CHAPTER X

FOOD AND THE ACID-ALKALI BALANCE OF THE BODY

IN ADDITION to their caloric, vitamin and mineral value which we have just discussed, foods exert an acid, alkaline or neutral effect in the body. But before we consider this aspect of nutrition, we should pause to explain what acid and alkaline signify with reference to the tissues of the body. Probably no phase of nutrition or bodily functioning is so misunderstood, thanks to the advertising of "alkaline" foods, cathartics, saline beverages and a host of remedies for "colds" and other common illnesses. We are commanded to "alkalize our systems", prevent colds by alkalizing, we are threatened with acidity if we don't change our brand of cigarettes and fair promises of beauty, vitality, popularity, husbands and phenomenal—really miraculous—business careers are promised us if we but alkalize. Small wonder we have become "acid-minded" and, having lost faith in the wonderful powers nature has given our bodies for maintaining the proper reaction, frantically seize the nearest alkalizer! Small wonder local conditions such as a "sour" stomach are mistaken for a systemic acidosis and persons have made themselves seriously ill by over-alkalizing.

One of the most remarkable powers nature has given us is the power to constantly maintain the

composition of the fluids which surround the cells of our bodies. Small chemical changes, too small for our detection, are continuously occurring and being adjusted as a part of the ordinary activity of the body. When such changes exceed certain limits, a state of disordered metabolism is set up. And this is important to remember—the changes need not be pathological, but they are always indications of the body's effort to control the situation.

Now this constant state which the body strives to maintain is a state in which there is a very fine balance between the acid and alkali of the fluids, both of the tissues and of the blood. It must be maintained in order that the living organism may carry out its various functions properly—in fact, in order that it may live.

The regulation of the balance between acid and alkali of the tissue fluids is probably one of the most delicately adjusted of the regulating processes. Yet strangely enough, until recently very little attention was given to the question of acidity or alkalinity with reference to the body fluids. Now, however, with our greater knowledge of chemistry of the body, the importance of maintaining or restoring the acid-base balance in the cure of disease is not only one of the principal objects of physiological and clinical research, but is constantly uppermost in the minds of the practicing physician and surgeon.

The ratio of acid to alkali or base is not equal—there is a slight, very slight excess of alkali. Even a moderate departure from normal may lead to serious interference with the various activities of the tissues. On the other hand, alterations in the metabolism of

the tissues themselves have a profound influence on the balance and many of the phenomena in disease are manifestations of the body's activity in preventing the reactions of its fluids. In other words, a disorder such as constipation may lead to an upset in the acid-base balance and its grave consequences, or an upset in the acid-base balance, due to dietary or other causes, may lead to constipation.

The slight excess of base or alkali over acid is known as the alkaline reserve. The alkaline reserve represents the amount of base or alkali that is available of an additional acid that may be formed or absorbed by the system. In other words, the alkaline reserve of the blood is the amount of alkali available for the transport of acid.

If, because of diet, disease or any other reason, there is an excess of alkali which the blood has not disposed of, a state of alkalosis results, that is, a state in which there is more alkali than normal. (The reaction of the blood is taken as an index of the reaction of the body in general.) When, for like reasons, the amount of alkali is less than normal, a state of acidosis results.

It is wrong to consider acidosis and alkalosis as disease entities. They are only signs or symptoms of disease, like a headache or fever. Both conditions are manifestations of the body's reactions to pathological conditions or processes. It is, therefore, of supreme importance to discover the cause of the upset and treat the cause. Masking an acid condition with so-called alkalizers or treating only the symptoms is dangerous. This is particularly true in the case of the growing child, as disturbances are more frequently encountered in childhood and the ability to overcome the

upset and establish a normal equilibrium is less perfectly developed.

To be sure, it is logical to suppose that the administration of alkali will relieve acidosis—which is the case. Under no circumstances, however, can we say such administration will cure a diseased condition—it cannot. All that can be claimed is that the acid-base balance will generally be restored to normal and that as a result the body will be able to carry on its functions with renewed vigor, thereby combating the disease with more or less success. An alkali, then is merely supportive.

Now as the tissues of the body are burned to form heat and energy, acids are formed such as carbonic and lactic acids, which are received by the blood, as well as alkalies such as sodium, potassium, calcium and magnesium. The diet, too, as we pointed out, contains varying amounts of acid and alkali. The digestive juices dispose of some of the acid (in gastric juice) and some alkali (in the bile and pancreatic juice). But the net result of catabolism, that part of metabolism concerned with the breakdown or conversion of tissue into heat and energy, is the production in the body of a great excess of acid over base.

While it is true that life can be sustained with a blood and tissue reaction more alkaline than normal, death ensues at once if the system becomes even slightly more acid than normal. In this respect the term acidosis is misleading, to say the least. It refers only to a *lesser amount of alkali:* hypo-alkalinity or alkalemia is by far more accurate, but it is not extensively used.

It is quite obvious then, that there must be some

mechanism or mechanisms for dealing with the excess formation of the acid products of metabolism, as well as excess alkali. Furthermore, provisions for the disposal of acid must be greater than the arrangements for combating an excess of alkali. This is because the products of normal metabolism—carbonic, lactic and phosphoric acids—can be used to neutralize excess alkali.

Unfortunately, excess acid cannot be similarly dealt with by the utilization of base, since practically none of the products of metabolism is alkaline in nature. Accordingly, a breakdown in the defenses against an excess of acid should be more serious than a collapse of those against an excess of alkalis. This is indeed the case. As we have said, the former is an acute condition which may cause rapid death; the latter, on the other hand, seldom endangers life.

The manner in which the acid-base balance is maintained is an extremely interesting subject as well as one of supreme importance. It is accomplished by chemical, physiological and physical means. Broadly speaking, it is accomplished by three methods—by the buffer action of the blood and tissues, by respiration and by excretion. The whole mechanism, however, is so delicately adjusted and the various processes are so interdependent, that it is necessary to take into account all defensive reactions whenever an instance of a disturbance of the acid-base equilibrium comes under consideration.

A buffer is a substance which tends to make the change in the reaction of the fluid less than it would normally be when acids or alkalies are added. The buffer salts of the body are the bicarbonate, carbonic

acid, phosphates and proteins. Proteins have both acid and alkali properties which enable them to perform a dual function: one group combines with acid, the other with alkali.

Carbonic acid, unlike other acids of metabolism, is not neutralized immediately after formation and is found in appreciable amounts in the blood. With sodium bicarbonate, free carbonic acid forms an important buffer and it is the ratio of it to bicarbonate which regulates the activity of the respiratory center and the functioning of the lungs: an increase in free carbon dioxide stimulates the lungs to greater activity. The result is that extra carbon dioxide is given off through the lungs until the ratio is normal. Inorganic phosphates are present in the blood in two forms—alkali and acid salt. These two salts are powerful buffers and act similarly to bicarbonate and can easily and readily be excreted by the kidneys.

The buffer system of the blood, even with the help of the lungs, would frequently be overwhelmed if the defense against acid accumulation ended there. Fortunately, whenever this system is overtaxed by acid, the body rids itself of the excess acid by way of the kidneys, the sweat glands and the alimentary canal, the kidneys being the most important for this purpose.

The intestines play an important rôle in the excretion of the minerals, especially calcium and phosphorus. It has not been established yet, however, whether or not they exert any other protective action in the prevention of an excess of acid or alkali. We all know, however, often to our sorrow, that in conditions in which there is a disturbance of the acid-base equilibrium, the functioning of the intestines is disturbed

with a resulting indigestion, constipation or some other disorder; and, on the other hand, a disturbance in the regular functioning of the intestine may be accompanied—and often is—with an upset in the acid-base balance.

It should not be thought that variations in the acid-base balance are all pathological. On the contrary, there are constantly occurring slight variations which are purely physiological and normal. As the healthy body is capable of adjusting these variations and restoring the balance, there are no pathological effects.

The intake of food, without reference to their acid or alkaline reaction in the body, affects the acid-base balance. About one hour after breakfast there is a rise in the bicarbonate of the blood which is the result of the loss of chlorine secreted in the gastric juice. At the same time, the urine is more alkaline. This is known as the "alkaline tide". As the food passes into the intestines and the reabsorption of the chlorine of the gastric juice is taking place, the balance is gradually restored. The alkaline tide is not so marked and may even be absent after meals taken later in the day, since it is washed by the effects of previous meals and the acids produced by muscular exercise.

In health the starches, sugars and fats are completely burned to carbon dioxide and water which are removed so quickly that no disturbance of the acid-base balance is apparent. The oxidation of proteins, however, leads to the fermentation of sulphates, so that a high protein diet has an acid effect. The amount of minerals, whether acid or alkaline in nature, influences the acid-base balance in a corresponding direc-

tion, but the excretory system is usually capable of preventing any manifest changes.

When our muscles contract and expand, lactic acid is produced. However, since a slight increase in breathing is sufficient to remove the extra carbon dioxide, formed from a part of the lactic acid, there is no obvious change in the acid-base equilibrium. This is not the case, however, if the muscular exercise is of such a vigorous nature that enough oxygen cannot be taken in to complete the oxidation of the lactic acid. Under such circumstances the bicarbonate of the blood is reduced and breathing is increased. If this is not sufficient to maintain the normal ratio between acid and alkali, the urine shows an increase in acidity and in ammonia.

The application of heat, such as a hot bath, leads to an excessive pulmonary ventilation or breathing with a consequent washing out of the free carbon dioxide and the production of alkalosis. This is just what happens when you climb a high mountain and why when you brave alpine heights you feel nauseated and vomit.

All abnormal or pathological changes in the acid-base balance are the results of an impaired functioning or overtaxing of one or more of the protective mechanisms which we have described. There are many factors responsible for such conditions. Faulty digestion (systemic acidosis is not to be confused with sour stomach), disturbed excretion, dehydration, poor respiration, ingestion of acid foods, circulatory disturbances and many other disorders may contribute to the production of an acidosis. Indeed, it is not surprising that acidosis is a common pathological state and that

enterprising commercial concerns have been capitalizing it.

The signs and symptoms depend upon the nature of the acidosis. In the gaseous type, which is rare, breathing is slow because the respiratory center is depressed and therefore requires more carbon dioxide to stimulate it. The sufferer is usually drowsy or comatose.

Of the commoner, non-gaseous type, diabetic acidosis presents the classical picture. The most distinctive symptom is "air-hunger". In severe cases breathing, that is pulmonary ventilation is greatly increased, but the increase in rate is not so marked as the increase in depth of breathing. Breathing is painless and noisy and lips are cherry-red. This is, of course, an extreme case. There are many signs and symptoms which are common to all acidotic conditions regardless of the underlying cause. Some of the earlier symptoms—and those which most of us have experienced at some time or other—are an abnormal fatigue and feeling of general lassitude, lack of appetite, breathlessness, gastro-acidity, nausea, vomiting, headache, aching in the muscles, sleepiness, a flushed face and a sweet, fruity odor of the breath.

In severe cases there is a stupor or coma. Fever is frequently present and the condition, if neglected, may present such toxicity that it resembles typhoid. Often there is considerable tenderness in the abdominal region, even suggesting appendicitis.

In all cases of acidosis, of course, alkali in some form is prescribed in order to restore the normal acid-alkali ratio. However, in the usual methods of treating hyperacidity of the gastro-intestinal tract and acidosis, the "cure" is sometimes worse than the dis-

ease. This is frequently the case when large doses of a single alkali are employed. Many authorities have drawn attention to the fact that there is a danger of setting up an imbalance among the various alkalies of the body, with the possibility of the production of an alkalosis from this procedure. And we have pointed out—this is of such importance that it cannot be repeated too often—that the alkali treatment does not cure the underlying cause of the acidotic condition, it merely relieves it, and by restoring the acid-base balance, helps the body in its fight against the disease or condition which has tended to upset the balance, as well as enabling the body to resist additional disease.

Let us take as an example, that "uncomfortable nuisance", the so-called "common cold", for we have all suffered from them—at least two good, hard common colds are the average common lot yearly of everyone in America. But, of course, it shouldn't be! There is still much dispute about the direct and underlying causes of the cold. However, research and experimentation of the past twenty years have proved quite conclusively that a "filtrable virus" is the direct cause. In other words, a cold is caused by organisms too small to be seen with the aid of a microscope and which will pass through a clay filter so fine that other microorganisms are held back.

This filtrable virus, however, is only the *direct* cause of a cold. In many instances it is well known that a cold does not begin with the respiratory tract. For a week or two one might suffer with malaise, unusual loss of sleep associated with an usual amount of dreaming, or gastro-intestinal disturbances of vari-

ous kinds — indigestion, constipation, nervousness. And throughout the time there will be no signs of respiratory trouble.

The causes which interfere with the normal functioning of the respiratory tract may be classified as local conditions, such as adenoids or enlarged tonsils; external or active influences as sudden changes in temperature, drafts, dust, etc.; and internal influences including the general state of health.

The internal influences are those which cause a disturbance of the quality and quantity of the blood supply to the upper respiratory tract. Among these are acidosis, imperfect metabolism, a diet deficient in vitamins or otherwise poorly balanced, a sudden chilling, intestinal putrefaction with a possible absorption into the blood stream of the toxins from the intestinal tract, fatigue, exhaustion and starvation. All of these lower the natural immunity of the body to bacteria and virus.

With too much rich food, especially during the week-ends and holidays, we overload our digestive organs with food material that cannot be burned up. The resulting toxic condition of the blood or disturbance of the acid-alkali balance, hinders the nourishment of (according to some authorities, directly irritates) the mucous membranes of the respiratory tract and the bacteria multiply in the weakened membrane, resulting in colds, sinusitis, tonsillitis, bronchitis, etc. On the other hand, a cold or any other ailment, can produce an upset in the acid-base balance, and obviously the cure of that particular ailment can be hastened by restoring and maintaining the proper ratio between acid and alkali.

The most natural way, and therefore the simplest and safest way to keep the proper balance is via the alimentary tract and the diet. When food is normally digested, the bowels regularly emptied of waste matter and the diet well balanced, there is little danger of an acidotic condition arising in the average person. Some foods, we pointed out, have an alkaline effect in the body, and others an acidic effect. The taste of the food or its acidity before taken into the body, is no indication of its effect after it is consumed. For example, few of us can drink plain lemon juice without making a wry face and chemical tests confirm the verdict of our tongues that it is highly acid, yet generally speaking its effect in the body is alkaline.

Foods that are rich in proteins tend to have an acid effect in the body because when they are oxidized or "burned", many of the resulting "end porducts" are acidic such as uric acid, sulphuric acid and phosphoric acid. Under normal conditions these acids are neutralized by being balanced with alkaline material to form neutral .salts which are eliminated by the kidneys. Among the foods that produce acid are meat, eggs, peanuts, walnuts, crackers, bread and oatmeal.

Broadly speaking, fruits and vegetables exert an alkaline effect. This is because they contain salts of alkaline metals such as calcium, magnesium, potassium and sodium. The acid parts of the salts, such as the acid of the lemon which we mentioned before, are burned in the body to carbonic acid which is easily expelled while breathing. Thus the alkaline metals are left behind ready for neutralizing the acid products from the foods rich in protein. The proteins, you will recall, along with bicarbonates and phosphates act as

buffers to maintain the normal faintly alkaline reaction of the blood and tissues.

In some fruits, such as cranberries, plums and prunes, there are certain organic acids which are not burned in the body. In such cases, the effect is acid.

In planning your diet with reference to the acid and alkaline effect of the various foods, remember this—the excess of alkali over acid is very slight and there is just as much danger in "over-alkalizing" your system through foods as through drugs. "Acid" is as necessary for normal health as "alkali" is. Moreover, many of our foods most valuable in other respects—in their vitamin, caloric or mineral content are acid in effect.

Probably the best rule to follow if you are in average health and lead a fairly regular life, is to eat almost as much acid producing foods as alkaline producing, and to eat a wide variety. That this is necessary can be easily proved by citing the action of that glorified vegetable—spinach—when it enters the body. Spinach, like rhubarb, cranberries, gooseberries, chard and beet leaves contain a large amount of oxalic acid. This acid is but poorly acidized in the body and prevents the utilization of an equal amount of calcium. Therefore, when you indulge (or martyr yourself) in spinach, be sure to maintain a high calcium balance by eating liberal quantities of foods rich in calcium, such as beans, eggs or milk.