94. Hold a candle or lighted match near each crack of the room and notice that usually the flame is blown towards the inside from cracks near the floor, while it is blown outward in cracks higher up.

95. Clap two blackboard erasers together to make a small cloud of dust, and watch the movements of the particles in a ray of sunlight, so as to detect the direction of the air currents in the room.

96. Show methods of ventilation by lowering the upper sash; by raising the lower and inserting a board in the opening. Show and explain the methods of ventilation adopted in the school.

REVIEW TOPICS

1. Give the composition of the air.
2. Describe ozone; argon; nature's method of removing dust from inspired air; and the dangers of inhaling dust in certain trades.
3. Tell how much oxygen is needed in the air to sustain life, and give a simple test to determine whether sufficient is present.
4. Give the effects of rarefied air, and air under increased pressure.
5. Give the effects of carbonic acid gas.
6. Describe foul air and its effects.
7. Discuss the meaning and the effects of bad odors; of sewer gas; of night air; and of cellar air.
8. Describe *malaria*.
9. Show how fire and lights contaminate the air.
10. Describe coal gas poisoning.
11. Show that foul air may contain disease germs.
12. Calculate how much fresh air should be admitted into a given room for a given number of persons.
13. Describe how ventilation naturally goes on, and tell some ways of assisting nature in ventilation.
14. Tell how a schoolroom may be ventilated.
15. Tell how the atmosphere is purified.

CHAPTER XXV

HEAT AND CLOTHING

404. Temperature of the body. — During health a man's body has a temperature of $98\frac{1}{2}°$ F., which does not change either upon the warmest day in summer or the coldest day in winter. The body is warmed by the oxidation of its own cells and of digested food.

405. Change of heat to energy. — The power which the body puts forth in performing work is derived from the heat of oxidation. The work of the heart requires the use of $\frac{1}{16}$ of all the heat produced in the body; the respiration requires $\frac{1}{60}$; digestion and absorption require a smaller amount. An ordinary day's work requires $\frac{3}{16}$ of the total amount of heat. So nearly three fourths of all the heat produced is used simply to heat the body.

406. Uniformity of temperature. — In some parts of the body oxidation is many times more active than in others. Probably most of the sugar is oxidized in the liver, and most of the fat in the lungs. As fast as heat is developed it is carried all over the body by the blood, so that there is scarcely half a degree's difference between the temperature in any two parts. Only the surface of the skin is cooler because it comes in contact with cooler air.

407. Fever. — When the temperature of the body is raised only a degree there is a feeling of warmth and discomfort, which is called a *fever*. The discomfort is worse as the temperature is higher. A temperature of 104 degrees is a high fever, and if continued may cause death.

408. Sensation of heat and cold. — If the temperature is lowered only a degree, there is a feeling of coldness called a *chill*. A chill is a recognized sign of beginning illness. The ordinary feeling of heat or cold is due to the state of the nerves of the skin, whose special duty is to conduct sensations of temperature. These nerves are so abundant in the skin that their sensations overpower the sensations of the rest of the nerves of the body. If the skin is warm, the whole body feels warm; while if the skin is cold, the whole body feels cold.

409. Chills during a fever. — It often happens during a fever that the blood goes to deeper parts, leaving the skin pale and without its usual supply of heat, and so the whole body feels cold, and the person has a chill, although the temperature of the body may be raised several degrees.

In severe sickness the heart is sometimes too weak to pump the blood to the skin, and so it feels cold, although the temperature of the inside of the body may be raised several degrees. This condition is often called *inward* fever. On the other hand, the body may be cold, and yet if the blood is brought to the surface, the person will feel warm.

410. Regulation of the heat produced. — The amount of heat produced in the same body varies widely at different times, and some persons always produce many times as much as do others. So in order to keep the temperature constant, heat must be given off at one time and saved at another. Nature regulates the temperature of the body by varying both the amount produced and the amount given off. The production of heat depends partly upon the amount of food. In summer man naturally eats less than in winter. Inhabitants of arctic regions eat large quantities of fat, the oxidation of which produces a large amount of heat, while the inhabitants of hot climates naturally avoid fat.

The production of heat also depends upon the amount of oxygen taken into the body. In work, deeper inspirations are taken, and more oxygen reaches the cells, and thus exercise warms the body.

411. Regulation of the heat given off. — Nature also regulates the amount of heat given off. The body loses some heat through the breath, and more by contact with the cool air. When the temperature of the inside of the body is raised, the blood tubes of the skin dilate, so that more blood comes in contact with the air. If the temperature falls slightly below the natural point, the blood tubes of the skin contract, so that less blood comes to the surface, and more heat is retained until the temperature rises to the natural point again. A change of temperature too small to be felt will produce these changes in the blood tubes of the skin.

412. Effects of tight bands. — When the circulation is hindered so that less blood enters any part of the body, its temperature falls. A finger whose veins are compressed by a tight string becomes perceptibly cooler in less than a minute. Garters often cause cold feet in the same way. Compression of the waist may cause the whole body to feel cold.

413. Effects of perspiration. — Sometimes men work in air which is hotter than their bodies. Then instead of giving, they receive heat. In order to keep them cool under these circumstances, nature has provided a self-acting bath by means of the *sweat*, or *perspiration*. When the temperature of the body is raised from any cause, the perspiration is poured out in greater quantity, which increases as the quantity of heat increases.

The heat of the body is used in changing the water of the perspiration to steam, which then passes off from the body. The process is

like the boiling of water in a teakettle, where the heat passes off in the steam, so that the temperature of the water does not rise beyond the boiling point. Some perspiration is given off even if the body is cold, but with an overproduction of heat more perspiration is often produced than can be turned into vapor. A person is usually said to perspire only when it is produced in so great a quantity that it collects in drops upon the skin.

414. Moisture in the air. — When there is a great amount of moisture in the air on a hot summer's day, the perspiration does not evaporate from the skin, and so heat is retained within the body, and the air seems "heavy" and oppressive. On such days the *humidity* of the air is said to be great. Dry air at a temperature of 90 or 95 degrees seems cooler than moist, humid air at a temperature of 80.

415. Sunstroke. — Men and animals, while working, produce a large amount of heat. On excessively hot and humid days the extra heat may not pass off so fast as it is formed, but may accumulate until the temperature rises several degrees. The increased heat overwhelms the body, and produces a sudden attack of faintness called *sunstroke*. The unconsciousness lasts for a long time, and is followed by great weakness, and sometimes by death. When a person is sunstruck he should be laid in a cool place, with his head lowest. Cold water should be dashed upon his head and chest. His limbs should be rubbed to help the circulation.

416. Damp days in winter. — While moisture in the air makes the body warmer in summer, in the winter it makes the air seem colder. Dry air is a poor conductor of heat, but a little moisture makes it a much better conductor. So a damp wind rapidly extracts the heat from the body, and seems to penetrate even thick clothing. Moist air at a temperature of 20 degrees seems colder than dry air at zero.

417. Heating living rooms. — In addition to the means provided by nature, man is often compelled to add devices of his own for regulating the heat of his body. Man lives

with the greatest comfort while the temperature of the air is about 70 degrees, which is but little more than halfway between the temperature of freezing and the heat of the blood. A temperature of 80 degrees feels too warm, while 90 degrees is hot, and $98\frac{1}{2}$, or the temperature of the body, is oppressive.

In winter a temperature of 70 degrees in a living room feels neither warm nor cold, and the change between it and the outside cold air is less noticeable than at any other temperature. A temperature of 75 or 80 degrees feels too warm, and when the person goes out of doors the cold air produces a sudden contraction of the arteries and a chill, which often results in taking cold. A sleeping room should be at a lower temperature than a living room.

418. Clothing. — Man protects his body against the loss of heat by covering it with clothes. Some kinds of substances readily permit heat to pass through them, and are called *good heat conductors*, while others carry heat poorly and are called *poor conductors*. *Linen* is a good conductor of heat. It is a poor protection against cold, for it lets out the heat of the body, but it makes good summer clothing. When the linen clothing is adjusted to one temperature, a change to cooler air is quickly and suddenly felt. Thus it is an undesirable clothing material in changeable climates or in cold weather.

Cotton, while being a poorer conductor of heat than linen, is yet too good a conductor to protect the body in cold or changing weather, unless a great deal is worn.

Wool is a poor conductor of heat. When the temperature is suddenly lowered, it permits the heat of the body to pass off but slowly, and thus gives the skin time to adjust itself to the change. In summer it retains too much heat, and does not make so good summer clothing as cot-

ton or linen, but when the temperature of the air is higher than that of the body, it prevents the heat from entering, and thus is cooler than linen or cotton. So men who tend hot furnaces are cooler if they wear thick flannel than if they wear linen or cotton.

Silk is also a poor conductor of heat. While more expensive than wool, it is lighter in weight and feels softer to the skin, and so makes the best kind of clothing.

Fur is the poorest conductor of all, and is the best protector against cold. Nature has given a thick coat of fur to animals that live in cold regions. In winter their fur is long and thick, but it drops out during spring, and a new fur grows during the summer, becoming thick and long again by the following winter.

Air itself is a poor conductor of heat, and when a considerable quantity is imprisoned in the meshes of cloth, the garment offers a greater resistance to the passage of heat. So loosely woven cloth is much warmer than cloth made up of tightly twisted thread. Fur is warm largely because of the amount of air which it imprisons. For the same reason loose clothing is warmer than tight-fitting clothes.

419. Color and heat. — When exposed to the sun, black objects take up twice as much heat as white objects. This difference of temperature is noticeable in clothing. Light-colored or white clothing is best for summer, and dark-colored or black for winter.

420. Distribution of clothing. — The different parts of the body vary in their ability to resist cold. The face and hands usually need no covering. The feet need less than the body, while the back, chest, and abdomen need the most. Nature has distributed fur upon the animal's body in the same way, leaving the head and feet poorly covered. The sense of warmth is the best guide as to the amount of clothing to be worn on any part. A person should wear enough to keep each part of the body comfortably warm, while no part, especially one which is usually left uncovered, should be covered so as to be uncomfortably warm.

Dampness produces cold by the evaporation of water. If all the clothing is wet, heat is taken from the whole body equally, and there is equal contraction of the arteries with no congestion or inflammation. But if a single part is wet, it feels cold, while the rest of the body is warm; so wet feet often produce inflammation of different parts of the body.

Cold feet. — When the feet perspire a great deal, the stockings and soles of the shoes become saturated with moisture and make the feet feel as cold as if they were wet. Thicker stockings make the feet perspire still more, and so do not add to their warmth. Tight shoes allow of no ventilation, and so the moisture is retained, and the feet are wet and cold.

Drying the shoes and stockings every night before the fire will prevent their becoming saturated with moisture. A new inside sole cut out of thick paper put in the shoe each morning will absorb moisture and help keep the feet warm. Rubber boots and shoes do not permit the moisture of insensible perspiration to pass off, and so they seemingly cause the feet to perspire.

Bathing the feet each morning in cold water and drying them by brisk rubbing improves the circulation, so that they will be more likely to stay warm all day.

421. Paper as a protection against cold. — Paper is a poor conductor of heat. A newspaper wrapped around the body under the coat is as good as an overcoat for warmth. A few newspapers spread between the quilts of a bed will make up for a lack of bed clothing upon a cold night. One need not suffer from insufficient clothing, day or night, if a few newspapers are at hand.

422. Sufficient clothing. — The amount of clothing which one needs depends largely upon a person's occupation and previous habits. A day laborer seldom needs an overcoat, but works in his shirt sleeves, while a clerk would be chilled were he to step outdoors without extra wraps. It is a mistake to think that by exposure to the cold one can always become hardened to it. It is true only when a person takes active exercise and lives out of doors continuously. The body cannot adapt itself to the sudden changes from hours spent in a warm room to an hour or two in the cold air. Enough clothing should be worn so that the body

does not feel chilled on entering the cold air. When by exercise the body feels warm, the overcoat may be unbuttoned or removed, but while resting it should be put on at once. Children often get cold by suddenly cooling off while warm, fearing ridicule if they should put on their coats during a few moments' rest from play.

423. Airing clothes at night. — At night it is usually best to remove all clothing worn during the day. Woolens have the power of absorbing a great deal of moisture without feeling damp. But the moisture and the waste matters from the skin should be removed each night by thoroughly airing the underclothes. If it is not done, the woolen may become so saturated with moisture that it affords no more protection than cotton, and so may render a person liable to take cold.

424. Beds. — Feather beds and thick quilts enable a person to get warm when he goes to bed on a cold night, but after he falls asleep he becomes too warm and perspires too freely. Then he throws off the coverings, and soon the evaporation of the perspiration makes him cold. The changes from one extreme to the other often produce colds. Feather beds warm the side of the body which is buried in them, while the other side is cold. This unequal distribution of heat is the common cause of catching cold. As a rule a plain mattress is more comfortable and gives a more even heat than a feather bed; but in beds, as in clothing, a person's sensation forms the best guide as to the kind to be used.

425. Effect of lowering the temperature of the body. — In extremely cold weather heat may be lost from the body faster than it can be produced, and thus the temperature falls. Then the body and mind cannot act, but become numb and sluggish, just as the hands become numb and powerless when cold. If the temperature continues to fall, the respiration becomes less, and as the cells cease to act

an agreeable feeling of drowsiness steals over the mind, until the actions of life cease. After the drowsy feelings begin, life can be restored only by applying heat to the body and performing artificial respiration so as to start the process of oxidation again.

426. Frost bites. When a part becomes very cold the cells may be seriously injured long before they are frozen. A toe or an ear which has been on the verge of freezing will begin to prick and tingle when warmed. For a long time afterward, sensations varying from an itching to severe pricking and smarting will cause great annoyance. In severe forms, short of actual freezing, the part swells and becomes red and inflamed, while the sensations are extremely annoying. A part which is actually frozen is likely to die. The part turns black soon after being thawed, and has no feeling. After a few days the dead part comes off, leaving a raw sore. Fingers, toes, and ears are very liable to become frozen, but the eyelids are almost the last thing to freeze.

427. Frozen limbs. — When a solution of a substance in water freezes, the first ice formed is composed of crystals of pure water, while that frozen last contains most of the dissolved substance imprisoned in the meshes of the crystals. The cells of the body are made of water in which albumin and mineral substances are dissolved. When freezing occurs, the first ice is composed of needles of pure water which has been taken from the cells. If the freezing takes place rapidly, the water produces swift currents which break down the delicate framework of the cells and cause their death. If freezing occurs very slowly, the water may leave the cells so slowly that no damage is done by the tiny flood. If thawing occurs just as slowly, the water may reënter the cells so that they may be preserved alive. When a hand or a foot is frozen, it should be rubbed gently either with snow or else while immersed in ice water, and the raising of the temperature of the water should be done very slowly, taking, at least, two or three hours for the thawing process. The preservation of the frozen part depends upon

its very slow thawing. Never apply warmth of any kind to a frozen part, and avoid sitting near a warm stove afterwards.

428. Effects of raising the temperature of the body. — When a living body is exposed to a higher temperature than is natural, the respiration and circulation are much increased by the extra heat and there is much mental excitement. In fevers there are usually excitement and delirium. A continuous temperature of 105 degrees is usually fatal.

It is possible to work in an atmosphere which has a temperature of 150 degrees or more, and men have remained in hot ovens for many minutes without harm. Their perspiration flows very freely, and its evaporation carries off the extra heat, so that the temperature of the body does not rise. If the perspiration should cease, the temperature of the body would rise at once, and death would soon take place.

429. Burns. — A temperature of 110 degrees feels very warm, 115 degrees is hot, while 120 degrees is all that a person can commonly stand. A temperature higher than this injures the cells so that a blister will be raised in a few minutes. A temperature of 170 degrees coagulates albumin at once and so destroys the life of cells which it touches. A temperature of 212 degrees, or boiling point, at once produces a deep scald, while higher temperatures burn the skin to a crisp.

Cold water applied at once to a burn prevents its extension and soothes the smarting, but it should be applied only for a short time lest it should injure the cells. Common baking soda is one of the most soothing applications. A mixture of linseed oil and lime water is a good application for continuous use. After a deep burn has healed, a puckered scar will be left, but the scar will be less noticeable if healing is hastened by skin grafting.

430. Burning clothing. — When the clothing on a person takes fire, a great danger is that the flames may be inhaled. It will take some time for the flames to penetrate to the flesh, but they may quickly spread upward. So a person should always *lie down at once.* Then let him roll over and over so as to crush out the fire. Even if the fire is not extinguished, the flames cannot reach the face, while the clothes can be removed as well lying down as while standing. In helping a person whose clothes are burning, at once *throw the person to the floor.* Many have lost their lives by persisting in standing up while attempting to remove the burning clothes.

If it is necessary to enter a burning building, or to carry a person whose clothes are burning, the best protection will be to wrap a thick coat or blanket around the body. A thick coat wrapped around burning clothes or thrown over the body after a person lies down will quickly smother the flames.

431. Alcohol and heat. — The amount of heat in the body depends upon the balance between its production and its loss. The rapid destruction of alcohol, in all probability, yields heat too rapidly to be utilized by the body. The most constant effect of taking alcohol is to dilate the arteries of the skin, so that an extra amount of heat is lost. More heat is always lost than is produced. Alcohol lessens the power of the body to endure cold. On a cold day when the arteries of the skin are contracted so that there is but little blood to warm its nerves, alcohol may send the blood to these nerves and produce an agreeable sense of warmth, but in reality this feeling of warmth is due only to the heat which is passing off from the interior of the body.

432. Regulation of temperature in the dog. — The temperature of many animals is slightly above man's temperature, but is regulated in the same way. Some, like dogs, sweat but little, but the animal takes short and rapid breaths through his open mouth, thus creating a strong current of air over its moist surface. The evaporation of the saliva cools the blood.

433. Hibernation of animals. — When winter comes on, some animals, like the woodchuck, retire into their holes and go to sleep. Their temperature falls to 50 degrees, or even lower, while respiration occurs only three or four times a minute. Only enough oxidation of their own bodies occurs to keep life from completely dying out.

When warm weather comes again, their respiration and temperature rise to the natural point, and the animal resumes its former condition, but is thin from the oxidation of its fat and albumin during his long sleep. The dormant state during the winter is called *hibernation.*

434. Cold-blooded animals. — In frogs and snakes, oxidation is not sufficient to raise their temperatures much above that of the surrounding air. So they feel cold to the touch, and are called *cold-blooded.* On warm days they do not lose heat so rapidly, and more heat is retained within their bodies, and thus they become more active. When cold weather comes on, they cannot produce enough heat to enable them to move, but they lie unconscious until warm weather comes again.

Insects cannot produce enough heat during winter to enable them to fly about, so they remain apparently lifeless until the warm weather comes again.

SUMMARY

1. The heat developed by oxidation is distributed through the body by the blood so that everywhere it has a temperature of 98.5 degrees.
2. The sensations of heat and cold are caused by the blood circulating in the skin. If little circulates, we feel cold; while if much circulates, we feel warm.
3. An increased quantity of food, oxygen, or exercise increases the amount of heat produced in the body.
4. Heat is given off by contact of the skin with the cold air and by means of the perspiration.
5. A temperature of about 70 degrees in a room is the most comfortable.

6. Moisture in the air prevents the evaporation of perspiration, and increases the feeling of warmth.
7. Fur, silk, woolen, cotton, and linen protect the body from cold in the order given.
8. Raising the temperature of the body causes excitement and delirium.
9. Alcohol dilates the arteries of the skin and permits an increased loss of heat, in spite of the feeling of warmth.
10. In animals while hibernating, and in all cold-blooded animals, oxidation is feeble, the temperature is low, and their movements are sluggish.

DEMONSTRATIONS

97. To show that more blood goes to a part, and that it becomes warmer while acting, let a boy roll up his sleeve and hang his arm by his side. Notice that the veins slowly fill, because the flow of blood is slowed by running up hill. Now have him open and shut his hand rapidly, and notice that at once the veins become filled full of blood. After a moment the hand feels warmer than the other, especially if they were a little cold at first.

98. Take some ice water, some water at the temperature of the air, and some hot water. Notice that the water at the medium temperature feels warm when the hands have just been taken from the ice water, but cold when they have just been in the hot water.

99. Feel of a piece of iron and of a stone after exposing both to the cool outside air. Notice that the iron feels colder, for it takes heat from the hand faster.

100. To show that obstructing the flow of blood makes a part cold, tie a string rather tightly around the finger. In a moment it becomes filled with venous blood, and feels cold, for the blood is not renewed.

101. That the sensation of heat and cold depends partly upon the amount of blood in the skin can be shown by holding a piece of ice in the hands for several minutes. At first, the hands feel cold, for the arteries are contracted. In a little while the blood circulates freely

again, and there is a feeling of warmth, although the ice still continues to cool the hand.

102. Take some cotton and some woolen cloth of equal thickness. Wet them and notice how much more quickly the cotton will dry than the wool. Wrap them around the hand and notice that the woolen feels warmer, because evaporation from it does not carry heat away from it so fast as from the cotton. Then blow upon them and notice how much colder the cotton feels.

103. Place two pieces of ice of equal size in the sun and cover one with a black cloth and the other with a white piece of the same kind, and notice that the piece under the black cloth melts faster.

104. Needles of water crystals can be shown by setting aside a cup of water out of doors until it just begins to freeze, if it is a cold day, or, if it is a warm day, by putting a large piece of ice in the sun and breaking it when it is half melted. Each needle is pure water.

105. A wasp or a fly will illustrate the hibernation of animals. In winter a few wasps can usually be found in a sunny garret window. When the air is quite warm, the wasps will be lively, and as it becomes colder they become more sluggish, until at night they are apparently lifeless.

REVIEW TOPICS

1. Give the temperature of the body and tell how the heat is distributed.
2. State what causes sensations of heat and cold, and how the body may feel warm while it is cold, and cold while it is warm.
3. State how the production of heat is regulated.
4. State how the amount of blood in the skin regulates the amount of heat given off.
5. State how the perspiration regulates the amount of heat given off.
6. State how tight bands about a limb cause cold feet or hands.
7. Give the best temperature of living rooms and of bed rooms.

8. Give the effect which moisture in the air has upon the heat of the body during summer and during winter.
9. Give the value of linen as a protection against heat and cold; of cotton; of wool; of fur; and of air.
10. State how color affects temperature.
11. State how much clothing should be worn, and how it should be distributed over the body.
12. Discuss feather beds and thick bed coverings.
13. Give the effects of lowering the temperature of the whole body; of frost bites; of frozen limbs; and their treatment.
14. Give the effects of raising the temperature of the body, as in fever and in sunstroke.
15. Give the effects of alcohol upon the temperature of the body.
16. State how a dog's temperature is regulated.
17. Describe the hibernation of animals.
18. Describe oxidation in cold-blooded animals, and in insects.