7. All through the oxidation and reconstruction of the body life remains the same, and no new life is created.
8. The Bible gives the only known explanation of the origin of life.

DEMONSTRATIONS

16. Lower a lighted candle into a wide-mouthed bottle. When it goes out pour in a little lime water, then stop the mouth of the bottle and shake it. The water becomes milky, showing that carbonic acid gas has been produced. By means of a straw or glass tube blow a little air through a cup of lime water and notice that again the water becomes milky. This shows the carbonic acid of the breath.

17. Hold a lighted match under a cold tumbler. In a few seconds drops of moisture will condense upon the inside of the glass. Explain that the water is formed by the union of the hydrogen of the match stick with the oxygen of the air.

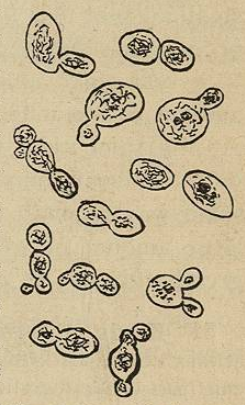
REVIEW TOPICS

1. Describe *oxidation* and its products.
2. Show how oxidation takes place in the body.
3. Describe the oxidation of each proximate principle.
4. Describe the series of changes by which the oxidized materials of the body are again built up into living bodies.
5. Define and illustrate *conservation of energy*, and apply it to man's body.
6. Define *organic* bodies.
7. Give points of difference between *plants* and *animals*.
8. Give the only known *source of life*.

CHAPTER IV

FERMENTATION AND ALCOHOL

49. Production of alcohol and vinegar. — Unless great care is taken to preserve it, a weak solution of sugar soon turns to *vinegar;* a stronger solution turns to *alcohol*, while a thick, sirupy solution remains unchanged. Everywhere there are scattered minute living germs which, falling into a moderately strong solution of sugar in water, grow and produce oval plants each about $\frac{1}{4000}$ inch in length. A collection of these plants is called *yeast.* By their growth and multiplication they change sugar to alcohol and carbonic acid gas. The gas bubbles up through the liquid and makes a froth upon the top, while the alcohol remains in the water.



Yeast plant cells (× 500).

If only a small quantity of sugar is present another kind of germ from the air enters and grows, becoming tiny rodlike plants, each about $\frac{1}{10000}$ inch in length. By their growth and multiplication they change the alcohol to vinegar. They collect in a mass called the *mother* of vinegar.

Boiling destroys both the yeast and vinegar germs. If the sugar and water are boiled and at once sealed tightly, so that new germs cannot enter, the solution will keep

for an indefinite time. Fruit when boiled and at once sealed in air-tight cans will keep unchanged for a long time. If there is a great deal of sugar present no germs at all will grow, and the solution will keep indefinitely. This is why fruit can be *preserved* in open jars if a great deal of sugar is used.

50. Fermentation. — Changing sugar to alcohol or vinegar is an example of *fermentation.* A substance which can change the composition of other bodies without losing its own identity or characteristics is a *ferment.* A very small amount of a ferment can change a very large amount of another substance.

A very small amount of yeast will cause an indefinite amount of sugar to become changed to alcohol or vinegar. At the same time the yeast may not grow weaker, but on the contrary may become stronger than at first. In the same way a small amount of "mother" will change a large amount of weak alcohol to vinegar, and itself will greatly increase in amount.

51. Kinds of ferments. — Nature uses many ferments in her actions. Some are living beings and some are lifeless substances. The chief part of the digestion of food is done by lifeless ferments. Fermentation is commonly spoken of as a process of decay, but the common process of decay or rot is in itself only a special kind of fermentation. Ordinary decay is caused by a living being like the vinegar germ. By its growth and multiplication it softens and liquefies the albumin of animal and vegetable matter. This process is called *putrefaction* (see p. 24). Some of the matter passes off as foul smelling gases, while the liquid part soaks into the soil. Putrefaction is nature's way of giving dead bodies back to the soil and air so that plants can build them into useful forms again.

Yeast germs are found everywhere, but they are often grown in wet meal or flour. The mass is then dried in cakes and sold as *yeast.* When a small piece is added to sugar and water it starts alcoholic fermentation at once. Alcoholic fermentation only is usually meant when the term *fermentation* is used alone. An adjective signifying the special form of fermentation is used to indicate any other form than the alcoholic. Thus there is acetous or vinegar fermentation, and putrefactive fermentation.

52. Bread making. — By the growth of yeast plants in bread dough some of the sugar in the flour is changed to carbonic acid gas and alcohol. The gas bubbles up through the dough, making it porous and light. When the bread is baked, alcohol is driven off and the yeast germs are killed by the heat. They are eaten with the bread, for they are perfectly wholesome. When germs of vinegar or other acid fermentations enter the bread and grow, the bread sours. These germs grow more slowly than yeast, and usually do not have time to develop. But if the bread is a long time in rising, they may grow and make the bread sour.

53. Fermented drinks. — Man uses the same process to produce drinks, which are erroneously supposed by many to act as a beneficial food, quenching thirst and giving strength to the body and power and joy to the mind. There are three classes of such drinks, all containing alcohol as an essential part.

54. Malt liquors. — The commonest form is what is known as *malt* liquors. Barley and other grain are moistened and permitted to sprout until the new stalk is about one half inch in length. This changes much of the starch of the grain to sugar. The sugar is dissolved out by boiling the grain along with hops and various other flavoring substances. Then yeast is added and alcoholic fermentation occurs. The result is *beer.* It contains from one to ten per cent of alcohol. Much of the flavoring which is often added to it is not only injurious, but actually poisonous.

55. Wines. — The second class of alcoholic liquors is *wine*. The juice is squeezed from grapes, blackberries, or some other fruit rich in sugar. Germs of alcoholic fermentation from their skins and the air set up fermentation in the juice and produce wine. Certain localities and cellars contain special kinds of germs which produce a peculiar flavor in the wine fermenting in that locality. In this way different kinds of wine are produced. Wine contains from five to fourteen per cent of alcohol. Fourteen per cent of alcohol in the juice kills the germs and stops the fermentation. So wine cannot contain more than that amount of alcohol unless more is added.

56. Distilled liquors or spirits. — The third class of alcoholic drinks is spirits, or *distilled* liquors. Alcohol boils at a temperature of 170° F., while water boils at 212° F. Thus when a wine, or beer, or any other alcoholic solution is heated its alcohol will be changed to steam very rapidly, while the water will evaporate slowly. Therefore the steam will contain a larger proportion of alcohol than the original liquor. This fact is put to use in separating alcohol from the solution in which it was produced. The steam is conducted through a coil of pipe kept cool by running water. Its temperature is lowered and it is changed back to a liquid form. This new liquid is whisky, or brandy, or other spirituous liquor, according to the substance used in its manufacture. The process of its manufacture is called *distillation*. Spirituous liquors are about one half alcohol.

57. Description of alcohol. — If the process of distillation is repeated the alcohol which passes over is still freer from water, until after three or four distillations it is almost pure. It is then a clear, colorless liquid like water. It has a sharp, sweetish taste and a peculiar odor. It causes a

severe smarting sensation when applied to a raw sore or to the eye or mouth. It is a valuable and useful article when rightly used in the manufactures and arts. But men have formed the bad habit of liking its taste and the feelings which it produces. They drink strong drink solely for the sake of the alcohol which it contains. The alcohol has an injurious effect upon every part of the body. These effects will be described in detail as each organ is studied.

58. Kinds of alcohol. — Alcohol is the name for a series of substances formed out of the same elements, but varying in composition, yet alike in essential properties. The simplest form is called *methyl* alcohol, or *wood spirits*, and is formed by distilling wood. It has an unpleasant odor and taste, but nearly the same properties as common alcohol. It is much used in manufacturing and in the arts, as a substitute for common alcohol, on account of its cheapness.

The next form, called *ethyl* alcohol, is the common alcohol made from wine, beer, etc.

The fifth in the series is called *amyl* alcohol or *fusel* oil, from the German *fusel*, bad liquor. It has a bad odor and nauseous taste, and is far more poisonous than common alcohol. It is formed in considerable quantities when potatoes are fermented. But if the whisky stands for some years, the fusel oil becomes changed to ordinary alcohol.

59. What becomes of alcohol in the body. — When taken into the stomach, alcohol passes into the blood with great rapidity. The body has the power of rapidly disposing of it either by giving it off, or, more probably, by oxidizing it to carbonic acid and water, and thus destroying it. At any rate, little or no alcohol can be found in any part of the body or in its waste, no matter how much is taken. But its oxidation takes place in an irregular way which is injurious to the body.

60. Effects of alcohol. — (1) *Prevents fermentation and decay.* — While alcohol is the product of fermentation, it has the power to *prevent* fermentation. The germs producing alcohol will not grow when alcohol is present in the proportion of 14 per cent. Germs of decay will grow in a much larger percentage of alcohol, but no germs will grow in a solution of one half alcohol. This fact is put to use in preserving specimens of animals and vegetables in museums, by placing them in spirits or alcohol. Since decay is dependent upon germs, the alcohol, by preventing their growth, prevents decay. It can also prevent the digestive ferments from acting upon food.

(2) *Extracts water from tissues.* — Water and alcohol mix very readily. An uncorked bottle of alcohol takes up water from the air, and so becomes weakened. When alcohol is in contact with a wet substance, it appropriates some of its water, and the substance then shrivels and becomes firmer. Strong whisky can produce the same result in the body to a limited extent.

(3) *Hardens tissues.* — Alcohol also hardens many animal and vegetable substances by extracting their water and by *coagulating* their albumin. In museums this fact is put to use in hardening soft and delicate specimens of animals and vegetables, so they may be preserved and examined safely. It is not probable that this action occurs in the body, for nature pours out an abundance of water to dilute the irritating alcohol.

Within the body the effect of extracting water from the tissues and of hardening albumin is to produce a smarting sensation which shows that the organs are being injured. There would be no limit to this action and death would soon take place if nature did not provide means for a partial protection against the substance. When any part

of the body is harmed, nature pours an abundance of water over the injured spot, so as to dilute and wash away the irritating substance, just as she pours out tears to wash a speck of dirt away from the eye. Alcohol attracts water to itself, and thus its power to do harm is greatly lessened. But this protection is only partial. If only a small amount of strong drink is used steadily for some time, nature becomes exhausted in her efforts of defense. Thus, while some exceptionally strong men seem able to use a large amount of strong drink with little harm, most men are greatly harmed by the smallest amounts.

61. Cause of thirst for alcohol. — The property of taking away water from substances which it touches, accounts in part for the failure of alcoholic drinks to satisfy thirst. A dry state of the surface of the lining of the mouth gives rise to thirst. If this lining is deprived of water by an alcoholic drink, the sense of thirst still remains, although the rest of the body is supplied with water. Moreover, this lining is somewhat injured by the alcohol of every drink, and to soothe the irritation another drink is needed. So the thirst goes on, growing stronger with every drink.

When he begins, no drunkard expects to use strong drink, or to drink more than a glass or two at a time, but his thirst always deceives him, and the momentary relief which drink gives him is only a deceitful addition to his thirst.

62. Adulteration of alcoholic drinks. — The manufacture of pure alcoholic liquors is a slow and expensive process. So cheap imitations are made which closely resemble the real article in taste and appearance. Beer is often made from cheap rye or corn and quassia, instead of barley and hops. Its fermentation is often hastened by an excess of yeast, and then the product is preserved by adding salicylic acid or other substances which destroy the yeast.

Whisky and brandy are also much adulterated. All kinds are alike in having a large amount of alcohol. In fact, the cheaper kinds of whisky and brandy contain the most alcohol.

Often, instead of good grain or fruit, rotten fruit, peelings, and refuse of all kinds are used in making liquors. When distilled and treated

with flavorings, a drink is produced which an expert chemist can scarcely distinguish from genuine liquor, and yet its evil effects are notoriously greater.

63. Temperance drinks. — Strictly speaking, water is the only *temperance* drink, for all kinds of flavored and fermented drinks are designed only to please the taste and not to fill a want of the body. The use of any except water is a form of intemperance, but those which contain alcohol are especially harmful.

Cider, root beer, and ginger ale, and other "homemade" drinks which are "worked" or fermented, all contain alcohol, and should be classed as strong drink. These drinks are particularly bad, for their use may lead one to indulge in stronger drinks.

SUMMARY

1. A sirupy solution of sugar will not become sour, but will "preserve" fruit from spoiling.
2. Sugar in a weak solution becomes alcohol.
3. The change is produced by the growth of microscopic plants called *yeast.*
4. Sugar in weaker solution becomes vinegar.
5. The change is produced by a collection of microscopic rodlike plants which form the "mother" of vinegar.
6. Changing sugar to alcohol or vinegar is fermentation.
7. Wine is made by fermenting fruit juice, and beer is made by fermenting a solution of sprouting grain.
8. Distilled liquors are made by boiling fermented liquors and collecting the vapor.
9. Alcohol prevents decay by killing the germs which produce rotting.
10. Alcohol takes water away from other substances and then hardens and shrivels them.

11. Alcohol disappears very rapidly after being taken into the body.
12. Alcohol takes water from the lining of the mouth and produces thirst.

DEMONSTRATIONS

18. Show fermentation by setting aside a bottle containing a little molasses in water. In a few days bubbles will rise, showing that fermentation has begun. Add a little yeast to another bottleful, and notice that fermentation begins within a few hours. Boil another bottleful and at once cork it tightly, and notice that it does not change. Explain that the first bottleful started with few germs and so fermentation at first was slow. The second had many and fermentation began at once. In the third the yeast germs were destroyed and so no fermentation took place.

19. Set aside a bottle of weak molasses and water for a week or two. Notice that fermentation goes on but that the liquid now tastes sour, for it has become vinegar.

20. Soak a yeast cake in water for a few hours and examine a tiny drop under the microscope with a power of at least 200 diameters. Notice the small oval cells, from the edges of which tiny cells seem to be budding. These are yeast cells. In the same specimen starch grains will appear as much larger irregular bodies of a shape depending upon the kind of grain used in making the yeast.

21. Procure some alcohol. Notice its sharp odor and taste. Show that it will dissolve and remove grease from the hands. Explain that in the arts, it is used to dissolve oils, resins, and such substances as water will not dissolve. Procure some wood spirits and contrast its odor and taste with that of common alcohol. Show that it, too, dissolves grease.

22. Pour some alcohol upon the white of an egg. Notice that the alcohol coagulates it and turns it white.

23. Place a small piece of tender meat in a bottle of alcohol for a day or two. Notice that it turns whitish in color and becomes shriveled, hard, and dry. Explain that the alcohol takes away the coloring matter of the meat, and also coagulates the albumin much in the same way as hemlock bark tans leather. Explain how alcohol preserves substances in this way.

24. Dip a small piece of paper in alcohol and touch it with a match. It bursts into a flame at once, and develops great heat but no smoke. Notice that the paper does not burn until the alcohol is nearly used up. Explain that in the body alcohol seems to be easily oxidized, and uses oxygen which should go to the proper food of the body.

25. Hold a cold stone in the mouth of a teakettle or in the steam of a pan of water. Notice that the vapor condenses in drops upon the stone. This will illustrate distillation as well as a complicated apparatus of coils and running water. Explain that dew upon the grass is a distillation of water.

REVIEW TOPICS

1. Describe how alcohol and vinegar are commonly formed.
2. Describe the *yeast plant*.
3. Describe *mother of vinegar*.
4. Describe *fermentation*.
5. Tell how fermentation is applied to bread making.
6. Describe *malt liquors*.
7. Describe *wine*.
8. Describe *spirits* and the process by which they are made.
9. Describe *alcohol*.
10. Give the three main properties and effects of alcohol.
11. Tell what becomes of alcohol when taken into the body.
12. Tell why alcohol does not satisfy thirst.

CHAPTER V

DIGESTION OF FOOD IN THE MOUTH

64. Food and digestion. — Albumin, fat, and sugar are continually being oxidized in the body, and the products of oxidation, together with mineral matter and water, are being thrown off. In order to keep up the strength and form of the body a constant stream of new material must be supplied.

Anything which, taken inside of the body, supplies it with weight, heat, or energy is food (see pp. 64 and 89).

In preparation for the use of the body, food is reduced to a form which can be dissolved in water, and drawn through the walls of the blood tubes. The blood distributes it to all parts of the body. The process of producing a *chemical* change in food so that it can be taken up by the blood is *digestion*.

Man uses as food a combination of albumin, fat, sugar or starch, mineral matters, and water, which are identical with the proximate principles of the body. Of these water and mineral matters can enter the blood without being changed, while the albumin, fat, sugar, and starch require digestion. Albumin is changed to a form called *peptone*, which can easily diffuse through the walls of the blood tubes, and so become a part of the blood.

Sugar and starch are both changed to *glucose*, a form of sugar found in the grape. Fat is saponified and emulsified.

65. Cooking. — Digestion is begun by applying heat to food, either with or without water. Preparing food by heat is *cooking*. The heat of cooking coagulates the albumin. It also softens and dissolves the connective