that there will be in the general population the same proportionality between the number of deaths from these two causes, on the one hand, and all the deaths which should really be attributed to alcoholism, on the other hand, as are found in his exclusively drunkard material between the deaths from the two causes and all other causes. Proceeding upon this assumption he gets the results shown in Table VII.

TABLE VII

Nelson's Calculation of the probable number of Drunkards in England and Wales in 1847.

Ages.	Males.				Females.			
	Population, 1847.	Drunkards.	Ratio of Drunkards to Population. per cent.	or 1 in	Population, 1847.	Drunkards.	Ratio of Drunkards to Population. per cent.	or 1 in
21–30	1,521,610	8,641	·57	176	1,677,442	2,221	·13	755
31–40	1,124,368	13,983	1·25	80	1,167,477	2,143	·18	545
41–50	822,161	14,469	1·75	57	852,367	2,870	·34	297
51–60	534,419	10,377	1·92	52	574,672	2,540	·44	226
61–70	350,649	5,443	1·56	64	399,580	1,339	·34	298
71–80	169,447	670	·40	253	199,368	110	·055	1,812

The significance of this calculation, from our present viewpoint, is simply that it defines numerically what 'intemperate habits,' 'drunkenness,' etc., mean in Neison's investigation. He was, in fact, as he planned from the beginning, dealing with what can only be fairly called excessive drinking, or, as he puts it, inordinately intemperate habits.

Keeping this limitation to his study clearly in mind, we are justified, I believe, in accepting his main result at practically its full face value. The research was well planned, and on the whole carefully carried through. There are only two important criticisms which can be lodged against it, I think. The first is that the actual number of individuals for which he had data, 357, is small. The weight of this objection would, it seems to me, be greater if there were anything equivocal about the results. But there is not. In these excessive drinkers the mortality is more than three times that of the general population. In view of the painstaking care and accuracy of Neison's work, he would indeed be a bold person who would try to maintain the opposite to Neison's conclusion; who would, in short, attempt to assert, because only 357 persons are included in the research, that there is no evidence that excessive drinking lowers the expectation of life. The second point of criticism is that no particular weight can be attached to the individual values of his life-table functions. He had a knowledge only of deaths from which to construct a life table. It is well known that this could give only approximate results when the calculations were made by any mathematical method known in Neison's time. The l_x line in Fig. 2 indicates plainly enough that his life table had an insecure foundation. This point that Neison's exposed to risk was the same as his deaths has been severely criticised by Westergaard. But this criticism does not shake his broad, chief result that heavy drinkers exhibit a mortality rate significantly greater than that of the general population.

Neison gives no specific information about the random character of the material in respect of social class, occupation, economic status, etc. From the method of collection, however, and from the internal evidence of the figures themselves, I think it may be safely concluded that there is no selective feature involved which could account for the results. His paper was promptly and favourably reviewed in the "Assurance Magazine" (cf. Anon., 1852), and the results were stated to be invaluable to assurance companies, indicating at once its pioneer character, on the one hand, and the opinion of contemporary actuarial critics as to its fundamental soundness, on the other hand.

B. *The Author's New Material*

The clean-cut character of the results obtained by Neison, as reviewed in the last section, emphasises, by contrast with others to be presented in later portions of this paper, the great importance, in the investigation of the problem of the influence of alcoholic beverages on the duration of life, of having material directly and specifically collected for the purpose of answering this question. There can be no comparison between the significance of results obtained from material of this sort, as against the indirect and inferential evidence which comes from the records of life insurance companies, etc., where the material was not originally so collected as to be adapted to the solution of this problem.

If one were required to set forth in advance just what kind of material would be ideally suited to furnish critical evidence regarding this problem, he would, I think make a statement something like the following:

There should be a mass of material sufficiently large in amount so that after it had been divided into the two sexes (of which there should be substantially equal numbers), and had furthermore been broken up into groups in respect of drinking habits, the numbers in these ultimate groups should be large enough to be statistically significant.

The information recorded regarding each individual's drinking habits should be so definite and precise that one could set up at least three groups for each sex. In one of the groups all the individuals should be known to have been total abstainers throughout their lives, in a second group all the individuals should be known to have been throughout adult life consumers of large amounts of alcohol, while in a third group all the individuals should fall in an intermediate position in alcohol consumption as compared with the other two groups. Each group should be homogeneous within itself in respect of the alcoholic habits of the individuals.

The whole material, that is the groups when compared *inter se*, should be homogeneous in respect of:

1. Race stock; to the end that all or the major portion of the drinking group may not have come from one race stock, whereas the non-drinking group came in the main from another race stock, with a different racial expectation of life.

2. Social and economic status. It would, for example, obviously be unfair to test the question of the influence of alcohol on the duration of life by comparing a group of drinkers with a group of non-drinkers, where the former group contained substantially only coalminers and the latter group contained substantially only clergymen. The differences in the general habits of life and heredity of these two groups, quite apart from any possible influence of alcohol, would be sufficient to account for a considerable difference in their expectations of life.

3. Environmental conditions, other than alcohol.

Finally, for each individual the age at death and the cause of death should be known. The former can and should be known accurately, and the latter with no more inaccuracy than inheres in vital statistics generally in regard to cause of death. The cause of death should be known in order that purely accidental deaths may be excluded, as well as for the purpose of making a more particular study of the effects of alcohol upon individual diseases.

To summarise, what is desired in this case is a mass of statistical material for man, collected *ad hoc*, which will be comparable in accuracy and cogency to what one would expect to get if he carried through a well-planned experimental study with a lower animal on the effect of alcohol upon the duration of life. Such material can only be got by special collection. It does not exist ready to hand, in either official vital statistics or in the archives of life insurance companies.

Essentially the same ideas regarding the desiderata in the case have been presented in the following words in Chapter IX, p. 115, of the Advisory Committee's Report on Alcohol:

"The extreme difficulty of the subject can be best displayed by considering the kind of data that would need to be provided for a solution on the experimental lines of the work used as a basis for the earlier chapters of this book.

"In effect we should require to have at our disposal a number of men or women of like ages, similar ancestry, occupations and civil condition. We should divide them at random into two groups, the members of one group would receive a fixed quantity of alcohol daily, and the fates of all would be recorded from the time of beginning the experiment until every one was dead."

It is believed that the material now about to be presented substantially meets all of the requirements which have been set forth above. This material, which has hitherto only been published in preliminary abstract form (Pearl, 1922), has been extracted from the Family History Records of the writer's laboratory. These Family History Records consist of elaborate detailed original pedigrees, collected by a staff of trained eugenic field-workers. In order that a clear understanding may be had of the significance of this material, some account of its history is desirable. Some four years ago at the request of the National Tuberculosis Association, and with its financial support at the outstart, and that of the Russell Sage Foundation and the Commonwealth Fund later, the writer embarked upon a comprehensive investigation of the factors involved in the etiology of tuberculosis, with special reference to the genetic elements in the case. The plan of the work, in outline, was as follows: It was proposed to collect a large number of much more detailed and elaborate family histories of tuberculous persons than any that had hitherto been compiled, doing this by means of field- or social-workers, carefully trained for this work. These field-workers visit the families of individuals whom it is desired to investigate, and get by personal interview the information to be set down in the histories. Proceeding in the matter in an entirely objective way and without preconceptions, it was felt to be essential, if any critical results were to be obtained, to get the most elaborate and critically exact records possible about the environmental situation, the habits of life, the health history, the racial stock, anthropological characteristics, exposure to tuberculosis, etc., of all the members of the family group.

The histories have, from the first, been divided into two groups. In one set the history starts with an individual, the propositus, who is known to have clinically manifest tuberculosis. In the other set each history starts with a propositus who is definitely known *not* to have tuberculosis in any form. The initial individuals for these two sets of histories have been obtained in the following ways. The tuberculous individuals were taken at random (except for race stock) from among those persons who were registered with the Baltimore City Health Department as having active tuberculosis, under the law which makes this a reportable disease ; or from those persons registered with the Phipps Tuberculosis Clinic of the Johns Hopkins Hospital, a free dispensary clinic. The non-tuberculous individuals were taken at random (except for race stock), either from among those persons who had, for some trivial offence (such as, for example, playing baseball in a vacant lot, etc.), been before the Juvenile Court and were known not to be tuberculous, or from the patients registering at the General Dispensary of the Johns Hopkins Hospital, and known not to be tuberculous.

Starting from the propositus the procedure is the same in both sets of histories. Through the work of the field-workers the family history is traced, both in respect of the ancestry and their collaterals, and in respect of descendants and their collaterals. The histories record identically the same kind of facts in the two groups in every respect. The only difference is that in the one case they start with an individual known to be tuberculous, and in the other case they start with an individual known not to be tuberculous. The same questions are asked and the same facts recorded for all the individuals in the family tree in both sets. The collection of this material is still going on, and it is expected that the goal which has been set as to the requisite number of cases will not be completed before at least another year. It may be well, however, to state, as indicating in some degree the magnitude of the investigation, that up to the present time detailed records of the life-history of approximately one hundred thousand individuals, comprised in about four hundred family trees, have been collected.

Every critical safeguard of the accuracy of the ultimate individual records that the writer has been able to think of has been thrown around this work. No fact is entered in a history finally until it has been corroborated by the independent testimony of at least two persons acquainted with the individual in question. The material has all been taken from one socially and economically homogeneous group of the population of the city of Baltimore, namely, what might inclusively be called working-men's families. By the employment of field-workers speaking a variety of foreign languages it has been possible to get representation in the histories of the different foreign race stocks in about the proportion that they are represented in the total population of the city of Baltimore, and in this way there has been no racial discrimination in the study. The only exception to this is that the negro has not been included, owing to the difficulty—indeed, impossibility—of getting accurate genealogical information about negro families. These people do not know accurately about their own ancestors.

The elaborate records which are taken regarding the environmental surroundings of the persons in the histories, demonstrate that they may be regarded as forming a homogeneous group in this respect. Space cannot be taken here to present the detailed statistics to prove this point, although they will be published later in another connection.

From the beginning of this work one of the points upon which emphasis has been placed in connection with the histories, is to get accurate information as to the habits of each individual reported, in respect of the use of alcoholic beverages and tobacco. These points were included in the beginning, without any thought of their ever being used in the present connection, but because it was thought that they might be of significance as etiological factors in the appearance of active tuberculosis. It has frequently been asserted that they are. It was hoped that with the mass of material we should finally have in these histories it would be possible definitely to settle the question. The workers were carefully instructed to take great pains to get particular and detailed information about these habits.

Some time ago it occurred to me that the material regarding alcoholic habits in these histories might well be used for the study of the problem of the influence of this agent upon the duration of life. In collecting the material, no intimation has been given the persons from whom the information was obtained that it was ever to be used for any such purpose. On the contrary, the particularity of the information asked for about alcohol was introduced and defended by the field-worker, in talking with the members of the family, on the ground that it might be a significant factor in the causation of tuberculosis, and that we were anxious to determine whether this was true or not. The reasonableness of the request for this information for the purpose stated appeals generally to the people visited, and consequently it is usually given frankly and without hesitation, and, so far as we have ever been able to determine, without reservation or bias. Pains are taken by the field-workers never to give an impression that any moral stigma attaches in their opinion to the use of alcohol, even to excess. They endeavour to give, and succeed in so doing, an impression of complete objectivity in their inquiries.

So then, in sum, we have here a mass of material about the alcoholic habits of a homogeneous group of individuals, together with other pertinent information about the same individuals, including their age at death, if dead. It has been directly and individually collected, with the exercise of every possible care to ensure accuracy.

For the purpose of the present study the material was extracted from the case histories according to the following plan. Only those persons were taken who fulfilled the following conditions :

1. The individual must be dead, at an age of twenty years or above. This restriction was placed upon the material on the ground that habits of alcohol consumption can, in general, hardly be said to have been definitely formed before age twenty. Furthermore, persons dying under age twenty can hardly have been, in general, systematic drinkers long enough for the alcohol consumption to have had any material effect.

2. Age at death, and sex definitely known.

3. Alcoholic habits throughout life definitely known and recorded.

All individuals whose records did fulfil the above three requirements were included (i.e. there was no selection of material), except those dying from some purely accidental cause, and by homicide.

The individuals, whose records according to the above specifications were extracted, were then divided into six groups relative to sex and drinking habits, as follows :

A. Males :
1. Total abstainers.
2. Moderate and occasional drinkers.
3. Heavy or steady drinkers.

B. Females :
4. Total abstainers.
5. Moderate and occasional drinkers.
6. Heavy or steady drinkers.

This division demands further explanation. The class "Total abstainers" includes only such persons as were known never to have used alcoholic beverages at all, even in the smallest amounts. If any person occasionally took a glass of beer, or wine, he went into the class of "Moderate and occasional drinkers."

The second class, "Moderate and occasional drinkers," includes all those persons whose drinking habits, in the opinion of family and friends, were very moderate in respect of amount consumed and not entirely regular or steady in respect of frequency. Here were included persons who "took an occasional glass of beer," the labourer who at irregular and not too frequent intervals took a drink of whisky, or other spirits. The person who made it a regular habit to take wine or beer with meals, even though the amount so taken was never excessive, was placed in the next higher class, the "Heavy or steady drinkers." This was done on the ground that a *steady* daily drinker, even in moderate amounts at any one time, consumes in the course of a lifetime a good deal of alcohol. Furthermore, there are in his life-history no periods measured in units of time greater than hours, in which his system is not metabolising some alcohol. I realise fully that in placing the moderate and temperate but *steady* daily drinker in the "Heavy" category that I am going contrary to common opinion and the common usage of descriptive language. But I believe that the classification here adopted is more nearly scientifically warranted in an objective study of the problem than is that based upon common opinion.

The third class, "Heavy or steady drinkers," includes all those whose habits are described by relatives and friends as coming under either of these categories. It includes the drunkards, on the one hand, and the steady daily drinkers who never or rarely at any one time drink to such excess as to become intoxicated.

The persons whose drinking habits radically change in the course of life present a difficult problem in classification, as between our second and third classes. Of course, if they have ever at any time in life used alcohol as a beverage they are automatically excluded from the total abstainers' class. In distributing individuals of changed habits among the second and third classes a sort of statistical "rule of reason" has been followed. That is to say, from a careful study of the record the attempt is made to classify the person on the basis of his lifetime *average* consumption. This may result in placing a person who was a heavy drinker in early life, and a total abstainer later, in the class of moderate drinkers. This will not be satisfactory to all critical readers of this article. They will argue that heavy drinking at any time of life did organic damage of a permanent character, and that the subsequent consumptive repentance acquires no merit in the biological court. It seems to me that this argument somewhat begs the question under investigation. From a strictly objective scientific point of view the only reasonable way to treat the material statistically is to classify individuals on the basis, so far as ascertainable, of average alcohol consumption throughout life. Then if one wishes to study as a special problem the influence upon longevity of heavy drinking in early life, followed by total abstinence, he can do so as a separate and distinct investigation. Practically this discussion is somewhat academic, as only comparatively few individuals failed to fall definitely and indubitably into one of our three categories.

Regarding the general question of the possibility of classifying persons in respect of their drinking habits, I am in entire agreement with Neison's remarks, already quoted (p. 229 *supra*), and can add nothing effective to them. In comparing my third class with Neison's it should be said that, in my opinion, his material represents a considerably higher average of consumption of absolute alcohol than my "Heavy or steady drinker" class. He included only the manifestly intemperate, in the literal sense of that word. My "heavy" class includes a considerable number of persons whom he would have called strictly temperate and excluded from his study. I refer to the group already mentioned of steady but, in quantity, moderate drinkers. As we shall presently see, the difference in this respect between Neison's group and my third class reflects itself clearly in duration of life.

What we then have in this material is, in effect, a sample of over two thousand persons drawn at random from the working-class population of the city of Baltimore, each at age twenty, divided into three classes in respect of drinking habits, and followed throughout life until its termination by death. In so far as we may regard the information as to drinking habits and age at death as accurate, the whole inquiry is essentially like an experimental investigation of the problem. Lest there should be any misunderstanding about the material, it should be stated specifically that tuberculosis occurs as a cause of death in this group of persons no more frequently than it does in the general population from which the material was drawn. This arises primarily from the fact that not every person in one of our tuberculous family histories is tuberculous. So far as the method of collection is concerned, there is automatic assurance only that at least one person, the propositus, is tuberculous in a tuberculous case history. But our family histories have, on the average, about 250 persons per history. Our material is so extensive that in respect of tuberculosis, as well as of other diseases, it represents, taken as a whole, simply a random sample of the general working-class population. It is this fact which makes the material available for many other kinds of investigation besides that for which it was specifically collected.

With so much by way of explanation of the source and character of my material, we may proceed to an examination of its results.

Of individuals fulfilling all the requirements set forth above, there were obtained from the Family History Records the following numbers, in the several categories :

Male :	Total abstainers . . .	271
	Moderate and occasional . .	474
	Heavy and steady . . .	514
Female :	Total abstainers . . .	493
	Moderate and occasional . .	269
	Heavy and steady . . .	26
	Total	2047

It will be seen at once that the material is much more extensive than Neison's. It is a respectable number of cases, even from the standpoint of a laboratory experimenter, and I would emphasise again that in respect of the critical accuracy of the individual records it compares much more closely with experimental data than with ordinary statistical data. The total number of persons, 2047, is about the equivalent of the total population over twenty of a town or city of roughly 4600 total inhabitants.

In Table VIII is shown the number of survivors in each of the groups, at each quinquennial age period, out of one thousand supposed starting together at age twenty.

These distributions are shown graphically in Figs. 3 and 4.

It is apparent, from the most casual inspection of Table VIII and the diagrams based upon it, that two broad conclusions at once emerge. These are :

1. That there is no indication in either sex that the moderate and occasional consumption of alcoholic beverages adversely affects duration of life.

2. That the individuals in the heavy or steady drinking group have a *significantly lower* duration of life than those in either of the other groups.

Before discussing the figures in detail, however, I wish to present the results in another form, better suited to precise comparisons. This is done in Tables IX and X. Table IX gives the mean age at death (and its probable error) for the groups of individuals attaining each quinquennial age point. Thus the first line of the table gives the mean age at death of all persons dying at age twenty or over. The second line gives the mean age at death of all persons in the material who lived to be at least twenty-five years old and subsequently died. The next line, the mean age at death of those who lived to be at least thirty and subsequently died, and so on for the other rows of the table. In actuarial terminology the

TABLE VIII

Survival Distributions of Persons of Different Drinking Habits. (Author's Data).

Age.	Male.			Female.		
	Abstainer.	Moderate.	Heavy.	Abstainer.	Moderate.	Heavy.
20	1000	1000	1000	1000	1000	1000
25	967	989	984	968	974	923
30	915	947	947	921	911	885
35	875	888	877	862	885	846
40	812	829	784	783	855	692
45	742	774	658	718	799	462
50	686	717	580	669	755	346
55	624	620	469	588	643	231
60	568	553	385	515	584	231
65	472	473	313	436	457	154
70	358	367	249	310	364	154
75	236	247	152	221	268	77
80	125	177	97	120	167	0
85	59	99	49	65	112	0
90	41	61	21	16	52	0
95	22	30	8	6	15	0
100	7	8	0	0	0	0

figures in Table IX correspond essentially, though not quite precisely, to the expectation of life at birth of persons entering at the ages indicated in the first column of the table. At first thought a critic might object to this statement on the supposition that I am confusing " mean age at death " with " mean duration of life " or " expectation of life." Many years ago Farr pointed out that in a general population the " average age at death " may differ unduly from the true "expectation of life at birth," or the true "mean duration of life." Average age at death is determined from a knowledge of deaths alone, whereas the other two constants involve also a knowledge of the numbers living (and therefore at risk of dying) at each age. In other words, average age at

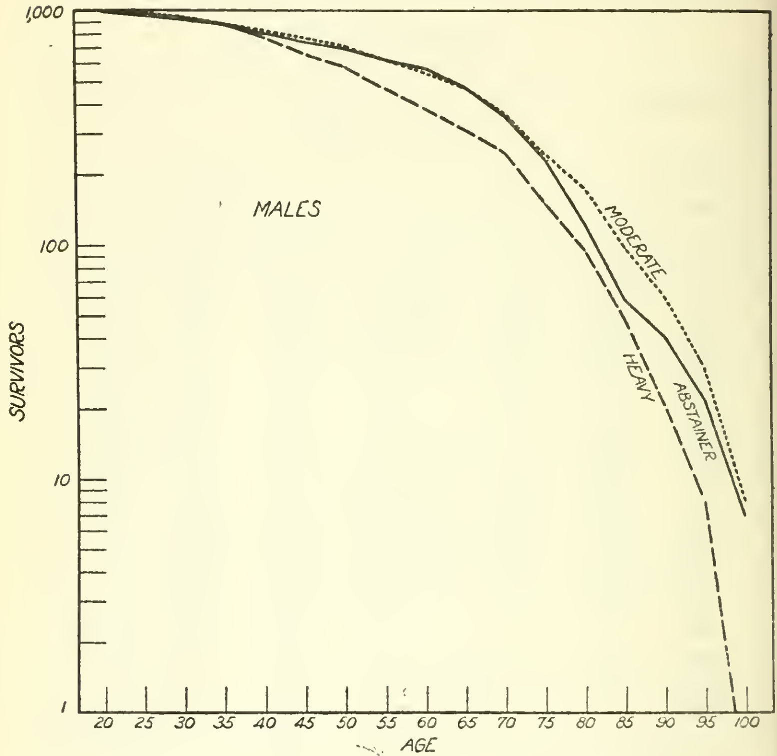

Fig. 3. Survival distributions for males of different drinking habits. Solid-line = total abstainers; dotted line = moderate and occasional drinkers; dash-line = heavy or steady drinkers.

death includes statistically only a part of the total population, while average duration of life includes the whole population. Now in relation to the present material, two further principles must be kept clearly in mind. These are:

1. In an experimental population, restricted by the terms

of the inquiry to a specific number (in our case 2047), the mean age at death and mean duration of life have identically the same value *for the experimental population* itself. This is self-evident, because all the individuals in the population are taken account of in calculating either value.

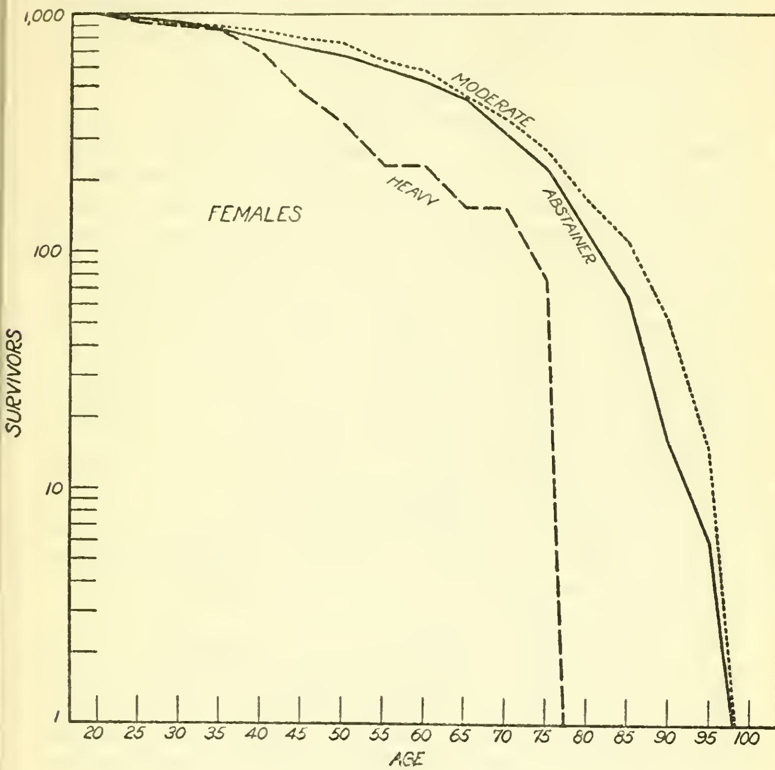

Fig. 4. Survival distributions for females of different drinking habits. Solid-line = total abstainers; dotted line = moderate and occasional drinkers; dash-line = heavy or steady drinkers.

But suppose, as will virtually always be the case, we wish to generalise, or transfer the conclusions derived from the experimental sample to the general population. Under what conditions will the average age at death of the persons in the experimental sample be identical with the true expectation of life (or mean duration of life) in the general population? The answer is:

2. If there is a point to point correspondence between the sample and the general population in respect of the general cause groups (which, of course, include age distribution of the population) determining the values of the instantaneous death-rates at each age (q_x), the mean age at death and mean duration of life will agree, even if, as will actually be the case, it is impossible to determine any true death-rates for the sample because of lacking knowledge of anything but deaths. This can be tested by seeing how the two values actually correspond. We shall see presently that in our present material the mean age at death of the abstainers and moderate drinkers is almost absolutely identical with the true expectation of life at birth of the white urban population of the U.S. Registration Area. This means that the persons in these two classes in our population died from age twenty on in a manner essentially identical with that which would have resulted had the life table death-rates (q_x) been applied at each successive age to the survivors of our abstaining and moderate drinking groups.

Table X gives the absolute numbers of persons upon which each of the means in Table IX is computed.

The data of Tables VIII and IX are the raw, ungraduated figures. Their smoothness is impressive, and is in itself an excellent indication of the accuracy of the original records.

We note the following points:

1. The normality and representative character of the data are indicated by the following comparisons with Glover's (1921) latest American life tables. On page 106 the expectation of life ($\mathring{e}_x$)for white males aged twenty, living in cities, is given as 40·51 years. This means that the total expectation of life at birth of white males living in cities who attain the age of twenty without dying is $20+40{\cdot}51=60{\cdot}51$ years. The reader will notice how closely this corresponds to the mean age at death of the total abstainer group of males ($60{\cdot}05\pm{\cdot}78$) entering at age twenty, given in the first column of the first row of Table IX. Closer agreement could not be expected. In the case of white females living in cities in 1910 Glover (p. 110) gives the expectation of life at age twenty as 43·51 years. This means for these individuals who have

attained age twenty without dying a total expectation of life at birth of 20+43·51=63·51 years. The agreement of this figure with the mean age at death for females in the first row of Table IX is not quite so close as in the case of the males, but still is not widely different. Our total abstainer group of females entering at age twenty has a mean age at death of 58·49±·57 years; 63·51−58·49=5·02 years, a

TABLE IX

Mean Duration of Life of Groups entering at the Specified Ages.

Age at Entranc.	Mean Total Duration of Life—Males.			Mean Total Duration of Life—Females.		
	Total Abstainers.	Moderate and Occasional.	Heavy or Steady.	Total Abstainers.	Moderate and Occasional.	Heavy or Steady.
20	60·05±·78	61·04±·59	55·37±·52	58·49±·57	61·70±·77	47·50±2·02
25	61·34±·75	61·82±·58	55·89±·51	59·70±·55	62·75±·74	49·58±1·92
30	63·25±·70	63·35±·56	57·00±·50	61·33±·52	65·19±·68	50·54±1·89
35	64·67±·68	65·40±·53	58·95±·49	63·30±·50	66·16±·65	51·36±1·89
40	66·67±·63	67·39±·50	61·51±·48	65·91±·46	67·15±·63	54·44±2·00
45	69·07±·59	69·15±·48	65·16±·47	68·02±·43	68·87±·60	60·42±2·24
50	70·81±·55	70·87±·46	67·53±·46	69·51±·41	70·14±·58	64·72±2·26
55	72·65±·52	73·74±·44	71·09±·45	71·86±·38	73·19±·55	70·83±1·72
60	74·12±·50	75·73±·42	74·04±·43	73·90±·36	74·79±·53	70·83±1·72
65	76·48±·49	77·97±·41	76·69±·41	75·97±·35	78·19±·52	75·00± ·84
70	79·36±·51	80·98±·42	79·06±·41	79·40±·34	80·92±·50	75·00± ·84
75	82·89±·58	85·11±·44	83·27±·44	82·18±·34	83·96±·50	——
80	87·65±·75	88·10±·45	86·50±·46	86·14±·36	87·83±·48	——
85	93·44±·85	92·50±·48	90·50±·50	89·22±·38	90·50±·44	——
90	96·14±·76	95·60±·45	94·32±·49	94·37±·58	93·93±·41	——
95	99·17±·65	98·93±·41	——	——	——	——

probably significant but not great difference. The moderate drinking groups of females, however, entering at age twenty has a mean age at death of 61·70±·77 years; 63·51−61·70 =1·81 years. This difference is to be regarded as almost certainly insignificant. In general it is to be noted that in the present material the only female group which shows the normal biostatistical relation of a greater duration of life in females than in males at corresponding ages is the moderate drinking group. The discrepancy in this respect in the other two groups is difficult of explanation. It may be that in the heavy drinking groups the explanation is that when women are real inebriates they are apt to be even more excessive drinkers than males in the same general class. No explanation suggests itself for the discrepancy in the total abstainer group. In spite of the peculiarity mentioned, however, it

TABLE X

Showing the number of Persons who attained the Specified and Higher Ages in the Several Groups.

Attained Age.	Males.			Females.			Totals.
	Total Abstainers.	Moderate and Occasional.	Heavy or Steady.	Total Abstainers.	Moderate and Occasional.	Heavy or Steady.	
20	271	474	514	493	269	26	2047
25	262	469	506	477	262	24	2000
30	248	449	487	454	245	23	1906
35	237	421	451	425	238	22	1794
40	220	393	403	386	230	18	1650
45	201	367	338	354	215	12	1487
50	186	340	298	330	203	9	1366
55	169	294	241	290	173	6	1173
60	154	262	198	254	157	6	1031
65	128	224	161	215	123	4	855
70	97	174	128	153	98	4	654
75	64	117	78	109	72	—	440
80	34	84	50	59	45	—	272
85	16	47	25	32	30	—	150
90	11	29	11	8	14	—	73
95	6	14	—	1	1	—	22
100	1	1	—	—	—	—	2

may be said with confidence that this material as a whole shows a sufficiently close approximation to the normal life table relations of the general population to give the results real critical weight in the discussion of the alcohol problem.

2. At every age up to eighty-five in the males, and to ninety in the females, *the moderate drinking group exhibits a higher mean age at death than the total abstainer group.* Mostly

these differences cannot be regarded as significant in comparison with their probable errors, but the steady agreement in the sign of the difference is impressive. There appears, in this critically collected material, no evidence whatever for the view that the moderate consumption of alcohol as a beverage in the slightest degree diminishes the expectation of life.

3. The heavy or steady drinking group shows definitely, in both sexes, a diminished mean age at death, as compared with either the total abstainer or the moderate and occasional groups. This result confirms that of Neison. The fact that the present results are not quantitatively so bad as those of Neison is probably to be explained chiefly on two grounds. First, and most important, is the fact that our third class unquestionably was not, on the average, composed of as excessive drinkers as Neison's group; in the second place, the mean duration of life has in general somewhat lengthened in the period of nearly three-quarters of a century which separates the two investigations.

The only point of criticism which, on the basis of the evidence so far presented, could be justly brought against these results, in my opinion, is that the groups of different drinking habits are not homogeneous *inter se* in other respects, and that on this account they are not comparable. Let us examine some evidence on this point.

Economic status may be considered first, as perhaps the most significant single index of human environmental conditions. Table XI gives the distribution of the individuals included in the investigation in respect of the income per week (in dollars) *of the family* to which they belonged, at the time the records were obtained. This means some time between the latter part of 1919 and the first few months of 1922. This was a period of relatively high wages, following the gross inflation of the war time. In consequence the whole scale of incomes shown in Table XI is undoubtedly considerably higher absolutely than these same families, or others of the same general rank in the social scale, would have shown in pre-war times. This fact, however, in no way invalidates the figures for comparison *inter se*. The totals of Table XI do not check with those of Table X, because it was impossible to get information as to income from some of the families. The families represented by the frequencies in the first row of Table XI (income 0–9·99 dollars) were for the most part receiving charitable aid.

TABLE XI

Economic Status of Families. (Author's Data.)

Family Income per week (dollars).	Total Abstainer.	Per cent.	Moderate and Occasional.	Per cent.	Heavy or Steady.	Per cent.
0– 9	16	2·4	13	1·9	12	2·4
10–19	89	13·1	92	13·6	97	19·5
20–29	219	32·2	231	34·2	150	30·1
30–39	220	32·4	163	24·1	116	23·3
40–49	96	14·1	88	13·0	70	14·1
50–59	24	3·5	40	5·9	27	5·4
60–69	8	1·2	27	4·0	9	1·8
70–79	6	·9	21	3·1	13	2·6
80–89	—	—	—	—	2	·4
90–99	2	·3	—	—	2	·4
Totals	680	100·1	675	99·8	498	100·0

It is at once apparent that there is certainly no considerable differentiation between the three groups in respect of economic status, as indicated by family income. This conclusion is made still clearer by the constants of Table XII, which have been calculated from the distributions of Table XI, by the usual procedures.

TABLE XII

Constants for Family Income per week (in dollars).

Constant.	Total Abstainers.	Moderate and Occasional.	Heavy or Steady.
Mean income . .	31·46 ± ·32	33·21 ± ·38	31·89 ± ·46
Standard deviation .	12·18 ± ·22	14·73 ± ·27	15·16 ± ·32
Coefficient of variation	38·7 ± ·8	44·4 ± 1·0	47·6 ± 1·2

There is clearly no chance here for an explanation of the differences in mortality between the heavy drinkers and the others, on the basis of differences in economic status. For practical purposes the mean family income per week may be taken to be the same in all three groups. It is actually $1·75 a week higher in the moderate than in the abstainer group, but this difference is statistically insignificant. An interesting point is the somewhat greater variability, both absolute and relative, of both the drinking groups as compared with the abstainer group, in respect of family income. A discussion of the possible economic and social meaning of this fact would, however, take us too far afield.

We may, then, take it as demonstrated by the figures of Tables XI and XII that the three groups of our material on the basis of drinking habits are homogeneous *inter se* in economic status, as indicated by family income per week.

Let us examine next the facts as to the racial constitution of the material. In collecting the case histories in the tuberculosis work, special emphasis has been placed upon getting as exact and comprehensive information as possible regarding the race stock of origin of each individual, because of the well-known racial differences in susceptibility to this disease (cf. Dublin and Baker, 1920, and Pearl, 1921). Because of the enormous racial intermingling which has occurred in the population of the United States, this is not an easy or simple task. An individual may, for example, be a composite of English–German–French–Irish–Dane–Cuban. In the population of Baltimore many persons are, in racial origin, combinations of English–German.

In Table XIII I have grouped the material into six large racial groups, a classification which is sufficiently fine for our present purpose.

I understand perfectly that these groups are not anthropologically homogeneous. Impeccable race classifications of mankind are practically impossible in any case. In Table XIII I have merely tried to give a common-sense picture of the kind of people involved in this study. The classes chosen are: (1) British, including English, Scotch, Irish, and Welsh; (2) Germanic, including German, Austrian, Bohemian, and Scandinavian (there are so few Scandinavians in our Baltimore material as not to warrant setting up a separate group); (3) Slavonic, including non-Jewish Russians, Slovaks, Poles, etc.; (4) Latin, including Italian, French, Spanish, Roumanian; (5) Hebrew, including all Jews, whatever the country of origin; (6) North Americans, which includes really those persons whose families had been so long in this country that they, the persons, had no knowledge of their racial origin.

It is to be understood that we are discussing here racial *origins* strictly. Most of the persons listed as British or German have been in this country for a long time, two or three generations at least. They are themselves Americans, but their ancestors were preponderantly of the stocks indicated. The recent immigrant stocks are found chiefly in the Hebrew and Slavonic groups, and to a less but still significant extent in the Latin group.

In allocating individuals of mixed racial origin the plan has been, where more than two stocks were known to be involved, to put the individual in the class of the preponderant stocks (for example, English–Irish–German was classed as British). Where but two stocks were involved, say English–German, one-half the cases were put with one, and one-half with the other group.

Both sexes are put together in the figures of Table XIII.

TABLE XIII

Distribution of Persons of Specified Drinking Habits, in respect of Racial Origin.

Race stock of origin.	Total Abstainer.		Moderate and Occasional.		Heavy or Steady.	
	Absolute.	Per cent.	Absolute.	Per cent.	Absolute.	Per cent.
British . .	316	41·4	177	22·8	201	37·2
Germanic . .	309	40·4	294	39·6	212	39·3
Slavonic . .	16	2·1	166	22·3	47	8·7
Latin . .	37	4·8	48	6·5	53	9·8
Hebrew . .	63	8·3	48	6·5	9	1·7
North American	23	3·0	10	1·3	18	3·4
Totals . .	764	100·0	743	100·0	540	100·0

As was to be expected, the different racial groups are not identical in drinking habits. But the differences in racial distribution of the heavy drinking group, as compared with the total abstainer group, cannot possibly account for the differences in mortality between these two groups. One has but to examine the percentage columns to realise this fact. The moderate group differs from the other two chiefly in the direction of a deficiency of British and an excess of Slavonic stocks. In the social stratum within which we are here operating, these figures accord well with what one would expect. American working men and their wives, several generations in this country and of generally British stock, which in Baltimore includes many Irish, are somewhat more likely to be either total abstainers or heavy drinkers, than they are to be temperate consumers. Recent Slavonic immigrants, whose families have not been in America more than two generations at the outside, and mostly a much shorter period, still retain old-world habits of moderate drinking.

We may summarise the results of this section of our inquiry as follows : *Critically collected material appears to demonstrate that heavy or steady drinking of alcoholic beverages significantly shortens the average duration of life, but gives no evidence whatever that the moderate and occasional use of such beverages leads to any different duration of life than that associated with complete abstention from alcohol.*

C. *Heron's Study of Chronic Inebriates*

A number of highly important studies of various problems of alcoholism have come from the Francis Galton Laboratory for National Eugenics of the University of London (cf. Elderton and Pearson, 1910 ; Pearson and Elderton, 1910 ; Barrington, Pearson, and Heron, 1910 ; Heron, 1912).[1] Of these the only one of particular importance to the present discussion is that of Heron.

Heron undertook a thorough statistical analysis of data regarding 865 female inebriates, committed to Inebriate

[1] The memoirs cited contain, in the main, the original contributions of these workers to the problems of alcoholism. In addition there have appeared in the *Question of the Day and Fray* series several papers answering criticisms of the memoirs.

Reformatories, between 1st January, 1907, and 31st December, 1909, the original data having been published by Branthwaite, 1911, in his annual report. Each of the 865 women dealt with was a heavy consumer of alcohol, in fact an "extreme inebriate" in the literal sense of the words, as indicated by the facts: (1) That they were committed to an Inebriate Reformatory; (2) that they had, on the average, been convicted twenty-four times before for drunkenness, and (3) had a history on admittance of an average of 12·1 years prior duration of alcoholism. These women, in short, fall evidently and distinctly into the same class, in respect of alcohol consumption, and were quite certainly on the average much greater consumers than those in my "heavy or steady" class.

One section of Heron's memoir (pp. 17–25) is devoted to the discussion of disease and mortality among these extreme inebriates. He shows, first, that these women were distributed as follows, relative to diseased conditions, on the basis of careful physical examination:

No organic disease	519	= 60	per cent
General debility	152	= 18	,,
Heart disease	73	= 8	,,
Syphilis	33	= 4	,,
"Other causes" (including 16 bronchitis, 10 cancer, 6 phthisis) . . .	88	= 10	,,
Total	865	= 100	,,

That 78 per cent of these drunkards, with an average alcoholic history for the whole group of 12·1 years, should exhibit no definite organic disease, when carefully examined by competent medical men, is an astonishing finding, and leads Heron to a more particular examination of the matter. He first attempts a comparison of the general death-rate among women committed to Inebriate Reformatories as compared with the general population of women. Taking the whole experience of the Reformatories, which includes 2767 women under observation 2½ years, he finds actually 39 deaths against 76·7 deaths which would be expected if these women had had the same death-rate as the general population. Believing that inebriates come, in general, from particular classes of population, he attempts a comparison on the assumption that the class from which the female inebriates are chiefly drawn bears the same relationship to the total female population as do general labourers to the total male population. On this basis there would be expected 171 deaths from 2767 inebriates in 2½ years. Actually, as before mentioned, there were but 39. More precise data from one Reformatory (Langho) gives 13 actual deaths from all causes against 12·5 expected.

By the same method of calculation the mortality from cancer and phthisis was investigated. Assuming the same death-rate as in the general population there would be expected in 2767 women under observation 2½ years 7·9 deaths from cancer and 12·9 from phthisis. Assuming as before that the class from which the female inebriates are drawn bears the same relationship to the total female population as general labourers do to the total male population, the expected deaths from cancer would be 14·9 and from phthisis 34·1. The actual deaths in the experience were 10 from cancer and 6 from phthisis.

One point of detail which Heron notes is that since Inebriate Reformatories were started in England there have been seen but two "very doubtful" cases of cirrhosis of the liver. This is interesting in connection with the well-known difficulty, if not impossibility, of inducing cirrhosis of the liver in experimental chronic alcoholism. Welch, 1903, says: "Genuine cirrhosis of the liver has not been satisfactorily reproduced by the experimental use of alcohol." Formad, 1886, found it in only 6 out of 250 autopsies of confirmed drunkards who had died from the effects of alcoholism.

The general result of Heron's treatment of Branthwaite's data, then, is, so far as concerns mortality, to indicate that, on the whole, the mortality rate among these extreme inebriates is certainly no greater than that prevailing among the classes of the general population from which they are drawn, and perhaps is considerably smaller. What shall we say of this result, which stands in such sharp apparent contradiction to the results of other studies, even the most critical? Do Heron's results represent the real truth of the matter? Or is there something overlooked, which invalidates them?

I think there is a factor not taken account of, that may be of great importance in the interpretation of the result. It may be put in this way: To what extent are Heron's 865 inebriates the end product of a stringent process of alcoholic natural selection? May they not have survived long and excessive addiction to be committed to a Reformatory only because of the inborn possession of an unusual physical constitution, capable of withstanding without marked harm a deleterious agent which long before eliminated their constitutionally less well-endowed sisters? Heron recognises this possibility, but his statement (p. 19): "To test this point completely we should require the complete alcoholic histories of a number of women from the onset of alcoholism, but in the absence of such data it may be said that an average duration of alcoholism of twelve years lends little support to such a view," obviously does not settle the matter. Unfortunately I have no data of my own to settle the question with, and offer the above remarks in no sense as a criticism of Heron's results on mortality. I merely wish to point out that until the selection question *is* settled, they cannot be accepted at their face value.

Before leaving this work it should be pointed out that these data from extreme inebriates agree, in their showing about mortality, precisely with the experimental results with fowls and guinea-pigs cited in an earlier section. Without wishing to stress this agreement at all, I believe that it should not be overlooked in any final summing up of the evidence on a difficult problem.

V. Indirect Evidence

We come now to the consideration of sundry ingenious attempts which have been made to find out what was the effect of the drinking of alcoholic beverages upon the duration of human life, by means of utilising data only indirectly or imperfectly bearing upon the case. As would be expected *a priori*, and will be seen to be the fact *a posteriori*, this evidence is much less satisfactory from the standpoint at least of an objective scientific effort to get at the truth of the matter, than even the small amount of direct and pertinent evidence which exists, and which I have reviewed in what has preceded. Nevertheless it is, curiously enough, this indirect and inferential evidence which forms the great bulk of the literature on the phase of the alcohol problem with which we are here dealing, and which has constituted the working stock in trade of propagandists for prohibition. Before beginning its detailed consideration, let me say, once and for all, that, in my opinion, much of this indirect and inferential evidence is interesting, is potentially significant, and must be taken account of in any scientific discussion of the problem of alcohol and mortality. But, from the standpoint of cold-blooded scientific objectivity—the single-minded desire to get at the truth regardless of what the moral, social, economic or other consequences or implications of that truth may be, in supposition or in fact—the trouble with all this indirect evidence on alcohol and mortality is that from its inherent character it cannot possibly prove anything, no matter how much it may be multiplied in amount. It merely suggests or implies what may be so. It has been repeatedly put forward by interested reformers, as completely probative, indeed to an extent that it is now generally so accepted by the public mind. But, in plain fact, it is only suggestive, not probative, and quite certainly in some cases suggests a wrong rather than a right conclusion.

A. *The Opinions of Physicians as to the Influence of Alcohol upon Mortality*

There are two contributions worthy of consideration which have attempted to estimate the proportion of all mortality which may be attributed to the effect of alcohol, by collecting the opinion of physicians on this point. The first of these is the Report of the Committee of the Harveian Society (see Stewart, H. C., *et al.*, 1883), and the second a memoir by E. B. Phelps, 1911.

The Harveian Society's report included 10,000 deaths, classified as follows:

A. Deaths in nowise due to alcohol . .	8598
B. Deaths accelerated or partly caused by its abuse	1005
C. Deaths wholly due to it	397

The report concludes that of the 10,000 deaths there were "as nearly as possible 14 per cent in the causation of which alcohol appears to have played some part."

Phelps' investigation was much more carefully planned and carried out. He took a copy of the 9th Annual Report of the Bureau of the Census of the United States containing the mortality statistics of the year 1908 in the Registration Area, and got a medical director of one of the leading life insurance companies to check off each cause of death "therein listed in the case of which, in his judgment, any male deaths between the ages of twenty and seventy-four, inclusive, could possible have been due in whole or in part to alcohol." There resulted 106 causes selected out of the whole list. Then a jury of physicians was appointed, consisting of Dr. Brandreth Symonds, Chief Medical Director of the Mutual Life Insurance Company of New York; Dr. Eugene L. Fisk, Medical Director of the Postal Life Insurance Company, and for many years Medical Director of the Provident Savings Life Assurance Society, which was absorbed by the Postal Life; and Dr. William L. Gahagan, Medical Director of the United States Casualty Company. All three of these physicans had more or less private and hospital practice prior to assuming the named positions, all of them had written and published various papers or books on medical subjects, and all of them had given especial attention to the relations of alcohol and mortality. These three men were asked to state independently their personal estimates of the percentage of male deaths from each of these causes, between ages twenty and seventy-four, inclusive, directly or indirectly due to alcohol.

The results of applying the average percentages obtained from these three medical directors to the total male mortality are shown in Table XIV.

Phelps, then, endeavours to work his figures over to a basis comparable to the Harveian Society results, by making allowances for females, etc. He finally reaches a figure of 11·2 per cent as against the Harveian figure of 14 per cent of a generation earlier, and concludes that there has probably been a real diminution in the period in the mortality attributable to alcohol.

In my opinion little weight can be attached to the results

TABLE XIV

A Recapitulation of the total number, and number between ages twenty and seventy-four, inclusive, of male deaths in the Registration Area of the United States in 1908 *from each of the* 106 *causes ; the number of male deaths between ages twenty and seventy-four, inclusive, from these causes directly or indirectly due to alcohol on the basis of the average percentage estimates of the medical directors of three leading insurance companies ; and the ratios of these deaths to* (1) *the total number of male deaths at all ages from these causes and* (2) *to the number of male deaths between ages twenty and seventy-four, inclusive, from these causes.*

Causes of death in each group.	Three groups of Deaths from causes in which alcohol may have been principal causative factor, or contributory factor.	Total Male Deaths from these causes.		Male Deaths between ages 20–74 inclusive, presumably due directly or indirectly to alcohol.		
		At all ages.	Between ages 20–74 inclusive.	Number.	Ratio to Male Deaths. At all ages.	Ratio to Male Deaths. Between ages 20–74 inclusive.
28	Causes of death in the case of which alcohol may have been an important contributory factor, and sometimes the principal causative factor .	107,586	73,747	18,337	17·0	24·9
48	Causes of death in the case of which alcohol may have been a minor contributory cause, or at least a distinctly disturbing factor . . .	174,244	107,422	13,664	7·8	12·7
30	Causes of death in the case of which alcohol was not primary or secondary cause, but may have been a harmful contributory factor . . .	38,300	17,689	852	2·2	4·8
106	Causes of death .	320,130	198,858	32,853	10·3	16·5

of these two investigations (and still less to the British Medical Association Committee's Inquiry in 1885–1886, reported by Isambard Owen, 1888). My chief reasons for this view are:

1. What these inquiries really estimate is *not* the true point at issue, namely the effect of alcohol upon the incidence of mortality or morbidity, but rather in an indirect and very rough way, the relative prevalence of different drinking habits in the community. This is clearly and overtly the case in the Harveian Society inquiry, and in somewhat camouflaged form is just as inherent in Phelps' study.

2. Physicians' estimates of the percentage of deaths from any particular cause or from all causes due to alcohol, are simply a rough measure of medical ignorance, in any scientific sense, of the effects of alcohol upon the living organism. Take the plainest case: one of Phelps' jury estimated 80 per cent and another 90 per cent of all deaths from cirrhosis of the liver to be due to alcohol. But if anyone will take the trouble to study the existing literature with some care, he is bound, I think, to have the gravest doubt as to the real significance of alcohol in the etiology of this disease. The fact is that, in the first place, cirrhosis of the liver can be produced experimentally with alcohol only in the rarest of instances, and, in the second place, extreme and chronic inebriates only rarely exhibit at autopsy cirrhosis of the liver. Phelps' third member of the jury estimated 30 per cent of deaths from this cause to be attributable to alcohol. Which one of the three was right? In the present state of our ignorance I submit that no one can say. The average of the three estimates was 66·7 per cent. Does this average represent a scientific truth—a measurement? To ask the question is to reveal the absurdity of the whole case. If the public wants a *scientific* determination of the effect of alcohol upon mortality this surely is not the route to its attainment.

B. Statistical Comparisons of Alcohol Consumption and Death-rate

The idea must have occurred to many statisticians to compare the consumption of alcohol per head of population with the death-rate of the same population, either on the basis of different countries or cities, or on the basis of different times. Figure 5 shows such a comparison, on a time base, between (*a*) consumption of alcoholic beverages, reduced to an absolute alcohol basis, per head of population in gallons, from 1880 to 1918 inclusive, and (*b*) crude annual death-rate from all causes per one hundred population in the Registration Area of the United States between the same dates, except that prior to 1900 the mortality figures are available only at decennial intervals.

The diagram is plotted on an arithlog scale in order that slopes may be directly comparable.

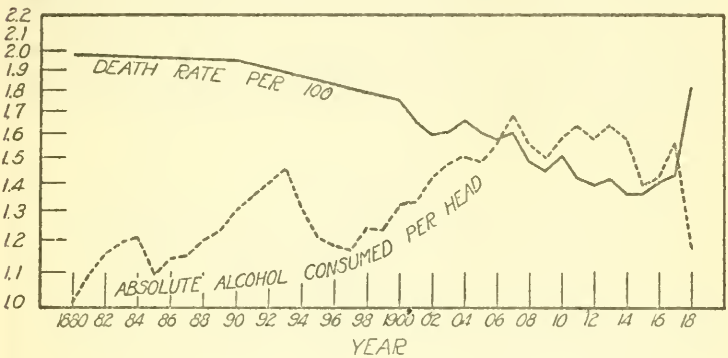

Fig. 5. Comparison of consumption of absolute alcohol per head of population, and crude death-rate per 100 population in the United States Registration Area.

This diagram is rather striking, and at a first quite uncritical appraisement might seem to be filled with significance of a sort likely to be discomforting to the prohibitionist. Up to about 1906 the consumption of alcohol steadily rose, and the death-rate just as definitely declined. From 1906 on till the epidemic year, 1918, the two curves ran a course suggesting, but not very closely fulfilling, a condition of parallelism. In 1918 the alcohol consumption abruptly dropped, as a result of war-time prohibition, and the mortality rate shot up, as a result of the influenza pandemic. This last year really exposes beautifully the essential weakness, from a scientific view-point, of all such crude statistical comparisons as these. In this particular year we *know* definitely why the two curves took the course they did, and we know, furthermore, that unless one is prepared to maintain that war-time prohibitory legislation was the cause of the influenza epidemic, or on the other hand, that the epidemic was the cause of the statutes (passed, by the way, some time before the outbreak of the influenza), he will be forced to the conclusion that there is no causal connection between the movements of alcohol consumption and mortality in this particular year.

An ingenious study of this phase of the problem on an international basis was presented a few years ago by the distinguished Danish statistician and actuary, Arne Fisher (1916). He determined the correlation between consumption of alcohol per head and the male mortality rate. His data are given in Table XV, and the correlation coefficients deduced from them in Table XVI.

TABLE XV

Consumption in Liters per head of 50 per cent Spirits and Beer, and the Mortality Rates of twelve countries.

50 % Alcohol.	Beer.	Male Mortality per 100,000 of Population by Age.							Country.
Liters.	Liters.	25	30	35	40	45	50	55	
1·02	2·0	676	673	716	850	1056	1364	1877	Italy
2·31	7·8	710	710	760	910	1130	1460	1980	Finland
2·87	33·0	887	770	737	713	916	1096	1446	Norway
3·97	43·9	372	422	525	685	830	1101	1542	New Zealand
4·07	55·6	448	519	633	816	1083	1395	1816	Australia
4·17	121·6	454	566	732	931	1233	1657	2308	Great Britain
5·51	79·6	645	754	901	1053	1277	1585	2095	United States
6·89	47·8	628	604	637	757	925	1124	1526	Sweden
7·12	101·3	513	556	697	922	1244	1693	2357	Germany
7·16	29·4	492	475	537	679	898	1177	1686	Netherlands
8·82	40·0	752	786	842	1104	1363	1701	2153	France
10·44	84·0	404	447	528	689	938	1187	1707	Denmark

It will be noted that all the correlations are insignificant, having regard to their probable errors. For the earlier ages the coefficients are negative and of higher values than the remainder. If these figures could be taken at their face value they would indicate that mortality prior to age thirty-five or forty tends to be lower the higher the consumption of alcohol per head of population.

Again, however, it is my opinion that all such studies of these can have but little real scientific value in the elucidation of our problem. Statistical comparisons between alcohol consumption per head and death-rate, however skilfully dressed up mathematically, leave out of consideration so many important factors of the problem as to make their results of, at best, no more than suggestive value. Before such correlations as those of Fisher could begin to approach

TABLE XVI

Correlation Coefficients calculated from the Data of Table XV.

Ages.	50 % Spirits.	Beers.
	$r =$	$r =$
25	$-\cdot3012 \pm \cdot2624$	$-\cdot5447 \pm \cdot2029$
30	$-\cdot2704 \pm \cdot2726$	$-\cdot3344 \pm \cdot2564$
35	$-\cdot1080 \pm \cdot2852$	$+\cdot0421 \pm \cdot2881$
40	$+\cdot0080 \pm \cdot2884$	$+\cdot1844 \pm \cdot2788$
45	$+\cdot0982 \pm \cdot2858$	$+\cdot1717 \pm \cdot2800$
50	$+\cdot0654 \pm \cdot2875$	$+\cdot1155 \pm \cdot2846$
55	$+\cdot0298 \pm \cdot2884$	$+\cdot0264 \pm \cdot2884$

probative significance, the material would have to be corrected for racial and occupational influence on mortality, to mention only the most obvious defects. The same considerations apply to graphical comparisons like the one presented in Fig. 5. What such comparisons *suggest* is that if a properly critical statistical study, by the method of partial correlation, could be made, it would probably show that there is no significant correlation between the alcohol consumption of a population and its death-rate, when other pertinent variables are held constant. This is only another way of saying that all the existing evidence indicates that other factors are vastly more important than alcohol in determining the magnitude of the death-rate of any large population aggregate under present conditions of existence.

C. Occupational Mortality

It has been repeatedly shown by many students (cf. Farr, 1885; Guttstadt, 1904; Bl., H., 1905; Medico-Actuarial, Hunter, 1914, 1914a, and b, 1915; Denchar, Sprague, and Low, 1897; Neison, 1872; Stott, 1876, etc.) that publicans and persons engaged in the liquor trades, both of manufacture and wholesale and retail distribution, tend to have higher rates of mortality than persons in various other occupations. This fact has been interpreted to mean, first, that persons engaged in these occupations are, in general, excessive consumers of alcoholic drinks, and second, that their higher mortality is a result of the consumption of alcohol in excess. The papers cited cover English, America, Scottish, and German experience. Anyone interested can find the detailed evidence in these papers. I shall not present any of it here because of limitation of space, and because none of it has any significant bearing upon our problem, for the following reasons:

1. No account is taken of the other hazards inherent in these occupations except that of drinking alcoholic beverages. Before one can accept these figures as demonstrating anything about the effect of alcohol *per se* upon mortality, he would want some evidence as to the mortality of *abstaining* inn-keepers, brewery employees, etc. No such evidence is forthcoming.

2. No account is taken of the occupational selection factor involved. Do persons engaged in the liquor trades tend to come from stocks which constitutionally are poor insurance risks? There is some indirect evidence that they do. In so far as this is the case, alcohol has nothing to do with their higher mortality rate.

3. The material is widely heterogeneous in respect of drinking habits. These occupations do not represent a homogeneous group of excessive drinkers.

Altogether this occupational mortality evidence has about as little truly scientific bearing upon the question of the effect of alcohol upon mortality as any which could be found. No critical person could possibly accept it at its face value.

D. The Experience of Insurance Companies

We come now to the consideration of the rather extensive literature derived from the experience of life insurance companies regarding the influence of alcohol upon mortality. This literature may be divided into two moieties: on the one hand, those papers which make a definite original contribution to the evidence, of which there are comparatively few; and, on the other hand, those papers, of which there are a great many, which are essentially propagandist preachments based, for such facts as they contain, upon the original papers of our first group. A sufficient sample of this class of literature to satisfy, I think, even the most greedy will be found in the following list: Tiffany; Burns, 1864; Wey, 1875; Drysdale, 1887; Bentham, 1890, Whyte, 1895–1896; Webster, 1899; Crothers, 1904; Millman, 1905; Eccles, 1907; McMahon, 1907; Hamilton, 1907; Jacquet, 1912; Crothers, 1914; Hunter, 1914 and 1915. Taken as a lot, this class of literature is quite uncritical. It was, in the main, written for purposes of prohibition propaganda, and has served that purpose well.

Turning to the scientifically more satisfying first class, we have as the first important original contribution Neison's, 1889, analysis of the mortality and morbidity experience of the Order of Rechabites from 1878–1887. His results and conclusions have been excellently summarised in the report of the Advisory Committee of the Central Control Board (Liquor Traffic), 1918 (pp. 122–123), and may be here quoted from that source:

> "Comparing the Rechabites (a society of total abstainers) with the Oddfellows and Foresters, a difference very similar to that found in the experience of the United Kingdom Temperance and General Provident Institution is seen. The Rechabites had only 69 per cent of the deaths calculated on the basis of the Foresters' experience, and their expectation of life at age 30 was more than 4 years longer than that of the Foresters. This comparison, however, probably overstates the advantage, as the Rechabites' statistics cover the period 1878–1888, while the Foresters' data were for 1871–1875 and the Oddfellows' 1866–1870.

With regard to sickness the average weeks of sickness claim per member were higher among the Rechabites up to age groups 40–50, but lower for ages 50–60 and 60–70 than in the non-abstaining societies. The average numbers of weeks of sickness, not per member, but per member sick, were about the same among Foresters and Rechabites, and the actuary concluded that the higher general rates at earlier ages among the Rechabites were due to less perfect medical examination at entrance, his reason being that new entrants shewed a much higher percentage of sickness claims than members of the same age, but longer standing in the society. This, which is contrary to the usual experience of Friendly Societies, pointed, in his opinion, to less careful selection of entrants."

It was pointed out in the same place (p. 123) that these observations are subject to certain obvious criticisms. Again we may quote :

"(1) The Rechabites were a very much smaller society than either of the non-abstaining societies ; both the Oddfellows and the Foresters' statistics covered in each case more than ten times as many years of life and more than fifteen times as many deaths, as the Rechabites, while the comparison does not relate to the same calendar years. (2) Both occupational and geographical distribution may be important factors of mortality, especially in industrial populations, and neither could be analysed."

Of more recent investigations of insurance data there are four which warrant particular examination. They are the papers of Moore, 1904 ; Medico-Actuarial Investigation, 1914 ; Phelps, 1915 ; and Porter, 1915.

Moore analysed the experience, over a period of sixty years, of the United Kingdom Temperance and General Provident Institution. This company has operated in two sections, a Temperance and a General. The basis of the division is described by Moore as follows :

"Persons are eligible for the Temperance Section who do not take alcohol as a beverage in any form. The continued adherence of the assured to the principles of

Abstinence is checked by an annual declaration to that effect. Such persons are described throughout this paper as 'Abstainers,' 'Temperance Lives,' or 'Teetotalers.' Persons who do not come within these conditions are eligible for the 'General Section' only, and are herein described as 'Non-abstainers.' If an Abstainer cease to abstain he is transferred to the General Section, and, on the other hand, policy holders in the General Section who become Abstainers are generally eligible for transfer to the Temperance Section."

As the most simple and striking way of presenting the net results of Moore's detailed and technical analysis, I have chosen the function of expectation of life (which means the average after-lifetime) at several ages as shown in Table XVII (from Moore's Table XXII, p. 247), the non-abstainer figure being the combined experience of twenty-three British companies.

TABLE XVII

Expectation of Life of Male Abstainers and Non-abstainers.
(Moore.)

Ages.	Expectation of life.	
	T^M	O^M
(1)	(2)	(4)
10	55·021	51·459
15	50·973	47·323
20	46·949	43·182
25	42·967	39·083
30	38·827	35·067
35	34·595	31·159
40	30·328	27·360
45	26·100	23·668
50	22·016	20·107
55	18·130	16·722
60	14·554	13·571
65	11·338	10·716
70	8·491	8·208

It will be seen that throughout the abstainers enjoyed the greater expectation of life. The same is true, but to an insignificant extent, of female lives, but the experience is much smaller. It is also true for those holding endowment policies.

The Medico-Mortality Investigation of forty-three American and Canadian insurance companies presented several sorts of data, of a somewhat fragmentary character.

In general it was found, in all the comparisons made, that there was an excess mortality associated with alcohol consumption. But it should also be noted that the experience was extremely small.

Porter's paper deals with the 1907–1912 experience of the Mutual Life Insurance Company of New York, classifying certain occupational groups of males according to drinking habits, *as stated at the time of application for the policy.* The results are shown in Table XVIII.

TABLE XVIII

Mutual Life of New York Experience, 1907–1912.

On Application.

	Exposure.	Deaths.		Ratio.
		Actual.	Expected.	
Class 224—Indoor Clerical Service				
Total class	39·657	90	192·110	46·9
Total abstainer . . .	16·979	37	76·816	48·1
Temperate	19·926	44	99·790	44·0
Moderate	2·752	9	15·504	58·1
Class 226—Merchants and Dealers				
Total class	58·090	243	389·150	62·5
Total abstainer . . .	16·565	42	104·400	40·2
Temperate	34·616	163	236·324	69·1
Moderate	6·909	38	48·426	78·7
Class 229—Salesmen (not in Liquor Business)				
Total class	32·157	97	159·918	60·6
Total abstainer . . .	11·443	30	52·144	57·6
Temperate	17·985	55	93·256	58·9
Moderate	2·729	12	14·518	82·7

	Exposure.	Deaths.		Ratio.
		Actual.	Expected.	
Class 233—Farmers				
Total class	65·399	243	374·109	64·9
Total abstainer . . .	32·026	103	170·966	60·3
Temperate	32·315	133	196·122	67·8
Moderate	1·058	7	7·021	99·4
Class 240—Factories and Mills Proprietors, Managers, and Superintendents				
Total class	15·718	76	114·365	66·4
Total abstainer . . .	3·651	17	26·014	65·5
Temperate	10·133	53	74·645	71·0
Moderate	1·934	6	13·706	43·7
Total classes 224, 226, 229, 233, 240 combined				
Total class	211·021	749	1229·652	60·9
Total abstainer . . .	80·664	229	430·340	53·4
Temperate	114·975	448	700·137	64·1
Moderate	15·382	72	99·175	72·7
Total non-abstainer . . .	130·357	520	799·312	65·0

It should be noted that the ratio figures of actual to expected mortality are not directly comparable between different investigations. The value of this ratio depends upon the number of "expected" deaths, which in turn depends upon the particular life table used in making this calculation.

Comparing the ratios of actual to expected deaths of Table XVII *inter se*, as is legitimate, it will be seen that the supposed abstainers exhibit a lower death ratio than the supposed non-abstainers at all ages, and in practically all groups, amounting in the total to 11·6 points.

Phelps presented, in 1915, a tabulation of the experience of the North-Western Mutual Life, made by the actuaries of the company itself. The table is here reproduced as

Table XIX. Unfortunately the mortality ratio is figured on the basis of monetary loss, involving therefore not only mortality *per se*, but the amounts of the several policies as well. It has, however, been repeatedly shown that, if the whole experience is large, the error involved in this procedure is negligible.

TABLE XIX

Mortality experience of the North-Western Mutual Life Insurance Company on Abstainers and Non-abstainers for the year 1886 *to* 1895, *inclusive, figures to the end of* 1900.

A = Abstainers; B = Beer or Wine Drinkers; D = Whisky Drinkers and a few large users of Beer or Wine.

	No. of Policies.	No. of Deaths.	Expected Death Loss.	Actual Death Loss.	Per cent of Expected Death Loss.
			Ages 15 to 29		
A	47,293	1,298	$4,616,350	$2,321,656	50·29
B	17,156	512	2,063,651	1,204,635	58·37
D	3,977	140	630,643	378,449	60·01
			Ages 30 to 39		
A	38,841	1,255	$5,755,681	$2,824,570	49·07
B	17,177	598	3,336,726	1,614,659	48·39
D	7,363	296	1,804,842	1,073,242	59·46
			Ages 40 to 49		
A	15,802	830	$4,351,042	$2,212,873	50·86
B	6,838	405	2,546,517	1,391,599	54·65
D	3,952	285	1,845,384	1,157,160	62·71
			Ages 50 to 59		
A	4,315	497	$2,518,685	$1,700,857	67·53
B	1,800	231	1,412,400	809,215	57·29
D	1,242	193	1,196,951	1,053,429	88·01
			Ages 60 to 69		
A	541	130	$667,418	$432,213	64·76
B	227	51	323,072	242,244	74·98
D	151	34	292,204	195,026	66·74

	No. of Policies.	No. of Deaths.	Expected Death Loss.	Actual Death Loss.	Per cent of Expected Death Loss.
			Ages 70 and upward (full paid under their new numbers)		
A	16	14	$12,953	$24,842	191·79
B	2	1	200	94	47·00
D	1	0	483	0	0·00
			Total—All ages		
A	106,808	4,024	$17,922,129	$9,517,011	53·10
B	43,200	1,798	9,682,566	5,262,446	54·35
D	16,686	948	5,770,607	3,857,306	66·84

Mortality Experience with Non-Abstainers.

Class B.	Policies.	Deaths.	Expected Loss.	Actual Loss.	Per cent.
Under age 40 .	34,333	1,110	$5,400,377	$2,819,294	52·21
Age 40 and over	8,867	688	4,282,189	2,443,152	57·05
Total .	43,200	1,798	$9,682,566	$5,262,446	54·35
Class D.					
Under age 40 .	11,340	436	$2,435,585	$1,451,691	59·60
Age 40 and over	5,346	512	3,335,022	2,405,615	72·13
Total .	16,686	948	$5,770,607	$3,857,306	66·84

These figures indicate that the supposed wine and beer drinkers had substantially the same mortality as the supposed total abstainers, while both were well below the supposed whisky drinkers. In so far as any insurance figures have scientific meaning as to the alcoholic habits of the insured (which, in my opinion, is not far) the beer and wine group of this North-Western tabulation may be supposed to be moderate drinkers, in the usual sense of the words, and Class D heavy drinkers. Phelps is strongly of this opinion, but as we shall presently see, we are here on very shaky ground. If we do accept this classification, the North-Western results agree with my specially collected material presented in an earlier section.

Results similar in sense to those cited above have been shown by the experience of the following insurance companies among others: Sceptre Life, British Empire Mutual, Abstainers and General Office, Scottish Temperance Office, Scottish Imperial Office, Sun Life, etc.

Up to this point I have presented, without critical comment, the results of the more important investigations of the experience of insurance companies. It now becomes necessary to ask what valuation is to be put upon the results, from our present standpoint, which is to determine with scientific accuracy what the effect of the consumption of alcoholic beverages is upon mortality and the duration of human life. In 1917 I said (Pearl, 1917b, p. 169):

> "There is a widespread popular opinion that life insurance statistics have 'proved' that even the most moderate use of alcohol definitely and measurably shortens human life. In common, as I suppose, with most persons who have made no special personal investigation of the original literature on the subject, I had supposed this statement to be true. . . . My curiosity was aroused to examine critically the actuarial evidence. The results were somewhat astonishing. The evidence on which the current statements are based would not be accepted by anyone trained in the critical valuation of statistical and biological evidence as 'proving' anything."

A complete re-examination of this literature five years later has only served to strengthen the conviction I then expressed. I shall briefly present my reasons for this conviction. I shall not review here the many technical actuarial criticisms of this work which have been published, but merely refer the reader to such papers as those of Andrae,[1] Westergaard, and Phelps, 1913a, where these matters are thoroughly treated.

The broad grounds for rejecting this material for the *scientific* study of our problem, whatever their practical value to insurance companies in the rejection of risks may be, appear to me to be these:

1. There is no definite knowledge of the alcoholic habits of the individual over any significant portion of his life. The only knowledge an insurance company has of an individual

[1] Berichte d. 5ten. Internat. Kong. f. Versicherungs-Wiss. 1906. p. 401.

is (*a*) the statements of the individual himself when he applies for a policy; (*b*) the continuance of his life evidenced by payment of premiums, and (*c*) his death, as evidenced by a claim under the policy contract. Now granting that every applicant told the truth when he applied, the picture of his alcoholic habits then set down is, and can be, only of that time and the immediate past. But nothing is more certain than that the drinking habits of many individuals change from what they were at the comparatively early age at which insurance was applied for. These habits may and do change in both directions. Some persons become heavier drinkers, others less heavy, than when they applied for insurance. So then, in fact, it may be taken to be the case that in the non-abstainers section of insurance experience such as we have cited, there is a mixture, in wholly unknown proportions of (*a*) persons who, for the major portions of their lives, have been total abstainers; (*b*) moderate drinkers; (*c*) excessive drinkers. There will also be the same three classes, again in quite unknown proportions, represented in the abstainers' class in the experience of all companies except those, like the United Kingdom Temperance and General Provident, which require an annual statement from the policy holder as to his continued abstention.

2. Since most insurance companies are known to discriminate against persons using alcohol as a beverage in more than a certain (to the applicant unknown) amount or degree, an incentive is at once created for the applicant to understate the amount of his alcoholic indulgence. The discrimination may take the form of refusal to accept the risk, or an increased premium rate, or a reduced participation in so-called bonuses or dividends. But in either case there is a powerful incentive for the applicant to make out as favourable a case as possible for himself.

To those of my readers who have any acquaintance with the canons of experimental laboratory procedure, I can make the force of my criticisms of the insurance data plain, I think, by the following illustration:

Suppose an experimenter, wishing to determine the effect of the typhoid bacillus upon longevity, fed a varying and unknown amount of a culture of varying and unknown concentration of typhoid bacilli to a number of animals of varying and unknown hereditary constitutions and innate degrees of immunity to typhoid, and then shut them up in a room with free and unlimited access to cultures of typhoid germs, and made no further observations upon them whatever, except of the time of their death. What would be the scientific value of any deductions made from such an experiment? Yet in all essentials such a procedure would yield data of *precisely the same value* as those gained from the experience of life insurance companies regarding the influence of alcohol upon human longevity.

VI. Conclusions

The purpose of this paper has been solely to evaluate critically and from a purely objective scientific point of view the existing evidence as to the effect of the use of alcohol as a beverage upon the duration of human life and mortality. So far as this discussion is concerned no moral or social values are involved.

From this standpoint the conclusions which may safely be reached in the present state of our knowledge seem to me to be plain. They are:

1. The weight of the pertinent and critically significant evidence indicates that the consumption of alcoholic beverages up to an amount and frequency which in common parlance is called moderate (the precise measure of this amount and frequency probably varying to some extent with each individual) does not sensibly shorten the mean duration of life or increase the rate of mortality, as compared with that enjoyed by total abstainers from alcohol. This conclusion is a *statistical* one. It may or may not be true for any particular single individual.

2. The weight of the pertinent and significant evidence further indicates that the excessive use of alcohol as a beverage definitely diminishes the mean duration of life and increases the rate of mortality. In view, however, of the experimental results on the subject, and the experience with chronic inebriates, there is need for further critical study to determine to what extent the *statistical* experience of greater mortality among the intemperate is due to a direct pathological effect of the alcohol upon the tissues of the

body, and to what extent it is due to an indirect effect through alterations of behaviour, etc.

To some these conclusions will perhaps appear devoid of significance, because of their lack of novelty. It will perhaps be said that they simply restate what has been the common-sense conclusion of unprejudiced persons who have, in a general way, made an unbiased review of human experience with alcohol. All this cannot be gainsaid. But it would seem to be of some significance that one finds that a critical and strictly objective examination of such scientific evidence as exists regarding the matter leads to the same conclusion that common sense has reached.

The responsibility for any deductions from these conclusions as to the practical conduct of life must rest with the reader.

VII. Literature

The following list of bibliographical citations makes no pretence of completeness. It represents merely those treatises, out of a welter of literature, the great bulk of which is wholly devoid of any scientific value, which seem to me to be most valuable to anyone who wishes to inform himself about the subject. Doubtless I have omitted some titles which other workers would esteem more valuable than those I have given. This cannot be helped. But if anyone will read the memoirs and books here listed, he will, at the end of the process, be quite able to pursue any further literary researches in the field, without the need of extraneous guidance. I have myself felt obliged to read, I regret to say, a great deal more of the literature on alcohol than appears in the present bibliography.

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INDEX

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