PHYSIOLOGY.

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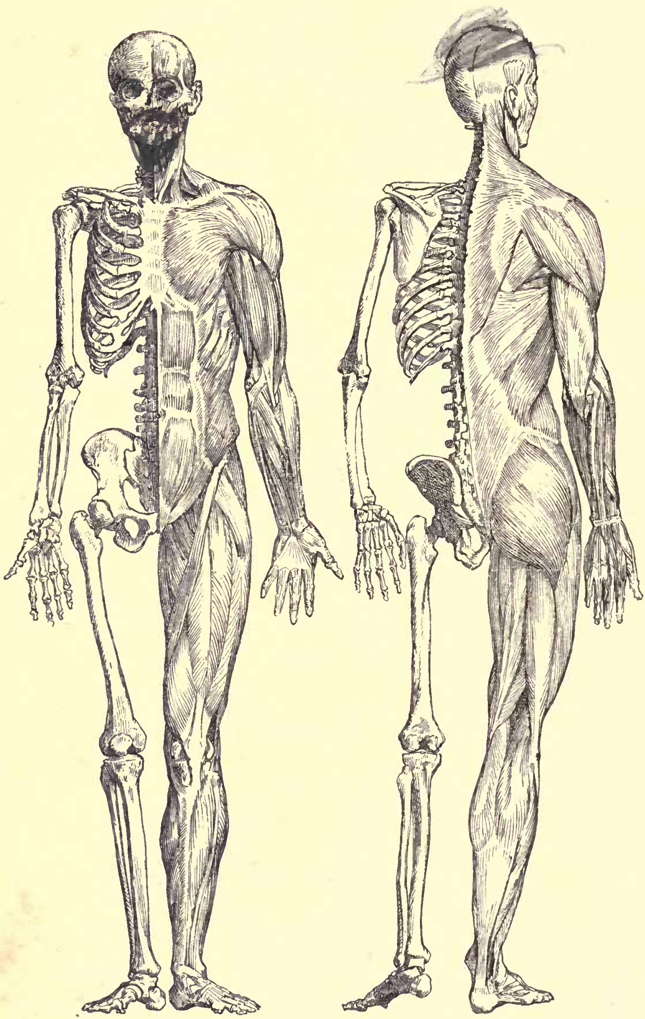

ELEMENTS

OF

PHYSIOLOGY

AND

HYGIENE.

BY

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PREFACE.

THE following lessons in Physiology and Hygiene were prepared in response to a resolution of the INDIANA STATE TEACHERS' ASSOCIATION. They were designed originally to meet a demand in that State, where the law introduces these branches of study into common schools. In the execution of this design the author has endeavored to prepare a work adapted to the wants of families and the general reader.

Physiology and Hygiene having been but recently introduced into the common literature of the country, parents, generally, have only a limited knowledge of a subject which stands in most intimate connection with the well-being of those intrusted to their care. To such persons the following lessons present the elementary principles of human physiology, and the laws of health, deduced therefrom, divested, as far as possible, of the technical dress which too often places these subjects beyond the comprehension of common readers.

It is of the first importance to those who have the care of children, whether in the family or the school, that they make themselves familiar with the laws of health, in order that they may establish, in early years, habits of correct living in those under their charge. The value and duration of human life are more intimately connected with the establishment of such habits than is generally admitted. If wrong ones are formed in childhood, the power to correct them in maturer years is often wanting; and even if efforts in that direction prove successful, still the evil consequences remain.

It must be remembered that habits injurious to health, when established in youth, while the vital organs are in a state of development, leave an impression of a deeper and more permanent character than similar habits formed in after life. To *prevent* these evils rather than to *reform* them is the true philosophy.

To this end the author invokes the aid of parents and teachers, and as his contribution to what he conceives to be the best method of instruction, presents these lessons, trusting they will tend toward awakening an interest in subjects of vital importance to all.

Many text-books on the science of Physiology and Hygiene have been presented to the schools and colleges of this country during the past few years. These are chiefly abridgments of the larger works used in medical colleges; and as physiology is taught in those schools with a direct reference to the cure of disease, these books retain more or less of this character. But the study of physiology in other than medical schools should have direct reference to the *preservation of health*, rather than to the *cure of disease*. It has been the leading purpose of the author to make HYGIENE the prominent feature of this book, and all other studies introduced subordinate to it.

To the scientific reader the author wishes to say, that while he has aimed to present his subject in a popular form, and avoid the discussion of many purely scientific questions which might have been introduced, it has, at the same time, been his purpose to treat it in the light of the latest discoveries.

In the use of such terms as *vital force*, etc., the author does not intend to commit himself to any particular theory of life, but merely uses such phrases as *signs* of the unknown.

HINTS TO TEACHERS.

This book is divided into fifty lessons, with the intention of adapting it to the common division of the school year into terms of about twelve weeks each. If five lessons are recited each week, the work can be completed in a term, and ten recitations be left for review.

If it is desirable to give more time to the study, the lessons may be divided and the work distributed over two terms, devoting the first to Physiology and the second to Hygiene.

For the purpose of easy reference, the work is divided into sections and each one is numbered. To adapt it to the method of teaching by topics, each section is introduced by a head-line in full-faced type, embracing the leading subject.

Brief recapitulations are appended to the lessons, for the assistance alike of teachers and pupils in the work of reviewing.

Much of the work of teaching this science should be done by lectures, or by familiar conversations between pupils and the teacher; and in the arrangement of the matter of these pages this feature has been kept constantly in view.

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CONTENTS.

PART I.

PHYSIOLOGY.

LESSON I.

INTRODUCTION.

1. Classification of Bodies.—The material things that are around us in this world may be divided into two classes—those which were formed by the coming together of particles of matter under the simple laws of attraction, and those which have grown to their present size and shape under the influence of that force which we call Life.

Chemistry teaches us how the first class of bodies are formed; and Mechanical Philosophy tells how they operate on each other, and defines the laws governing their movements.

Physiology instructs us in the mysteries of life-formed bodies, as far as these may be known. It may therefore very properly be called *The Science of Life.*

2. Organic Bodies.—The difference in the growth of a living body, and the increase in size of a body which is not alive, have given rise to the following method of classifying and naming bodies, which is now very generally received.

A plant takes up the matter intended for its growth by means of vessels, or open mouths provided for that purpose, either in its roots or leaves. In these vessels, this matter undergoes the changes that fit it to become a part of the living plant, and by them it is carried to its proper place and built into the structure of the body. These instruments by which the food is absorbed, prepared, and deposited are called *Organs*, and the body thus formed is an *Organic body.*

3. Inorganic Bodies.—A stone placed in water which holds lime dissolved in it, as the waters of many springs do, will increase in size by the addition of particles of lime to its outer surface; but in making this apparent growth, no vessels are employed to carry the lime to its place, and no instruments are used to change either its form or place.

A rock thus formed is, therefore, an *Inorganic body.* These two classes embrace all bodies of matter on the earth. To the inorganic group belongs the great mass of material of which the globe is formed, such as rocks, earths, metals, etc.

4. Character of Organic Bodies.—The organic world is made up of but a few simple elements; but the bodies are very complex, both in their form and composition. They are, moreover, much less fixed and permanent in their character than inorganic bodies.

While an organic body lives, it is constantly undergoing change by growth, or by decay and repair; and as soon as it ceases to live, a tendency to decomposition ensues, and the body—it may be slowly, but very surely—returns its matter to the inorganic world from which it was taken.

5. Division of the Organic World.—Organic bodies are of two kinds—*Vegetable* and *Animal*. These are alike formed under the influence of the life-force, and by means of organs, yet they differ from each other in their general characteristics. This difference is most apparent in the higher and more perfect forms of both classes; but as we descend in the scale of life, these two grand divisions approach so near to each other that it is almost impossible to define the line separating them.

The distinction which most persons would first observe is that plants are fixed to one spot, while animals enjoy the power of changing their place. While this is generally true, it is not so universally. The sponges and corals of the ocean are as firmly fixed to one spot as the trees of the forest.

6. Animal Characteristics.—Animals are described as having a nutritive cavity—a stomach into which food is taken, and where it is prepared to be used for the growth and repair of the living body. In the vegetable, the food is absorbed either by the roots or leaves, and it undergoes no previous preparation to fit it to be thus absorbed.

This distinction applies only to those animals whose structure conforms to the regular types of animal life. No internal cavity can be found in many of the lower and irregular forms of animal life. Plants live on inorganic food; animals digest and assimilate only that which has been organized. This, in the strict meaning of its terms, is true; yet it is evident that animals appropriate water, and various mineral substances, though probably without any digestive change.

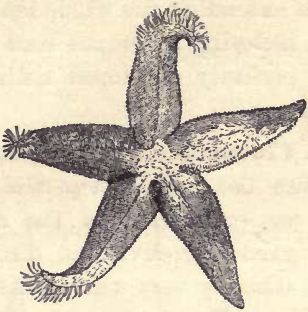
7. Nervous System—the true distinction.—The real difference between animal and vegetable life consists in the possession of a *Nervous System*, and the manifestation of its functions, in a greater or less degree, by all animals. These are the powers of sensation, perception, and voluntary motion. In the lower forms of animal life, the nervous system is very imperfect; yet the unmistakable evidence of feeling, and the power to move at the command of the will, though the motion may be to a very limited extent, demonstrate its existence, even though the microscope may not reveal the nervous centers.

8. Animal Sub-kingdoms.—While all animals have an apparatus of voluntary motion, and organs for receiving, transmitting, and perceiving sensations, yet the degree of perfection in which these animal powers are possessed, is so widely different as to give room for the division of the animal kingdom into several sub-kingdoms, each distinguished by some common element of form, which constitutes what is called the type of the sub-kingdom.

At the base of the pyramid of animal life lies a group of forms, exceeding in numbers, perhaps, all other classes of animals, yet so minute as to be seldom visible to the naked eye, and are therefore studied chiefly by aid of the microscope. They are called *Protozoans*, a word which means *first life.* These are exceedingly simple, yet they present endless varieties of form. As they do not conform to any special type, they are very difficult of classification.

Rising above these, we have four well defined types of life, which we enumerate in the ascending order.

FIG. 1.—STAR-FISH.



1st. *Radiate Animals*, or those with arms or feelers extending in every direction, like rays, from the mouth, which is simply an opening into the central, digestive cavity.

FIG. 2.—SNAIL.

2d. *Mollusks*, or soft-bodied animals without limbs; such as snails, oysters, clams, etc.

FIG. 3.—DRAGON-FLY.

3d. *Articulates*, or animals whose bodies are made of rings joined together, as in the lobster, craw-fish, and insects generally.

FIG. 4.

4th. *Vertebrates.* Animals with a bony column extending the whole length of the body, and inclosing a nervous cord with a more or less perfectly developed brain at its forward termination.

9. Classification of Vertebrate Animals.—Of this last and most perfect type of animal life we enumerate, in the ascending order, four grand sub-divisions, distinguished from each other by very well marked natural peculiarities. These are:

1st. *Fishes.* Inhabiting the water, and breathing by means of gills. They are usually covered with scales.

2d. *Reptiles.* Breathing air with very imperfectly formed lungs, and generally having the body naked. Fishes and reptiles are cold-blooded animals, the temperature of the body being nearly that of the water or air in which they live.

3d. *Birds.* Warm-blooded animals, covered with feathers, and provided with wings for flying. With the exception of a few reptiles, these three classes produce their young from eggs.

4th. *Mammals.* Animals which suckle their young. Their bodies are usually covered with hair.

Recapitulation.

An Organ is any thing used as an instrument to accomplish a purpose.

That which is done by an organ is called its function. Example: The teeth are organs; chewing food is their function.

A body which grows and maintains its repairs, by means of the life force exerted through organs, is called an *Organic body*, and the laws regulating the proper action of these organs constitute its Physiology.

LESSON II.

DEFINITIONS AND CLASSIFICATIONS.

10. Range of Physiological Science.—Anatomy describes the different parts or organs of an organic body, while Physiology teaches the use of each organ, and describes its mode of action. As we have vegetable and animal bodies, and both are organic, so we have vegetable anatomy and physiology, and animal anatomy and physiology. The first of these belongs properly to the science of Botany; the last is very appropriately divided into two sections: Comparative Anatomy and Physiology, and Human Anatomy and Physiology.

The first of these sections is devoted to the peculiar forms of the several organs and their functions in the lower animals, as compared with the corresponding organs and functions in the human body.

11. Limits of the present study.—In the following pages we propose to confine the discussion to the subject of Human Anatomy and Physiology, chiefly. No more of descriptive anatomy will be given than will enable the reader or student to understand the functions of the several organs described, and to treat these organs and functions so as to maintain, in the most perfect manner, their natural condition and proper action. This is health.

What Life is, we may not know; but what it does, and the laws by which it acts, are legitimate subjects of knowledge, as clearly within our reach as any other science.

12. Animal and Vegetable Nutrition — the difference.—Though the laws of animal life, in their leading and essential features, are the same in the lower animals as in man, yet in many of the details, both in the form of special organs, and the manner in which these perform their functions, there is a wide difference between the merely animal and the human.

All living bodies grow by absorbing substances unlike that of their own body, and by so changing it as to convert it into a substance exactly like that of their own organs. This is nutrition, and is a function common to all organic bodies. In vegetables, the matter thus appropriated remains a part of the body till the whole structure or organ dies, and by decay returns to the inorganic world.

In animals the matter furnished by nutrition, after it has served its purpose for a time, is removed, particle by particle, new matter being prepared and furnished by digestion to supply the place of the worn-out particles removed.

13. Animal Functions.—The work of repair is a feature which characterizes animal life, and is common to all its forms; indeed, this change of matter is not only common to all animals, but is essential to the maintenance of active life in them.

The manner in which motion is performed, is the same in man as in all other animals, however widely they may differ from the human form, or from each other. The breathing apparatus differs in many particulars in different animals; but to breath air, either by itself or in mixture with water, is a condition of active life from which no animal can escape.

14. Relation of Man to the lower Animals.—In all these respects man is an animal, but in other respects he is more than an animal. He has many characteristics that are purely human. In the frame-work of his body, man is constructed for an upright position; while in all other animals the natural position is that in which the spinal column, or backbone, is horizontal, or nearly so. Even the monkey when taught to stand erect does so with evident difficulty, and all his movements show his position to be a constrained one.

The configuration of the human face differs in many features from that of any other animal. For example: the lower jaw of all the inferior animals drops back immediately from the front teeth, while that of man projects forward, forming a chin. Certain very expressive functions or actions are peculiar to man, such as the power to shed tears, to laugh, to communicate his thoughts by articulate language, etc.

15. Classification of Man.—Naturalists concur in placing man at the head of the animal creation. They place him in an order distinct and separate from all other animals; and recognizing the fact that he alone has two hands, they name that order BIMANA; while monkeys are regarded as four-handed animals, and therefore as constituting the order *Quadrumana*.

If we study carefully the structure of that wonderful organ—the human hand, and observe closely its marvelous endowments and capabilities, we shall hardly be willing to say that a baboon is furnished with four such organs! The feet of a monkey are not real hands.

16. Mental and Moral Distinctions.—But it is chiefly in the perfection of his nervous system, and his superior mental endowments, that man rises above the mere animals that surround him, and stands alone in his endowments and capacities. The inferior animals certainly think and make inferences with regard to matters of their own personal experience—and so far they may be said to reason; but they are wholly incapable of reasoning on the abstract qualities of things, or of deducing general truths from special manifestations.

The moral sense—the abstract idea of right and wrong—is exclusively a human faculty, and belongs to man's spiritual nature. This is not merely a higher degree of the reasoning power of brutes, but a different kind of reasoning.

17. Abstract Thought—a human attribute.—It is to this power of abstract thought that man is indebted for his ability to contrive and construct machines to relieve his hands from the drudgery of manual toil; by this he discovers and applies natural laws, invents science, and perfects literature. While he is an animal—a very perfect animal in all his physical organs and faculties—he is something more than an animal in this.

This superior mental endowment should be made the basis of his classification; and as only organic life is displayed in the vegetable world, and this, with the animal-powers of sensation and volition superadded, is embodied in the animal kingdom, so both these, with the powers of abstract reason, moral sensibility, and the devotional attributes of his nature mark him as belonging to a grade of life as much above the mere animal as the animal is above the vegetable.

18. Form of Matter composing the Organs of the Body.—But our present task is to study man in the structure of that body which he has in common with other living organisms, and in the laws by which the various movements of that complicated machine are governed. Before entering on the study of this subject in detail, a few general statements and explanations may be of use in its introduction.

The human body is composed of solids, semi-solids, and fluids. These are constantly changing while the body lives. The semi-solid flesh, as well as the firm, compact bone, was once fluid in the form of blood; and, in due time, particle by particle, they will be dissolved, and becoming fluid again, will be carried away.

19. Tissues — their several offices. — The several parts of the body differ from each other in the character of their structure as well as in the substances out of which they are formed. These different structures are called Tissues. So we have the bony or osseous tissue in the bones which form the solid frame-work of the body; the fibrous tissue in the muscles which move these bones; the membranous tissue in the delicate skin or membrane which covers each organ, and lines every cavity of the body; the areolar or cellular tissue which fills all the spaces between the organs, and gives roundness and symmetry to the outlines of the body; the nervous tissue, that delicate structure seen in the substance of the brain, and in those white cords—the nerves—which extend from it to all parts of the body.

20. The three Systems.—The living human body, though evidently a unit; may yet be regarded, in its varied and complicated actions, as three systems acting in concert with each other. These are:

1st. *The System of Nutrition*, consisting of the apparatus of Digestion, of Circulation, and of Respiration.

2d. *The System of Voluntary Motion*, consisting of a bony skeleton with its joints and ligaments, and a muscular apparatus so constructed and arranged as to produce a great variety of motions.

3d. *The System of Nervous Sensibility and Motor Force.* This consists of the brain and spinal cord, with numerous nerves branching and ramifying through every tissue of the body. These several systems we shall proceed to consider in order.

Recapitulation.

Comparative Physiology likens the organs of inferior animals to those of man. This book treats of organs and their functions chiefly with reference to the preservation of health.

Vegetables acquire matter for growth which becomes permanent. Worn-out animal matter is replaced by new. Man is more than an animal in figure, face, and functions. Man forms the order Bimana; is distinguished by mental capacity, moral nature, and capability for abstract thought.

The body is composed of solids, semi-solids, and fluids. Tissues are osseous, fibrous, membranous, areolar, and nervous. The three systems in one body.

LESSON III.

NUTRITION.

21. Classification of Food.—The process of supplying material fitted for the growth and repair of the living body is properly nutrition; but as the maintenance of animal heat is intimately connected with this matter of nutrition, we shall consider them together, as parts of one process.

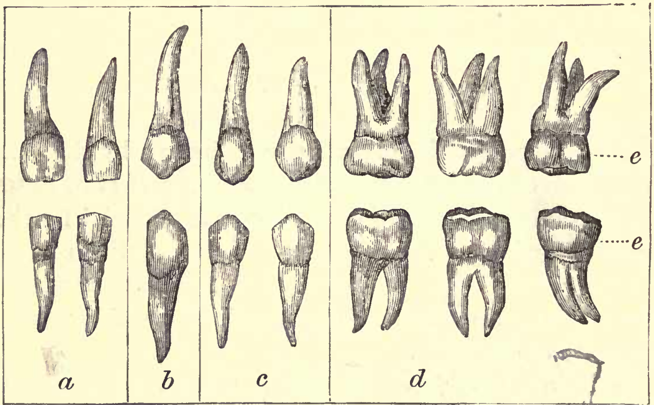
The crude material of nutrition is known by the general name of Food. This consists, however, of two classes of substances—that which supplies the material for the growth, and also to repair the wastes of the several tissues of the body; and that which, being consumed, constantly gives off heat to maintain the uniform temperature of the body.

The first class, from the close resemblance, in chemical composition, which all the articles of it bear to albumen (which is the substance of the white of eggs), is called albuminate food, and the latter class is known as carbonaceous food.

22. The Mouth—its functions.—The first act of nutrition is performed in the mouth, and is called *mastication.* It consists of crushing and grinding the food, thus reducing it to a state of fine division, and at the same time moistening it with a fluid furnished for the purpose called saliva. The mouth, where this work is done, is lined with a smooth covering always kept moist, when in a healthy condition, by a glairy fluid known as *mucus*, and hence this surface is named the mucous membrane.

This kind of a membrane lines all cavities of the body which communicate in any way with the air; while all the closed cavities, and the organs contained in them, are lined and covered with a dense, smooth, shining coat, called a serous membrane.

FIG. 5.—PERMANENT TEETH.

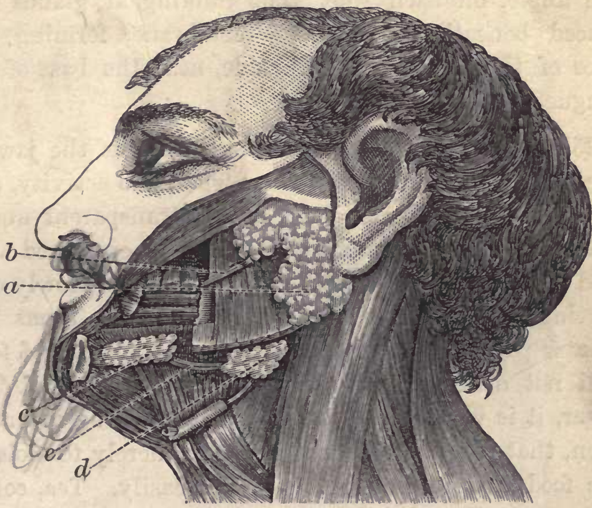


a. Incisors. *b.* Cuspids. *c.* Bi-cuspids. *d.* Molars. *e.* Wisdom-teeth.

23. Mastication—Classification of the Teeth.—The grinding of the food is performed by the Teeth. These are composed of a very hard, compact, bony substance, covered with a material still harder called enamel. There are two sets of teeth. The first, or temporary teeth, consist of ten in each jaw. They appear in infancy, and continue six or eight years, when they become loose and are crowded out by the permanent teeth. Of these there are sixteen in each jaw, or thirty-two in all.

The teeth are divided into four classes, as follows: The four front teeth in each jaw are called incisors, or cutting-teeth; the next tooth on each side of these is the cuspid, or canine-tooth; next follow two bi-cuspids on each side; and, lastly, three molars, or grinding-teeth, in each jaw. The last of these, on each side, is called the wisdom-tooth, because it does not appear until a person is twenty, and sometimes twenty-five years old.

FIG. 6.—SALIVARY GLANDS.



a. Parotid gland. *b.* Parotid duct. *c.* Sublingual gland. *d.* Submaxillary gland. *e.* Submaxillary duct.

24. Salivary Glands.—The saliva, with which the food is moistened in mastication, is furnished by a set of bodies called Salivary glands, whose office it is to separate this fluid from the blood. All the special fluids of the body are produced in a similar manner, so that the glands form an important group in the vital economy. Their action is called secretion.

The salivary glands are three in number on each side. The largest of these, called the Parotid gland, is situated behind the angle of the lower jaw, and forward of the external ear. It sends its saliva into the mouth through a tube or duct which opens opposite the second molar tooth, in the upper jaw.

The second pair, the Submaxillary glands, are located on the inner side of the lower jaw, a little forward of the angle, on each side. The Sublingual glands are placed beneath the mucous membrane, forming the floor of the mouth, on each side, near the base of the tongue.

25. Saliva — its use.—The movement of the jaw in the act of chewing excites these glands to activity, and they pour out a bland fluid, nearly transparent and a little heavier than water. This saliva, when mixed with food of the nature of starch, has the power of slowly converting it into sugar. Now starch, which forms the greater part of bread, potatoes, and such articles of food, will not dissolve in water; but when converted into sugar, it is very readily dissolved. It will be observed, then, that the saliva is not intended merely to moisten the food that it may be swallowed easily. Tea, coffee, water, or milk may be used for that purpose, but neither of these can be substituted for saliva without injuring digestion, for neither of them can change starch into sugar, or render it soluble in water.

26. Pharynx—its office.—In the act of chewing, the tongue is used to keep the food pressed between the teeth; and finally, when it is thoroughly reduced to a pulp, the tongue rolls it into a little ball, and carries it along its upper surface to the back part of the mouth, passes it between the pillars of the fauces, and under the hanging palate. These organs form a kind of gate-way from the mouth into the Pharynx. This is a funnel-shaped, muscular sack, covered on the inner surface with a continuation of the mucous membrane of the mouth.

The pharynx is a kind of common chamber, communicating with the mouth through the fauces, and with the nose by two passages called the posterior nares; with the ears, by two small funnel-shaped openings called the Eustachi n tubes; with the Larynx, or voice-box, by the glottis, which is closed by a firm valve called the epiglottis, that shuts down on it, and over which the food is carried to the opening at the small end of the funnel, where it terminates in the Œsophagus, or gullet.

FIG. 7.

a. Oblique fibers.
b. Longitudinal fibers exposed.

27. Œsophagus — its structure and function.—The Œsophagus is a tube extending from the pharynx to the stomach, and lies directly back of the windpipe. It is made of two coats or layers—an inner covering of mucous membrane, continued downward from the mouth through the pharynx, and an outer muscular coat composed of a layer of fibers running lengthwise, and a double set of fibers running spirally around the tube in each direction, and consequently crossing each other. The longitudinal fibers serve to hold the tube steady in the act of swallowing; while the oblique fibers, contracting behind the little ball of food, partly close the tube, and, the closure extending downward, carries it to the stomach.

Recapitulation.

Nutrition is that function which supplies the material for the growth of the body, and to repair its wastes; including, also, the material for the production of animal heat. This material is called food, and is divided into the albuminate and carbonaceous classes. Mastication, the first act of nutrition, is performed in the mouth, and consists in grinding the food and mixing it with saliva. The principal organs concerned in this are the teeth and the salivary glands.

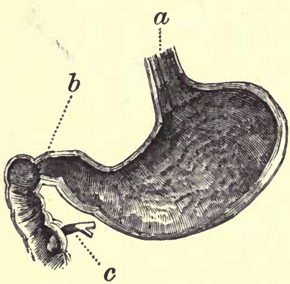
The pharynx receives the masticated food and passes it into the œsophagus, by which it is transmitted to the stomach.

LESSON IV.

DIGESTION.

28. Anatomy of the Stomach.—The Stomach, into which the œsophagus carries the food, is a curved sack or bag, lying obliquely across the body immediately below the diaphragm, which is a kind of partition separating the cavity of the chest or thorax above, from the abdomen below. The larger end of the stomach lies in the left side, and its greater curvature or rounded side is below.

FIG. 8.—THE STOMACH.



a. Cardiac orifice. *b.* Pyloric orifice. *c.* Pancreatic duct.

On the upper or concave side, a little nearer the left end of the stomach than the right, the œsophagus enters it. This is called the Cardiac orifice. Toward its right extremity the stomach becomes narrow, and finally passes into the intestines. At this point there is a band of muscular fibers, which are capable of contracting so as to close the opening entirely. This is called the Pyloric orifice.

29. Functions of the Stomach.—The stomach is composed of three coats. The inner or mucous coat is a continuation of that of the œsophagus, though differing from it in many particulars. It is very delicate and soft like velvet, and besides the little mucous glands or follicles it has a number of more complicated glands, whose mouths, opening on its surface, throw into the stomach a thin acid-fluid (the gastric juice) as often as food is taken. This gastric fluid, besides the acids dissolved in it, contains also a peculiar substance called *pepsin*, which, with the aid of a uniform heat, enables it to dissolve albuminate food.

30. Muscular and Peritoneal Coats of the Stomach.—The second coat of the stomach is a strong, muscular envelope, consisting of two sets of fibers—one running from end to end of the organ, and another running around it, and crossing the first nearly at right angles. The third coat of the stomach is a serous membrane—smooth and dense—it being a continuation of the Peritoneum, which membrane lines the whole cavity of the abdomen, and covers all the organs contained in it. This covering is reflected off from the lower surface of the diaphragm to the outer surface of the stomach, at the point where the œsophagus passes through that partition.

31. Process of Digestion.—A strong sympathy exists between the mouth and the stomach, for as soon as mastication commences, and the salivary glands begin to act freely, the peptic glands of the stomach pour out, at their numerous mouths, the gastric juice, ready to receive the food when it arrives.

As soon as this reaches the stomach, the muscular coats of that organ begin to contract, gently rolling the food from side to side, thus mixing it thoroughly with the gastric fluid constantly exuding from the inner coat of the stomach. In the meantime, the salivary glands are actively furnishing saliva, which is slowly converting the starchy part of the food into sugar, and thus dissolving it.

32. Formation of Chyme.—This action of the salivary glands has more of importance than is usually attached to it. The poisoning of the saliva by a quid of tobacco or a cigar, thus interfering with an important part of the process of digestion, is one of the fruitful sources of dyspepsia, however little the unfortunate victim may suspect it.

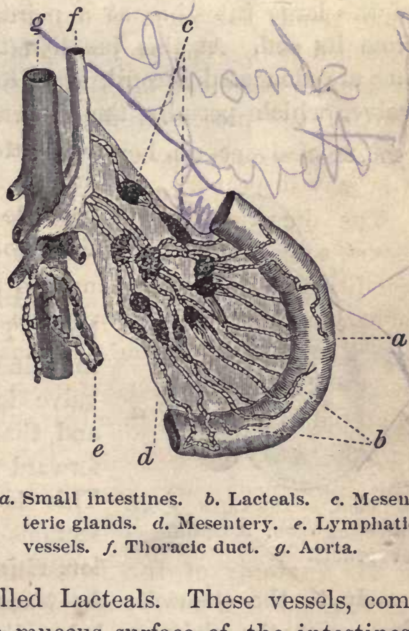
The digestive action continues from two to four hours, according to the nature of the food, the healthy condition of the organs engaged in the work, and the general vigor and activity of the body. The food thus acted on becomes a semi-fluid mass, nearly of a uniform character, however various and unlike the original material may have been. This substance, called Chyme, is now ready to be passed through the pylorus into the intestines, where it enters on the third and last stage of digestion.

33. Anatomy of the Intestinal Canal.—The Intestinal canal is a tube, varying in length from twenty-five to thirty feet, or even more than this in some individuals. This tube is divided into two sections, the small intestines and the large. The first section, or small intestines, are divided, for the sake of convenience in describing them, into three portions, called the Duodenum, Jejunum, and Ileum.

The canal, in all its parts, has an inner mucous membrane, a middle muscular coat, much thinner than that of the stomach, and an outer covering of serous membrane, the peritoneum, it being a continuation of that which covers the stomach.

34. Lacteals and Mesentery.—This peritoneal covering is reflected off from the back part of the tube, in its whole length, forming a double-fold of the membrane called the Mesentery, which binds the whole intestinal apparatus firmly to the posterior wall of the abdomen. The space between these folds of the peritoneum, forming the mesentery, is filled with a net-work of blood-vessels, nerves, and a class of vessels called Lacteals. These vessels, communicating with the mucous surface of the intestines, carry a milky fluid containing the nutritious part of

FIG. 9.—MESENTERY AND LACTEALS.

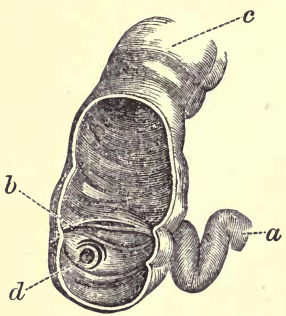


a. Small intestines. *b.* Lacteals. *c.* Mesenteric glands. *d.* Mesentery. *e.* Lymphatic vessels. *f.* Thoracic duct. *g.* Aorta.

the food in a dissolved state. The lacteals, in their passage through the mesentery, form clusters called mesenteric glands, in which the lacteal fluid undergoes an important change, by which it acquires many of the properties of blood.

35. Colon and Ileo-colic Valve.—The large intestines differ materially in their form from the small. There are contractions at short intervals, diminishing the size of the tube at those points, and forming an enlargement or kind of cell between them. The small intestines do not enter the large tube in a continuous line, but appear as if the ileum was spliced on the side of the large intestine, at a point three or four inches from its end. At this junction the lips of the opening are elongated inward, so as to form a very perfect valve, which permits the contents of the small intestines to pass into the large, but arrests all passage in the opposite direction. This is the Ileo-colic valve.

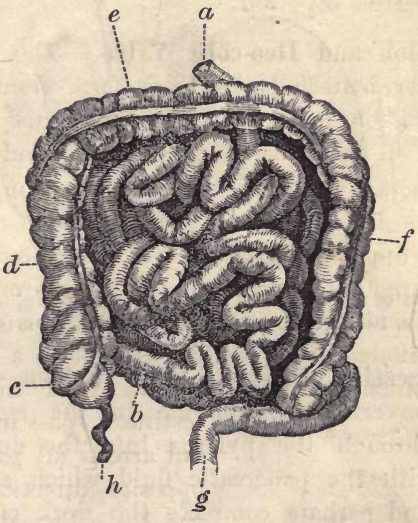
FIG. 10.—ILEO-COLIC VALVE.



a. Ileum. *b*. The valve. *c*. Ascending colon. *d*. Opening of appendix.

36. Direction of the Colon.—The closed end of the intestine lying back of this valve is called the Cæcum, and that portion which lies forward of it is the Colon. This is divided into three sections—the ascending colon, rising on the right side nearly to the stomach; the transverse colon, extending across the abdomen below the stomach; and the descending colon, passing down the left side to the rectum, which is the last division of the large intestines, and the termination of the intestinal canal.

FIG. 11.—INTESTINAL CANAL.

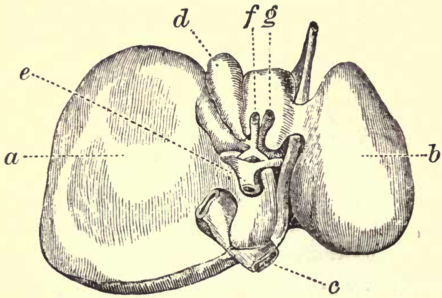


a. Duodenum. *b.* Ileum. *c.* Cæcum. *d.* Ascending colon. *e.* Transverse colon. *f.* Descending colon. *g.* Rectum. *h.* Vermiform appendix.

37. The Liver—its function.—The Liver, the largest gland of the body, is situated immediately below the diaphragm, and chiefly on the right side of the body. Its office (which will be more particularly described hereafter) is to separate from the blood a slightly tenacious yellow fluid, called bile, which is collected into the gall bladder, and from thence passed into the duodenum, a short distance below the stomach.

The Pancreas is a long, slender gland, lying under the convex surface of the stomach, and secreting a fluid very nearly resembling saliva, which it throws into the duodenum.

FIG. 12.—THE LIVER.



a. Right lobe of the liver. *b.* Left lobe. *c.* Vena cava. *d.* Gall bladder. *e.* Portal vein. *f.* Bile duct. *g.* Hepatic artery.

38. Digestive Process. The Spleen.—The food being converted into chyme in the stomach, and passed through the pylorus into the duodenum, is mixed with the pancreatic fluid which serves to dilute it, and perhaps complete the work of the saliva in converting the starch into sugar. The bile being alkaline, from the soda which it contains, neutralizes any acid which the chyme may have brought from the stomach; and it also has an effect on the oily portions of the food, so as to make them dissolve readily.

These changes convert the chyme into chyle, which, as a milky fluid, is absorbed by the lacteal vessels, and transmitted through the mesenteric glands into the Thoracic duct, which is the common trunk of all the lacteals. This vessel carries the lacteal fluid upward, and pours it into the large vein which returns the blood from the left arm. A little to the left, and below the great curvature of the stomach, lies the Spleen. It is made up chiefly of a net-work of blood-vessels. Its use, in the animal economy, has not been clearly determined.

Recapitulation.

The stomach is composed of three coats: an inner mucous coat, a middle muscular layer, and an outer serous membrane. The function of the stomach is to change the various forms of food into a homogeneous mass, and to render it soluble in water. This semi-fluid mass is called chyme. The intestinal canal is divided into two sections—the large and the small intestines. The mesentery, a double fold of the peritoneum, binds the intestines to the posterior wall of the abdomen, and contains the lacteal vessels between its folds. The liver secretes bile, which acting on the chyme, converts it into chyle.

LESSON V.

CIRCULATION.

39. The Apparatus of the Circulation.—Having, in the last lesson, followed the food through the first stage of preparation for nutrition, we now find it, if the work of digestion has been well done, prepared to enter the circulation, that it may be carried to all parts of the living body—to supply material for its growth in early life, and its repair at all times. This work of distributing the nutriment prepared by the changes it has undergone in the mouth, stomach, and intestines, to become a part of the living tissues, is performed by the *Heart, Arteries, Capillaries,* and *Veins.*

The heart consists of a right and left side, separated from each other by a strong partition, which, after birth, is entirely closed, so that there is no more communication between the right and left cavity than if the two sides were distinct and separate hearts.

40. Anatomy of the Heart.—Each side is composed of two chambers or cavities, capable of holding about two ounces of blood each. The first or upper one of these chambers is called the Auricle, and the lower one the Ventricle; and the two auricles and ventricles are distinguished from each other by the terms *right* and *left.* The right side of the heart receives the blood returning from all parts of the body, and sends it to the lungs to be purified and materially changed, from whence it is returned to the left side of the heart to be distributed again throughout the system.

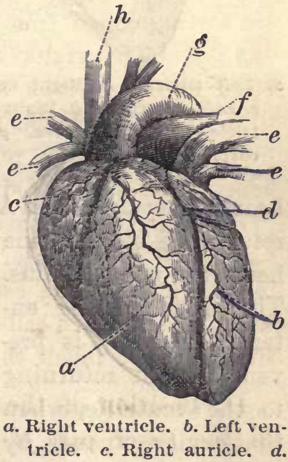
The lungs being near by the heart, the right side has much the lighter task, though the quantity of blood sent out from each side, in a given time, is the same. From this cause the walls of the right side of the heart are much thinner than on the left.

41. Position of the Heart.—The heart is situated in the lower part of the chest, between the folds of the partition separating the lungs from each other. It is a cone-shaped organ, with the base or large end directed upward and backward, pointing toward the right shoulder, while the apex or small end projects downward, forward, and to the left side.

When in vigorous motion, the point of the heart strikes against the front wall of the chest, and can be felt distinctly near the fifth rib on the left side. Its under side rests on the arch of the diaphragm, which separates the chest from the abdomen. The heart is inclosed in a membranous sac called the pericardium, between the inner surface of which and the heart there is always a small quantity of water, which serves to protect the heart from the effect of blows on the chest, or sudden movements of the body.

42. Action of the Heart.—The blood reaches the right auricle as it is returned from the veins; and by the contraction of the auricle, the venous blood is forced into the ventricle, through three triangular folds of a membrane. These are called the Tricuspid valves, and they are so arranged as to permit the blood to pass freely toward the ventricle, but close so as to arrest its passage in the opposite direction.

FIG. 13.—FRONT VIEW OF THE HEART.

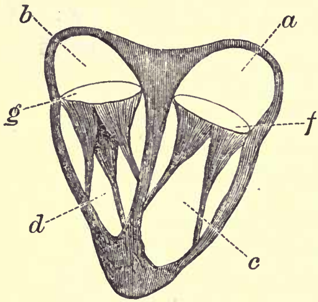


a. Right ventricle. *b*. Left ventricle. *c*. Right auricle. *d*. Left auricle. *e, e, e, e*. Pulmonary veins. *f*. Pulmonary artery. *g*. Aorta. *h*. Vena cava.

The ventricle being now filled, contracts on its contents, and the blood is forced into the Pulmonary artery, by which it is carried to the lungs. After passing the pulmonary capillaries, and undergoing a change of which we shall speak in the proper place, it is returned to the heart by the pulmonary vein.

43. Valves of the Heart and their use.—Entering the left auricle, the blood is transmitted through the valves, which, on this side of the heart, consist of two membranous folds called Mitral valves, into the left ventricle, whose walls consist of a firm and powerful muscle. It is now contracted, and the blood, propelled with considerable force, is thrown into a large tube called the Aorta.

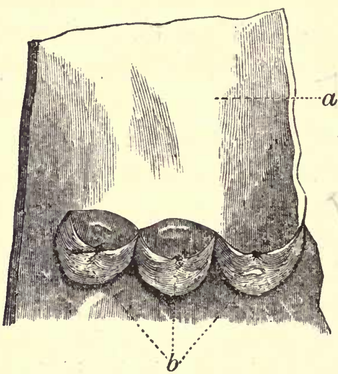
FIG. 14.—VALVES OF THE HEART.



a. Left auricle. *b.* Right auricle. *c.* Left ventricle. *d.* Right ventricle. *f.* Mitral valves. *g.* Tricuspid valves.

This tube may be taken as the representative of the whole class of blood-vessels whose office it is to carry the blood *from* the heart. They are called Arteries, while those vessels which return the blood to the heart are named Veins. The blood having entered the aorta, is prevented from returning to the ventricle, when that cavity expands, by three folds of the inner coat of the artery, which from their shape are called Semi-lunar valves.

FIG. 15.—SEMI-LUNAR VALVES.



a. A section of the aorta laid open. *b.* The semi-lunar valves.

44. Arteries, Capillaries, and Veins — their anatomy. — The arteries are firm, elastic tubes, made of three coats. The external coat is of a spongy, cellular texture; the middle coat is of very dense, fibrous material, generally regarded as muscular; the inner coat is a smooth and very fine serous membrane, being a continuation, from the heart, of the lining membrane of the ventricle. The aorta sends off branches to all the living organs of the body; even the heart itself receives a pair of arteries from the aorta, to carry to it material for its repair.

These branches, as they divide and sub-divide, grow constantly smaller, but more numerous, till at last they terminate in a net-work of hair-like vessels, called Capillaries, almost infinite in number. These vessels give origin to the system of veins which, running into each other, become less and less numerous, till finally they form one great trunk, the Vena Cava, through which all the veins of the general circulation communicate with the heart.

45. Forces concerned in the Circulation.—Several forces are concerned in the circulation of the blood, the first and chief of which is the contraction and expansion of the heart. Though the heart is a double organ, and concerned in carrying on two distinct circulations —one to the lungs and the other to the general system—yet all its parts work in concert.

The two auricles contract at one time, and while they are contracting, the ventricle is expanded on each side; but as soon as these are filled with blood, they begin to close the cavity, and, by a powerful contraction, the contents of each ventricle is injected into the artery united with it. While this is going on, the auricles are expanded to receive the constant stream of blood returned by the great veins.

46. The Pulse.—Each contraction of the ventricle gives a wave-like motion to the blood in the arteries. This is the Pulse. It is probably assisted by a contraction of the artery itself, following directly after the wave of blood. The changes which are made in the condition of the blood while passing through the capillaries, evidently exert a force in transmitting it through these minute passages. This force is entirely independent of the contraction of the heart. The blood is thus constantly forced into the veins; these vessels, being filled, must overflow into the right auricle. The veins are passive in the work of circulation.

Recapitulation.

The circulation is carried on by the heart, arteries, veins, and capillaries. The heart is a double organ, consisting of a right and left side, and each side is composed of an auricle and a ventricle. The heart is inclosed in a sac—the pericardium—and lies in the partition separating the lungs, its larger end looking upward and backward, and its smaller downward and forward. Valves are interposed between the auricles and ventricles on each side of the heart. The arteries convey the blood from the heart, and the veins return it to that organ. The capillaries unite the arteries with the veins. The contraction and expansion of the heart is the chief force concerned in the arterial circulation.

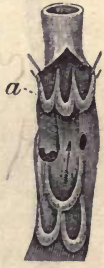
LESSON VI.

CIRCULATION.—CONTINUED.

47. Veins—their Valves.—The veins originating in the net-work of capillaries, and joining together, form constantly enlarging trunks; but these, unlike the arteries, are soft and easily compressed. The middle or fibrous coat is almost entirely wanting, and the two remaining coats are much thinner than those of the arteries. When emptied of their contents, the arteries remain open tubes; but the veins, under similar circumstances, collapse—the walls falling in on each other.

At irregular intervals, the internal coat of the veins forms pouches or folds, which operate most effectually as valves. They are so arranged that the open end of the pouch is turned toward the heart, and when the blood flows in that direction, the valve closes down against the wall of the vein; but an attempt to force a flow in the opposite direction, fills the pouch with blood, and, by its enlargement, closes the vein completely.

FIG. 16.—VALVES OF THE VEINS.



a. A vein laid open, exposing the valves.

48. Venous Circulation effected by Muscular Movements.—The veins being soft, and passing freely through and among the moving machinery of the body, are constantly compressed by these movements, and the valves preventing this compression from forcing the blood backward into the capillaries, become material aids in transmitting the blood through the veins.

It is sometimes important to be able to distinguish a vein from an artery at once. When the vessel is opened and blood is issuing from it—if it be an artery, it will flow in intermittent jets corresponding to the pulsations of the heart; if it be a vein, the flow will be a constant stream. If the vessel be not opened, the pulsating motion may be seen or felt even in a small artery, but in a vein no such movement is perceptible.

49. Lymphatic Vessels—their functions.—There is another class of vessels, called Lymphatics, which perform an important office in the circulation. They resemble small veins in their general structure, but carry a transparent fluid instead of blood. Their valves are more numerous than those of the veins, and the small tubes show but little disposition to unite, often running parallel with each other, in clusters, for some distance. In some parts of the body, as about the neck, groins, and armpits, the lymphatics form numerous clusters or balls, called lymphatic glands. These are the principal seat of scrofulous diseases. In their structure they are much like the mesenteric glands.

FIG. 17.—A LYMPHATIC VESSEL MAGNIFIED.

The lymphatics are chiefly employed in taking up and conveying to the blood-vessels the waste matter resulting from the constant wear of the tissues. They all communicate with the venous side of the circulation, so that the blood with which the lymphatic circulation is mingled is not sent out into the general circulation till it has been purified in the lungs. No lymphatics have yet been detected in the brain, in tendon, cartilage, or bone. In these tissues the office of the lymphatics is probably performed by veins. The lacteals, in their general character and work, very much resemble lymphatics.

50. Absorbents — their action. — A class of lymphatic vessels, called Absorbents, are engaged in the business of taking up fluids from the external surface of the body, and the surface of internal cavities. Various kinds of liquids, when applied to the skin, can be detected in the circulation, and in the different secretions, in a very short time. In the same manner, substances inhaled are taken up by the absorbents, and carried directly into the blood-vessels, to be mingled with all the fluids of the body. In this manner poisons are often imbibed and diseases contracted, without the slightest suspicion of the manner of taking the poison.

51. Absorbents in Serous Membranes. — Another office of the absorbent vessels is to take up and carry away the fluids constantly exhaled from the surface of membranes lining cavities. There is, in a healthy state of these serous membranes, a very nice adjustment in the work done by the exhalent and absorbent vessels, so as to keep the surface constantly moistened, and yet suffer no accumulations of fluids in such cavities. Dropsy is but the disturbance of this nicely balanced exhalation and absorption.

Simple fluids, like water, are not subject to any change in the stomach, nor do they take the circuitous route, by way of the lacteals and thoracic duct, to the circulation, but are absorbed directly from the surface of the stomach, and pass into the veins at once. Even alcohol or turpentine, taken into the stomach, can be detected in the air breathed from the lungs, in a very short time after it is swallowed.

52. Anastomosing Vessels. — The vessels constituting the circulatory apparatus, whether arteries, veins, capillaries, or lymphatics, often communicate by collateral branches, but always with vessels of their own kind.

By means of these vessels, called Anastomosing branches, the surgeon is able to preserve the life of a part, though he may be required to tie the principal artery supplying that part with blood. An anastomosing branch, connecting the injured vessel below the ligature with a neighboring artery, will furnish a partial supply of blood; and becoming enlarged by the increased work it is required to do, the anastomosing vessel soon acquires the capacity of the original trunk, and performs its office effectually.

Recapitulation.

The heart is a double organ, carrying on two circulations at the same time.

The right side of the heart is devoted to the pulmonary circulation, or that carried on through the lungs for the purpose of purifying and oxidizing the blood.

The left side of the heart is engaged in the distribution of the blood to all parts of the body, for its nutrition.

In health the heart makes about seventy-five contractions in a minute.

Arteries carry the blood from the heart — veins return it to that organ.

Capillaries connect the extremities of the arterial and venous circulations; hence all arteries terminate in capillaries, and all veins have their origin there.

The change from arterial to venous blood takes place in the capillaries of the general circulation, and the opposite change in the capillaries of the pulmonary circulation.

LESSON VII.

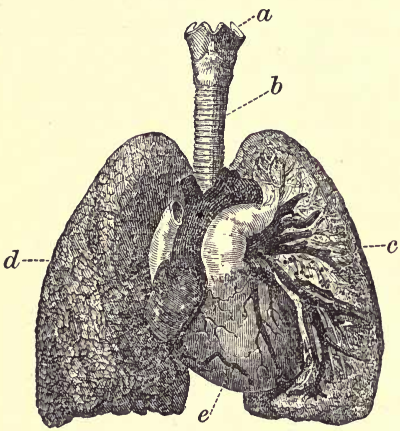
RESPIRATION.

53. The Respiratory Organs and their use.—The respiratory apparatus consists of a trachea or windpipe, two lungs, the bronchial tubes, and air-cells. Auxiliary to these are the ribs, and the muscles between them; the diaphragm, and the abdominal muscles. The purpose of this rather complicated apparatus is two-fold: first, to impart to the blood oxygen, which is one of the constituents of the air; and, second, to relieve the blood of carbonic acid and watery vapor, which it has acquired in passing through the capillaries, and which has resulted from the decomposition of the worn-out particles of the body and of the carbonaceous food.

54. Position of the Lungs.—The body or trunk is divided into two great cavities. In the abdomen or lower one of these is placed the digestive apparatus, which we have already described. The upper one is devoted to the Heart and great blood-vessels, which are situated in the space between the walls of a double partition that completely separates the cavity into two apartments; and to the Lungs, one of which fills each of these apartments. This cavity is called the Thorax or Chest. Unlike the abdomen, it is surrounded by bony walls on all sides, except the bottom, where it is separated from the abdomen by the diaphragm. The natural shape of the chest is that of a cone, with its small end upward, and its base resting on the diaphragm below.

55. Trachea and Bronchia.—The Trachea is a tube extending from the air-passages of the nose and the mouth to a point nearly opposite the top of the breast-bone, where it separates into two branches, which, from this point, take the name of Bronchia. These bronchial tubes divide and sub-divide as they distribute themselves through the lungs—each tube finally terminating in a little sac called an air-cell. These tubes, both the trachea and bronchia, are composed of rings formed of a hard, elastic substance, called cartilage. In the trachea the rings are not quite closed on the back part, thus leaving a soft side to the tube for the accommodation of the æsophagus, which lies immediately behind it.

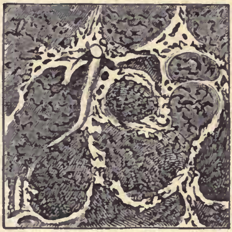
Fig. 18.—Respiratory Apparatus.



a. Larynx. *b.* Trachea. *c.* Left lung. *d.* Right lung. *e.* Heart.

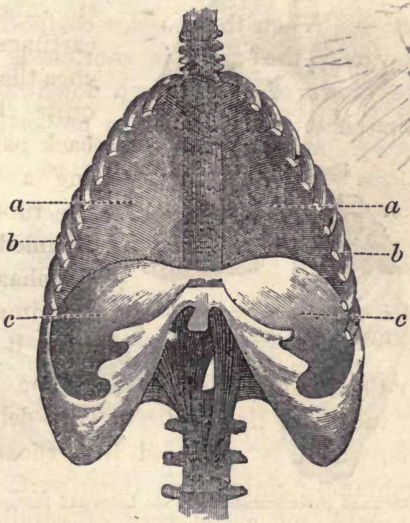
56. Air-Cells and their use. — The trachea and bronchial tubes are lined with a very delicate mucous membrane, which is extended into the air-cells. On this membrane, forming the inner surface of the air-cells, is spread out a net-work of capillary vessels—the terminations of the pulmonary artery. This membrane permits gases to pass through it readily, and thus the oxygen from the air in the air-cells is transmitted to the blood; and the carbonic acid contained in the blood-vessels passes in the opposite direction, and escapes with the air exhaled from the lungs.

FIG. 19.—AIR-CELLS.



Pure air is nearly one-fifth oxygen, and four-fifths nitrogen. These gases are not combined together, but are merely in a state of mixture. When the air is taken into the lungs, it contains about twenty-one per cent of oxygen, but it is returned with but about seventeen per cent; the loss, however, is filled by nearly four per cent of carbonic acid and

FIG. 20.—DIAPHRAGM.



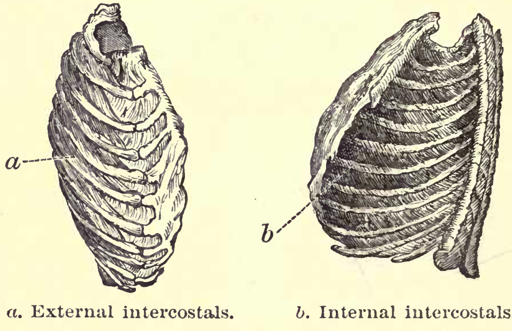
a, a. Cavity of the right and left lungs. *b, b.* Ends of the ribs, which are removed to expose the diaphragm. *c, c.* Arch of the diaphragm.

watery vapor. This proportion varies a little in different individuals, and in the same individual in different states of health; but this is about the average result in a healthy person.

57. Mechanism of Respiration. Diaphragm.—In the act of breathing, the lungs are passive, the air being drawn in by the enlargement of the chest, made by the action of the Diaphragm and the muscles between the ribs.

The diaphragm is the floor of the chest. It is composed of at least two layers of muscles, covered on its under side by the peritoneum, and above by the pleura, a serous membrane lining the cavity of the chest, and covering the lungs. The diaphragm has nearly the shape of an inverted basin, being an irregular arch in every direction. When the muscles composing the diaphragm contract, the arch is shortened, and consequently the crown of it is drawn downward, and the cavity of the chest made deeper in proportion.

FIG. 21.—INTERCOSTAL MUSCLES.



a. External intercostals. *b*. Internal intercostals.

58. Ribs and Intercostal Muscles.—The ribs are articulated to the spinal column by a movable joint, and in front they are attached to the breast-bone by a flexible cartilage. They are curved around the body like a hoop; but they are also bent downward from the back and to a little beyond the middle of the rib, from which they ascend to the breast-bone. The space between the ribs is filled by two layers of muscles, passing obliquely from one rib to the other. They are called the external and internal intercostals.

The upper rib, being nearly immovable, acts as a fixed point to which the whole series is attached by means of the intercostal muscles. And when these contract, the middle of each rib is drawn upward, and consequently the chest is enlarged in its transverse diameter.

59. How we Breathe.—Now, as the lungs completely fill the cavity they each occupy, and the fold of the pleura covering the lungs, and that lining the chest, are in actual contact, it follows that the increased space made by enlarging the cavity of the chest, can be filled only by the air passing into the air-cells, and thus enlarging the lungs sufficiently to fill the enlarged cavities they occupy. By this movement, about twenty-five cubic inches of air are drawn in at an ordinary respiration.

But a healthy pair of lungs will contain, in common breathing, about two hundred cubic inches of air, so that only about one-eighth of it is changed at each breath. The relaxation of the diaphragm and intercostal muscles, though necessary for the expulsion of the air inhaled, is not of itself depended on in the economy of respiration. From the arch of the large bone on each side, which forms the basin-like cavity terminating the abdomen below, there arise several muscles which form the walls of that cavity. A pair of these are attached, above, to the ribs, and, on contracting, draw these downward. Other muscles run transversely or obliquely around the abdomen, which, by their contraction, force the contents of the abdomen upward, and thus elevate the arch of the diaphragm, and expel the air inhaled.

Recapitulation.

Respiration is carried on by means of the trachea and lungs. The lungs consist chiefly of bronchial tubes, air-cells, and blood-vessels. The ribs and their muscles, the diaphragm and the abdominal muscles, give the movements in breathing. The lungs are entirely separated by a double partition. Respiration supplies oxygen to the blood, and removes impurities from it. These changes take place in the air-cells. The cavities containing the lungs are enlarged by the contraction of the diaphragm depressing its arch, and by the elevation of the ribs increasing the lateral dimensions. The space thus made is filled by air passing through the trachea and bronchia. The contraction of the abdominal muscles elevates the arch of the diaphragm, and thus expels the air.

LESSON VIII.

RESPIRATION — PURIFICATION OF THE BLOOD.

60. Two-fold Purpose of Respiration.—Respiration serves a two-fold purpose in the animal economy. First, it furnishes oxygen to the blood. This is carried by the circulation to all the tissues of the body, where it combines with the elements of the old and worn-out particles, forming with them new compounds, capable of being dissolved in the blood and thus carried forward into the veins. At the same time, in the capillaries, it comes into close contact with the carbonaceous elements of the newly digested food, combines with its carbon, forming carbonic acid, disengaging its other elements to form water. From these changes the heat of the body is supplied and maintained.

But these products, resulting from the combination of the oxygen with the tissues and with the food, being thrown into the circulation, load the blood with impurities. The second purpose of respiration is to relieve the blood of these impurities. All the carbonic acid generated in the living body, and a large portion of watery vapor, as well as numerous other substances which find their way into the circulation and are incapable of being made a part of the living body, are discharged by the lungs.

61. Chemical Changes — the Source of Animal Heat. — The production of heat by the chemical changes constantly taking place in animal bodies, appears to be intimately connected with the evolution and expenditure of force in the body. Every movement of the body, or any part of it, requires a certain amount of force to accomplish it, proportioned to the extent and violence of the movement; and, as many of these motions are constant, and all of them frequent, they demand a constant and uniform supply of this force. This they have in respiration and its results. Hence it follows, that as we increase the active exercise of the body, there is a corresponding increase of breathing; and more oxygen being thus distributed to the tissues, more chemical action takes place, and from this heat and force are evolved.

62. Products of Respiration.—But all this is consuming both the tissues of the body and the carbonaceous elements of the food, and this waste must be supplied by additional food, consequently exercise in the open air increases the appetite, and invigorates all the vital functions, thus furnishing new material, well prepared to replace the worn-out particles of the tissues, and enabling the several organs, whose duty it is to carry off and dispose of the old matter, to do that work effectually. A large proportion of this waste is converted into carbonic acid, which is formed by the direct union of the oxygen inhaled, and the carbon of the tissues. This being carried to the lungs, escapes with the air exhaled in respiration.

If we fill a vessel with clear lime-water, and, through a tube, blow our breath into it, we shall soon perceive it becoming milky from the carbonic acid of the breath combining with the lime. The hydrogen, another element of the worn-out particles, unites also with the oxygen communicated to the blood in breathing, and thus forms water, a great part of which is thrown off from the lungs as vapor.

63. Other Means of Purifying the Blood.—Other portions of this waste material, rendered fluid by combination with oxygen, are taken up by the absorbents, and carried into the circulation, from which they are separated by the process of secretion. This operation is performed by a class of organs called Glands. The largest gland of the body is the liver, whose duty it is to separate, from the venous blood circulating through it, a peculiar fluid, the bile, which, as we have learned (§ 38), performs an important office in the conversion of chyme into chyle. A large part of the bile, in performing this work, is itself changed into sugar, in which form it re-enters the circulation as a carbonaceous element of the blood. The remainder of the bile, which is incapable of this change, is passed off as excrement.

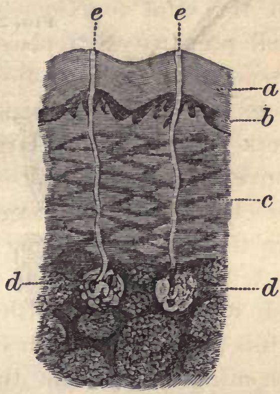


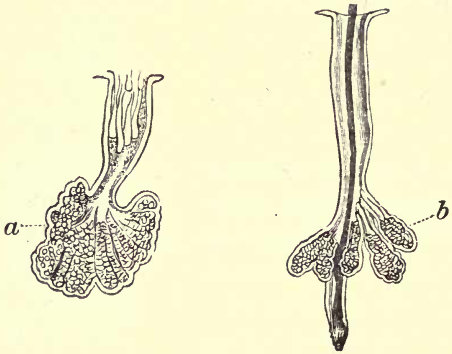
FIG. 22.—PERSPIRATORY GLANDS.

a. Cuticle. *b.* Colored layer of the skin (rete mucosum). *c.* True skin. *d, d.* Perspiratory glands. *e, e.* Perspiratory ducts.

The Skin is another important outlet of the wastes of the living body. A cluster of small glands forms the lower surface of the skin, and from each gland a small tube, called a perspiratory duct, winds its way in a spiral course through the skin to its external surface. The mouths of these form what are commonly called the pores of the skin. The perspiration consists chiefly of water, with various saline matters dissolved in it. Under ordinary circumstances, it passes off in the form of vapor, and is called *insensible perspiration*, because it is not observed; but when the secretion becomes more active, it is liquid, forming drops of sweat.

64. The Skin. Perspiratory and Oil Glands.—Another set of glands are located near the surface of the skin, smaller and much simpler than the perspiratory glands. They are the oil glands, or *sebaceous follicles*, which furnish oil to keep the surface of the skin soft and pliable. The kidneys also perform an important office in the work of purifying the blood. They are a pair of large glands, situated in the upper and back part of the abdomen, and are concerned in separating from the blood a peculiar substance called Urea, which is formed in the decomposition of the tissues.

FIG. 23.—OIL GLANDS.



a. Simple oil gland. *b.* Oil glands surrounding a hair.

Through these various outlets we see what ample provision is made for purifying the blood, and removing from the system the waste matter resulting from the tranformation of the tissues. No one of these organs can suspend action, or be impaired in its functions, without deranging the healthy condition of the whole vital machinery.

65. Temperature Measured by the Air Breathed.— But a result of respiration, no less curious than it is important, is that of enabling a living body to maintain a nearly uniform heat independent of the temperature of the surrounding medium. It required many years of patient observation, and investigation, to reach the cause of this wonderful phenomenon, and even yet there is much connected with it that is but imperfectly understood; enough however is known to satisfy scientific men that, primarily, animal heat depends on respiration.

Fishes, whose respiration is carried on by gills, obtaining merely a portion of the oxygen which water is capable of absorbing, have a temperature but little above that of the water in which they live. Reptiles, breathing with membranous lungs, and inhaling but a small volumn of air, and retaining but little of its oxygen, are cold-blooded animals, or nearly so. With them, breathing may be suspended for an hour or more, even while the animal is active; and when the temperature of the atmosphere falls to near the freezing point, respiration is suspended entirely and indefinitely, and the reptile remains torpid until the temperature rises again.

66. Mean Temperature of the Body. Effect of Evaporation.—Among warm-blooded animals the temperature varies somewhat, but is always measured by the amount of oxygen consumed. In man, the temperature, in health, varies but little from ninety-eight degrees Fahr.; in many of the inferior animals it falls below this; while in birds, it rises above one hundred degrees; but birds breathe more air, in proportion to their weight, than even man. The actual amount of air consumed in respiration is not to be measured by the number of cubic feet of air inhaled in a given time, as the volume of all gasses is materially increased by an elevation of temperature.

A person, breathing an atmosphere at zero, will inhale a much greater quantity of air in the same volume than he will with the temperature at eighty degrees. This important provision materially aids in maintaining the heat of the body in cold climates. The increased quantity of food required in the winter season, as well as the kind of food which the appetite demands, is a wise provision for accomplishing the same purpose.

To modify the effects of a high temperature, the perspiratory function of the skin is the chief agent. Evaporation is a cooling process; when, therefore, the heat of the air approaches the natural temperature of the body, a copious evaporation from the skin relieves the heat.

Recapitulation.

Respiration furnishes the blood with oxygen, and carries off impurities; these changes are the source of animal heat.

Secretion is performed by glands. The liver secretes bile. The cutaneous surface, prespiration. Oil glands. The kidneys separate urea from the blood.

Animal heat depends on respiration. Normal temperature of the human body is ninety-eight degrees, and is uniform in different climates.

LESSON IX.

GROWTH AND REPAIR.

67. Growth and Repair—why complex.—The immediate action of nutrition, that is, the original growth of all the parts of the body, and the repair of the constant waste which is the necessary result of every motion in the animal machine, is a very complicated process, and there is much about it which is but imperfectly understood; much which the human mind may never fully comprehend. What is done, we know; and the general laws under which the great work of growth and of repair is carried on, are understood in the main points relating to their practical application. From the very nature of the chemical and vital forces involved in this work, there must remain much that is unknown, perhaps unknowable.

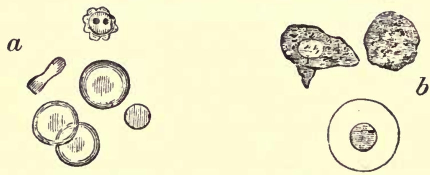
68. Composition of the Blood.—All the tissues of the body, from the tender and delicately organized brain to the most compact and solid bone, are formed from material taken into the body as food, digested in the stomach, dissolved in the blood, and from that fluid separated and built into its proper place, while that fluid is being transmitted through the capillaries. Healthy blood, on cooling, separates into a semi-solid substance called Coagulum, and a nearly transparent fluid, the Serum. This serum is the basis of the blood, and may be considered as water, holding the coagulum and several mineral substances in solution.

In every one hundred parts of blood, there are seventy-nine parts water, and twenty-one parts of dry solids. These solids are dissolved in the serum, and held in that condition by the living state of the blood, and its constant motion. If the blood be drawn into a basin, though it be kept at the natural temperature of the body, yet it rapidly separates into coagulum and serum.

69. Proportion of the Ingredients in the Blood.—The coagulum, if carefully washed in cold water, may be reduced to a white fibrous mass, much like muscles in composition and appearance. The matter which has been washed out is found to consist of a coloring substance rich in iron, from the oxide of which metal it has been supposed to derive its color.

Of the twenty-one parts, in one hundred, of solid matter contained in healthy blood, about one-seventh is composed of saline matter, (chiefly common salt,) of fatty substance, and sugar; two-sevenths consist of albumen, a substance like the white of an egg; and the remaining four-sevenths appear to be derived from the breaking down of minute disks, which the microscope reveals in great numbers in the blood.

FIG. 21.—BLOOD DISKS.



a. Colored disks—various forms. *b.* Colorless disks—different appearances.

70. Blood Disks—two kinds.—Of these disks, or corpuscles, as they are sometimes called, two kinds are observed in the blood of all animals which suckle their young, colored corpuscles and colorless ones. The colored corpuscles seen in the human blood, are small, circular bodies, flattened into thin plates or disks. The colorless corpuscles are more globular in form, and vary in number with the changing condition of the system.

While the colored corpuscles appear to be a constituent part of the blood itself, those without color seem in some way intimately connected with the appropriation of nutriment to the growth and repair of the various organs.

71. Cell Structure of the Tissues.—Among the astonishing revelations of the microscope, none is more marvelous than the truth that all living forms, animal and vegetable, are, in their ultimate structure, composed of cells. These cells, in their original form, are globular, or slightly elliptical, but when they are built into tissues, the pressure of the adjoining cells gives them a great variety of forms. Sometimes they adhere together like strings of beads, and form fibers, as in the muscular tissue; sometimes the cell-walls are absorbed at the point of adhesion, and thus the fiber becomes a tube, as in the white matter of the brain; and again, the globular cell will assume strange and irregular forms, as seen in the gray matter of the brain.

72. Cells—how formed and removed.—All the various tissues of the body are thus formed, and the original cells appear very much alike. They resemble little bladders or sacs, filled with a transparent fluid; but the cell-walls permit both fluids and gases to pass in and out of the cell readily, and by this means the cell becomes filled with the proper material to form the different tissues of the body. Thus earthy matter, filling cells, forms solid bone; fibrine, in a like manner, forms muscle; and, in like manner, all the other tissues are formed.

In the waste and repair of the tissues, the work on both sides proceeds by cells. In the activities of the system, the cells, one by one, are broken down, the material of which they were formed is taken up by the absorbents and conveyed to the proper organs to be disposed of, and instantly the place of each removed cell is occupied by a new and more vigorous one.

73. Modes of Cell Growth.—These cells, whether produced in the fluids of the body, or in more intimate connection with the tissues, are always produced from a pre-existent cell. In the production of cells in vegetable growth, we have been able to examine the process much more clearly than is possible in the animal tissues. Here we learn that they multiply in several ways. An existing cell may become lengthened, and growing narrow in the middle, may assume the hourglass form, and finally separate into a pair of independent cells; or cells may sprout from the opposite points of an existing cell, as from the poles of a globe, and, having attained their growth, disengage themselves from the parent cell.

In whatever way cells may be multiplied or produced, no well-established instance of the production of a cell without direct connection with a pre-existing one has been placed on record.

74. Life Force—its relation to Cell Destruction.—The transformation of the tissues by the removal of old cells, and the formation and deposition of new ones to supply their place, appears to be, in some way, intimately connected with the production and expenditure of force in the animal economy. Every movement of the body is accompanied with a correspondent waste of cells, and a proportional expenditure of force. We live by the death and renewal, one by one, of the cells composing the living machinery; and that machinery is kept in working order only by being constantly renewed. To impair or disturb this destruction and renewal of the cell structure, is to produce disease, and to arrest it, is death.

75. The Blood the Agent of Cell Transformation.—The blood is the immediate instrument of this vital action. It conveys the prepared material for the new cells to the tissues where it is to be used, and removes the remains of the decomposed cells; and as these changes must be constant and unintermittent, that life may be maintained, so the blood must be kept in constant and incessant motion, that the cell transformation may not be interrupted. The pulsation of the arteries, measuring the circulation of the blood, becomes the most important index of t[illegible] nner in which the life functions are being ca[illegible] at any given time.

76. Quantity of Blood.—The qu[illegible] cir-culating in the body is constantly [illegible] in the same individual; and in differ[illegible] es with age, state of health, habits [illegible] food, exercise, etc. As a general [illegible] to estimate the quantity of blo[illegible] of the weight of the body. It [illegible] to the tissues will depend m[illegible] and this will, to a great exte[illegible] be[illegible] quality of food, and its perfect digest[illegible]

Recapitulation

Growth and repair are complex, and [illegible]. All parts of the body are repaired from t[illegible] d substance of healthy blood. Blood disks [illegible]

All animal and vegetable structures ar[illegible] s of various forms. Formation and removal [illegible] their growth. Relation of the death and rene[illegible] al o[illegible] fe.

Cells are built by the blood. The blood constitutes about one-tenth the weight of the body.

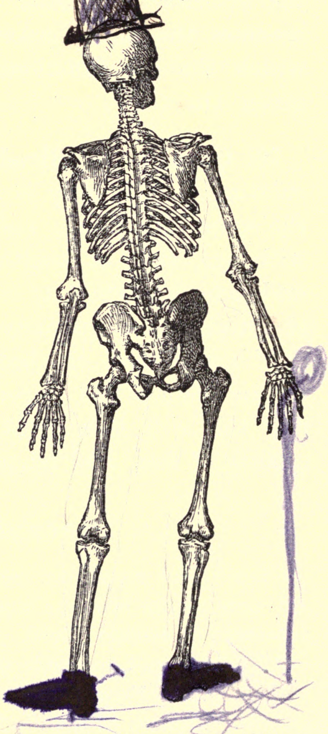
LESSON X.

SYSTEM OF VOLUNTARY MOTION.

77. Bones—their use—how formed.—Having briefly considered the system of nutrition, in the several functions which contribute to carry on that work,

FIG. 25.—FRONT VIEW OF THE SKELETON.

FIG. 26.—BACK VIEW OF THE SKELETON.



we proceed to look at the system of voluntary motion. This consists of a number of Bones, so formed as to serve as solid levers of motion, or to act as a protection from injury to the important and more delicate organs of the body.

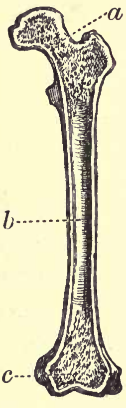
These bones are originally formed of an elastic, semi-solid substance called Cartilage. The earthy matter is afterward deposited in it, so as to give to bone the density and general character of a mineral substance. This process of changing cartilage to bone is called *ossification*. In the long bones, such as those of the limbs, ossification begins near the middle, and extends gradually toward the extremities, leaving a portion of the extreme end of the bone, which, except in very old persons, still remain cartilaginous.

78. Composition of Bone.—The proportion of animal and earthy matter varies with the age of the person, with the diet, habits of life, etc. In childhood, the earthy matter forms about one-half the weight of the bone; in adult life, four-fifths; and in extreme old age, as much as nine-tenths. The hardness and brittleness of bone depends on the proportion of earthy matter. And hence the bones of old persons are easily fractured, and unite slowly when broken; on the other hand, the bones of children are readily bent or distorted by confinement in improper positions.

The earthy matter of bone consists almost entirely of lime, in combination with phosphoric and carbonic acids, and, like every other part of the living body, is subject to the general law of removal and replacement; but the transformation goes on more slowly in the bones than in the softer tissues of the body.

79. Structure of Bones.—Bones are covered with a dense fibrous membrane, called the Periosteum, from which they are supplied with nutritive vessels. In the long bones, the center of the bone is hollowed out, leaving a cavity which is filled with fatty matter called marrow. This marrow cavity does not extend entirely to the ends of the shaft, but its place is supplied by a porous structure, which not only fills the cavity, but expands the extremity of the bone, so as to furnish a greater bearing surface at the joints. The flat bones, such as those of the head, are composed of two plates of solid, osseous matter, and an intermediate space filled with a cellular, bony structure.

FIG. 27.—STRUCTURE OF THE LONG BONES.



a, c. Spongy extremities of the femur.
b. Marrow cavity in the shaft.

80. Mechanism of the Long Bones.—Principles well known to mechanical philosophers are involved in this arrangement of bone material. Lightness is of great importance in a moving limb; but, at the same time, strength must be provided for in bones intended to sustain the weight of the body, and to afford attachment to powerful muscles which are to be the instruments of complicated, vigorous, and rapid motions. In no other way could both these objects be secured so effectually, as by making the shafts of the bones hollow.

But a firm articulation requires that the surfaces of the bones which bear on each other at the joints, should be broader than that which a cross section of the bone in the middle of the shaft would give. The spongy texture of the bones at their articulating ends, as seen in the long bones of the limbs, admirably accomplish this purpose, without increasing the weight or diminishing the strength.

81. Bones not Sensitive.—In a healthy condition, bones have no sensibility. When they become diseased, however, they are often acutely sensitive. The popular idea, that the marrow of a bone is very painful when touched, is altogether false. Marrow is simply fat deposited in the cavities of a spongy tissue. It receives nutriment by means of blood-vessels, which pass obliquely through the walls of the cavity at particular points, usually near the middle of the shaft.

82. Articulations.—Bones are joined together by three kinds of union, to wit: joints, sutures, and symphyses. A Joint is the union of two bones, admitting of motion at the point of union. In the true joints, the ends of the bones are covered with a pad, or cushion of cartilage, which readily yields to pressure, and thus serves to break the concussion when the bones composing the joint are violently forced together, as in jumping or running.

In youth, this cartilage is thick; but as age advances, ossification extends further toward the extremity of the bones; and in old persons, the cartilages of the joints are nearly obliterated. From this cause, old persons are cautious in all their movements, and carefully avoid leaping, or any other movement that might bring the ends of the bones violently together.

83. Ligaments—their form and use.—The bones uniting with each other in joints, have the surfaces which come together formed so as to fit very nicely, and they are held in place by bands of dense, fibrous substance, so arranged as to admit of motion within a limited range.

In the principal joints these bands, or ligaments, as they are called, are so connected as to form a continuous layer, completely surrounding the articulating extremities of the bones, and thus inclosing the joint in a kind of sac. This continuous band is called the Capsular ligament. The articulating surfaces of the bones, as well as the inner surface of the capsular ligament, is covered with a very fine, smooth membrane, from which is secreted a slimy fluid, that serves to lubricate the joint and prevent friction. This is the synovial fluid, commonly called "joint water."

84. Kinds of Joints.—There are several forms of joints; the most important, however, are the ball and socket and the hinge joint. The first of these admits of motion in all directions, and is well illustrated in the hip joint. In many respects, this is the most perfect articulation in the body. It allows a greater range of motion than any other; has a deeper socket and a more perfect ball than is found elsewhere; and it has, in addition to a most perfect capsular ligament, a strong cord binding the extremity of the ball to the bottom of the socket, thus securing a wide range of motion in all directions, and, at the same time, giving great strength to the parts. The hinge joint is well illustrated in the knee and elbow. It admits of motion but in one direction, or, rather, backward and forward on the same line.

85. Irregular Joints.—At the wrist and ankle we have examples of compound joints, formed by the articulation of a number of bones, so adjusted as to allow but little motion between any two bones, and yet the aggregate gives considerable motion in every direction. In the spinal column, or back-bone, we have still another contrivance for allowing motions, though there are no articulating surfaces between the several pieces of the column. An elastic cartilage is interposed between these pieces, adhering firmly to each, and thus, by compression and distention, furnishing a good degree of motion. Nearly akin to this is that kind of union between bones, called Symphysis, where two bones are joined by smooth edges, and held in place by a thin layer of cartilage interposed. This kind of union does not admit of motion. If the edges are indented, or dove-tailed into one another, and the cartilage omitted, the union is called a Suture.

Recapitulation.

Bones are formed from cartilage. Earthy matter forms from one-half to nine-tenths of the bones. They are covered by the periosteum, and contain marrow in central cavity. Form of bone best for strength and lightness. Bones are not sensitive. They are united by joints, sutures, and symphyses. Form and use of ligaments. Synovial fluid prevents friction. Varieties of joints, ball and socket, and hinge. Irregular forms. Symphysis and suture defined.

LESSON XI.

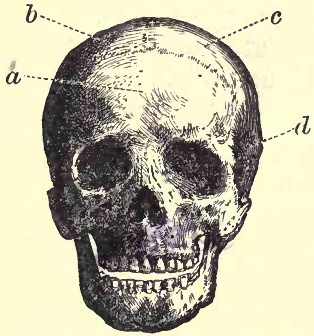
SKELETON.

86. The Skeleton—its division.—The bones of the body, arranged in their natural position, constitute a Skeleton. When the bones are held together by the ligaments, the group is called a natural skeleton; if these have been removed, and the bones are held in place by means of wires, it is an artificial skeleton.

Anatomists usually enumerate two hundred and eight bones in the skeleton, not including the teeth. Some, however, reckon more, others less than this number, for reasons which will appear in the further description of the particular bones. For convenience of description, the skeleton is divided into four sections: 1st. Bones of the head; 2d. Bones of the trunk; 3d. Bones of the upper extremities; 4th. Bones of the lower extremities.

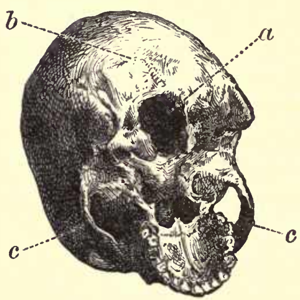
87. Bones of the Head.—The Head is divided into bones of the skull and of the face. The Skull, or cranium is composed of eight bones. The *frontal* bone

FIG. 28.—FRONT VIEW OF SKULL.



a. Frontal bone. *b*. Right parietal bone. *c*. Left parietal bone. *d*. Left temporal bone.

FIG. 29.—BASE OF THE SKULL.

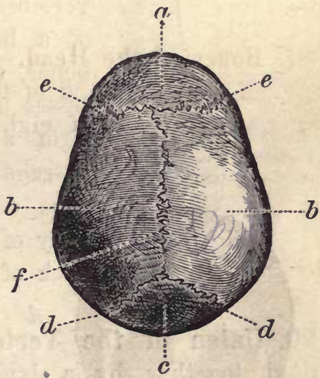


a. Foramen magnum.
b. Occipital bone.
c, *c*. Zygomatic arch.

occupies the region of the forehead. The side of the head has a pair of *parietal* bones in the upper region, and a pair of *temporal* bones below. The back part of the head, and most of the base of the skull, is occupied by the *occipital* bone. In the forward part of the base of the skull are two small bones, the *ethmoid* and *sphenoid*, which are seen only by removing the upper part of the skull.

88. The Cranial Arch — Bones of the Face. — The bones of the skull are joined firmly by sutures, and the shape of each bone is such as to present the form of an arch in whatever line it is measured; and the whole skull forms a dome, or arched roof of the chamber where the brain, the most important organ of the body, is carefully deposited.

FIG. 30.—VERTICAL VIEW OF THE SKULL.

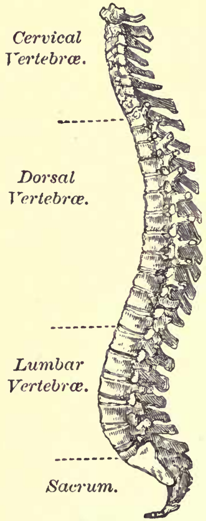


a. Frontal bone. *b, b.* Parietal bones. *c.* Occipital bone. *d, d.* Lambdoidal suture. *e, e.* Coronal suture. *f.* Sagittal suture.

The bones of the skull are made of two plates, separated by a thin layer of spongy bone. By this arrangement the concussion, or jar of injuries received on the outer plate, is mainly arrested before it reaches the brain. The bones near the base of the skull are much thicker than those which form its sides and upper part. This serves as a solid abutment to the arch, to enable it to withstand severe blows on the top of the head, or to resist great pressure at that point. The Face is composed of fourteen bones.

89. The Spinal Column. — The trunk is divided into the thorax and the pelvis. These, with the soft parts connected, form two important cavities — the chest and the abdomen. The thorax consists of the spinal column, the ribs, and the sternum, or breast-bone.

Fig. 31.
Spinal Column.



The Spinal column consists of twenty-four bones. Each bone is called a Vertebra. Seven of these are in the neck (cervical vertebræ), twelve in the back (dorsal vertebræ), and five in the loins (lumbar vertebræ). Each vertebra consists of a body and seven projecting bones, called *processes.* These processes unite at their base, so as to form a continuous tube for the passage of the spinal cord. This tube does not pass through the body of the vertebra, but lies just back of it.

90. Union of the Vertebræ. — The vertebræ are united together by a layer of cartilage which is firmly attached to each bone, and yet it has elasticity enough to admit of considerable motion; but the broad and strong band of ligaments which binds the articulating processes together, limits that motion, and renders the articulation more firm and secure than any other joint in the body.

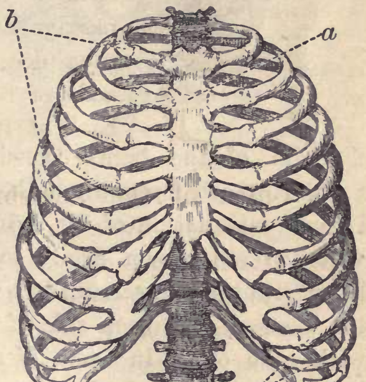
The spinal column, when viewed from the back, should present a straight line; but viewed laterally, it is slightly curved like the letter S. This form is a wise arrangement, serving to break the force of any sudden jar of the body, and thus save the brain from the concussion.

FIG. 32.—A LUMBAR VERTEBRA.

a. Body of the vertebra. *b, b.* Transverse processes. *c, c.* Articulating processes. *d.* Spinous process.

91. The Ribs—their articulation.—The Ribs form the side walls of the thorax. They are twenty-four in number—twelve on each side—and are divided into three classes. Seven are true ribs, three are false ribs, and two are floating ribs. Each rib has two curvatures — one which bends it around the chest horizontally, and another which gives it a downward curvature from the back forward.

FIG. 33.—THE THORAX.

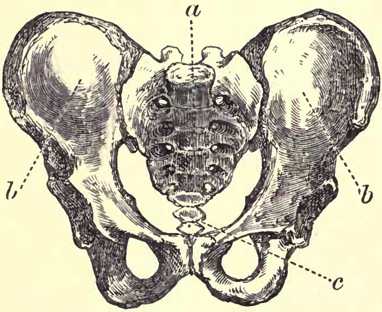


a. Sternum. *b.* Seven true ribs. *c.* Three false ribs. *d.* Two floating ribs. *e.* Dorsal portion of the spinal column.

The ribs are united to the vertebræ by true joints, but forward, the true ribs join the breast-bone by flexible cartilages. The three false ribs unite to a cartilage which is common to all of them, and by means of which they are attached to the breast-bone. The floating ribs have no forward attachment.

92. The Sternum. Bones of the Pelvis.—The Sternum, or breast-bone, forms the front of the thorax. In infancy, it is in eight distinct pieces; in youth, three; and in old age, but one. It is the last bone in the body to ossify, and, except in extreme old age, the point at the lower end remains cartilaginous.

FIG. 34.—THE PELVIS.



a. Sacrum. *b*, *b*. Right and left innominatum. *c*. Coccyx.

The Pelvis, or lower division of the trunk, consists of four bones. The Sacrum, which forms the back part of the basin, appears like a continuation of the spinal column, only that the vertebræ are grown firmly together. At the extreme lower point of the sacrum is a small conical bone, called the Coccyx. On each side of the sacrum, and uniting with each other in front, is a large, irregular formed bone, called the Innominatum. In early life this is composed of three pieces, and it is often described as three distinct bones; but in adults they become completely united.

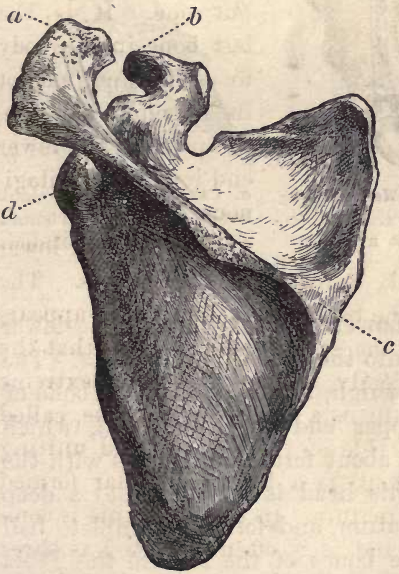
93. Shoulder, Arm, Forearm, and Hand.—The upper extremity is divided into the shoulder, arm, forearm, and hand. The shoulder consists of a large, triangular bone, the Scapula, or shoulder-blade, and the Clavicle, or collar-bone, which is attached to the upper end of the sternum at one extremity, and to the scapula at the other.

FIG. 35.—LEFT CLAVICLE.

a. Articulation with the acromion process of the scapula. *b.* Articulation with the sternum.

The arm has one bone, the Humerus, which is articulated, by a ball and socket joint, to the head of the scapula above, and to the bones of the forearm by a hinge joint below. The forearm consists of two bones, the Radius on the side of the arm corresponding to the thumb, and the Ulna on the other side. The ulna forms the principal part of the elbow joint, but the radius gives the chief articulation at the wrist.

FIG. 36.—LEFT SCAPULA.



a. Acromion process. *b.* Coracoid process. *c.* Spine, or ridge on the back of the scapula. *d.* Articulation of the humerus.

Three groups of bones form the hand. The Carpus, or wrist, consists of eight bones; the Metacarpus, or palm of the hand, has five bones; and the fingers have three bones, or phalanges, in each; while the thumb has but two.

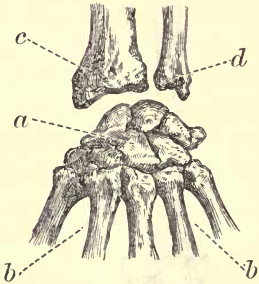
FIG. 37. HUMERUS.

a. Shoulder articulation.
b. Elbow articulation.

FIG. 38.—ULNA AND RADIUS.

a. Elbow articulation.
b. Wrist articulation.

FIG. 39.—CARPUS OR WRIST.



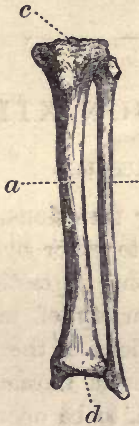
a. Carpus or wrist—eight bones. *b.* Metacarpal bones. *c.* Lower end of the Radius. *d.* The ulna.

94. Bones of the Lower Extremities.—The lower extremity is divided into the thigh, leg, and foot. The Femur, or bone of the thigh, is the largest long bone of the body. At the upper end it has a head, which stands at an angle of about forty-five degrees with the shaft of the bone. This head is received into a deep cavity in the innominatum, and forms a complete ball and socket joint. The bones of the leg are the Tibia which articulates with the femur by a hinge joint; the Fibula, a small bone placed on the outer side of the tibia as a kind of brace; and the Patella, or knee-pan, a flat, oval-shaped bone, placed on the front of the knee joint to serve as a kind of pulley. The foot consists of the Tarsus, or ankle, a group of seven bones; the Metatarsus,

FIG. 40.
FEMUR.

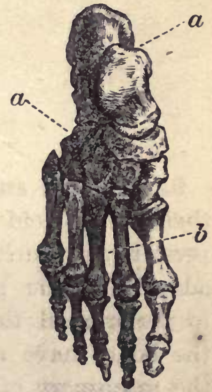
a. Head of the femur. *b.* Articulating surface at knee joint.

FIG. 41.—TIBIA AND FIBULA.



a. Tibia. *b.* Fibula. *c.* Knee joint. *d.* Ankle joint.

FIG. 42.—TARSUS AND METATARSUS



a. Seven tarsal bones. *b.* Five metatarsal bones.

or foot proper, with five bones and the toes, with three bones in each, save that the great toe has but two. Small bones, called Sesamoid bones, which are not enumerated here, are frequently found near the joints.

Recapitulation.

Skeleton, natural or artificial, consists of two hundred and eight bones. The skull consists of eight bones joined by sutures, and consisting of two plates separated by spongy matter. The face is composed of fourteen bones.

The thorax consists of spinal column, ribs and sternum. The spinal column consists of twenty-four bones united by layers of cartilage. There are twenty-four ribs, all jointed to the spinal column, ten on each side joined to the sternum.

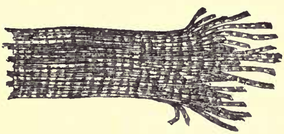
The sternum consists of from one to eight bones. The pelvis consists of four bones. The upper extremities consist of thirty-two bones each, the lower of thirty each.

LESSON XII.

MUSCLES.

95. Muscles and their functions.—The bones, with their joints held firmly together by ligaments, and yet permitting much freedom of motion, are admirably adapted to the great variety of movements required to perform all the functions of the human body. But the bones have no power of motion; they are merely the machinery of motion, to be operated on directly by the muscles, and remotely by the nervous system.

FIG. 43.—MUSCULAR FIBERS AS SEEN BY A MICROSCOPE.

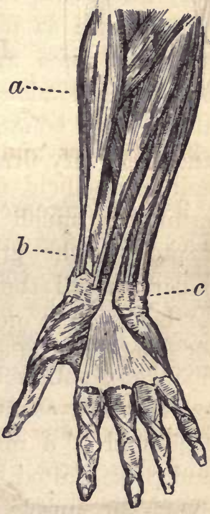


Muscles are formed of numerous bundles of fleshy fibers, bound together by a firm membrane, called the Facia. The fibers of which a muscle is composed are exceedingly fine threads; and yet the microscope reveals the fact that each fiber is composed of a string of cells slightly elliptical in form, and attached together by their longer axes. By changing the form of these cells so that they become more globular in shape, the fiber is made shorter; and this change taking place at the same time in all the fibers of a muscle, the parts to which the two ends of the muscle are attached are drawn nearer together. This is muscular contraction.

96. Tendons—their form and use.—The manner in which the will directs, and the extent it governs this contraction and consequent motion, and the part which the brain and nerves perform in this work, will be explained when we come to study the Nervous System.

The muscles which move the limbs, and perform the chief voluntary movements, have various forms, generally swelling larger near the middle, and tapering toward the end where motion is effected; they usually terminate in a dense, white cord called a Tendon. These tendons are sometimes very long, as, for example: the muscles which move the hand are situated on the forearm, just below the elbow, and their tendons are carried down over the wrist joint, and inserted into the bones of the hand and fingers.

FIG. 44.—TENDONS OF THE RIGHT HAND.



a. Muscles which move the fingers. *b.* Tendons extending from the muscles to the fingers. *c.* Annular ligament.

97. Union of Tendons with Muscles.—In this manner, symmetry and lightness is secured for the hand, while great variety and force give character to its motions. So, in other parts of the body, the muscles are placed where they will be least in the way, and where they will most conduce to symmetry and beauty of form; and the motion produced by their contraction is conveyed by means of tendons to the point where it is to have its effect.

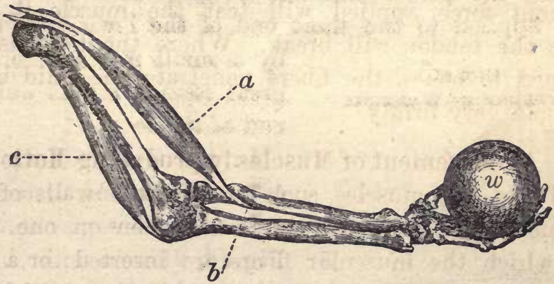
The muscular and tendonous fibers interlock, so that it is impossible to say precisely where the muscle ends and the tendon begins; yet the two kinds of fibers differ materially. The fibers forming the tendonous cords are very fine, hard, inelastic, and strong; and though the muscles are so much larger than the tendons, yet a sufficient force applied will tear the muscle in two before the tendon will break. Where the tendons are attached to bones, the fibers penetrate the solid bone, and hold very firmly.

98. Arrangement of Muscles in producing Motion.— The broad, flat muscles, such as form the walls of the abdomen, etc., commonly have a tendon on one side, into which the muscular fibers are inserted; or a tendonous band passes through the middle, into which the fibers run obliquely on each side.

The most common arrangement for motion is where each end of a muscle is inserted into a different bone, and these united by a movable joint. In this arrangement, the muscle is situated on the fixed part, or that which does not move, and the motion is conveyed over the joint to the movable part by means of a tendon. There are, however, a great diversity of arrangements in the smaller muscles, designed for the production of special and complicated motions.

99. Bones as Levers.—To understand the mechanism of muscular motion, we must learn that bones are true levers, having the fulcrum, or fixed point of the lever, at the joint, the attachment of the tendon to the bone answering to what is called the power, and the extremity of the limb or part moved representing the weight. There may be three adjustments of these points in every lever, and all of these are found in the human body; but that which is commonly called the third form of the lever—that which places the power between the fulcrum and the weight—is by far the most common arrangement.

FIG. 45.—MUSCULAR MOTION.

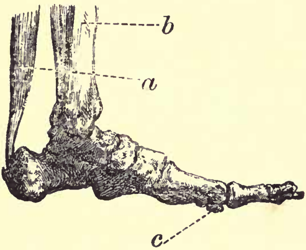


a. Flexor muscle of the arm. *b*. Tendon inserted into the radius. *c*. Extensor muscle. *w*. The resistance.

100. Economy of Motion.—The general principle on which muscles are arranged is that of producing a great measure of motion by a very small amount of contraction. In Fig. 45, the muscle which is marked *a* is fastened by its tendon to the forearm at *b*. Now, if the muscle *a* is made shorter, it will draw *b* upward to the extent of its shortening; but an amount of motion at *b* will move the weight at *w* as much further as the distance between *w* and *b* is greater than the space between *b* and the center of the joint. But this will require that the power applied at *b* be as much greater than the weight at *w* as the space through which *w* is moved is greater than that through which *b* passes. This is the economy of motion at the expense of power, and may be regarded as the general principle of muscular motion in the human body.

101. Levers of the second and third classes.—In reversing the motion of the arm, as seen in the above cut (Fig. 45), the muscle *c* is attached by its tendon to a process of the ulna, which projects backward and upward beyond the joint, and the fulcrum is placed between the power and the weight. But the power being applied to the short end of the lever, produces, by a small motion there, a great motion at the weight end of the lever.

FIG. 46.
MOVEMENT IN WALKING.



a. Large muscle of the leg. *b*. Tibia. *c*. The fulcrum.

In the foot we have the other adjustment, or second form of the lever, as seen in Fig. 46, where *a* is the large muscle on the back of the leg, which draws the heel upward when we rise on our toes; *b* is the large bone of the leg, by which the weight of the body rests upon the bones of the ankle joint; *c* is the fulcrum or fixed point, on which the whole weight of the body is raised in walking.

102. The Power of Muscular Contraction.—It will be seen, from what we have said, that the power exerted in the contraction of the muscles is many times greater than that manifested in the motions produced. This loss of power is not merely the effect of the application of the force to the short arm of the lever, but perhaps more is lost in power and gained in motion by the direction in which the force is exerted. This is seldom in the line in which the motion is to be obtained, but usually very obliquely to it; as, for example, when a limb is to be bent, as the arm at the elbow joint, the muscles on the upper arm contract, but the tendency is chiefly to draw the bones of the fore-arm up against the humerus at the elbow joint. The tendency to bend the arm would be almost nothing if it were not for a contrivance by which the direction of the tendon, in passing over the joint, is changed. This is simply an enlargement of the humerus at its lower end, so that the tendon passes over it as over a pulley.

103. Special Arrangements of Muscles. Number of Pairs.—There are many special contrivances for producing peculiar motions that are noticed and minutely described by anatomists, but which our purpose will not allow us to even name. The contrivance by which the eyelids are closed in winking, and that which draws the lower jaw downward in opening the mouth, are among the most curious and complicated of muscular movements.

The muscles of voluntary motion are arranged in pairs on each side of the body, so that the right and left sides correspond exactly in the number and position of their muscles. Anatomists have named and described about two hundred and forty pairs of voluntary muscles, many of these, however, are very small, and apparently unimportant.

Recapitulation.

Bones are moved by muscles. These consist of fibers, and each fiber of cells. Muscular contraction is effected by changing the form of cells. Tendons are used to attach muscles to bones, and to transfer motion. Muscles are not generally situated on the parts moved by their contraction. Bones are used as levers. Power moving them arranged to economize motion. Muscular contraction exerts a force greater than that realized through the mechanism of motion. Number of voluntary muscles — about two hundred and forty pairs.

LESSON XIII.

MUSCULAR MOTION—VOICE.

104. Muscular Motion — voluntary and involuntary.—There are a number of very interesting phenomena connected with muscular action, two or three of which will be considered in this lesson. All animal motion, of whatever kind it may be, is produced by muscular contraction. A part of these motions are under the control of the will, and are therefore called voluntary motions; another class of motions are entirely independent of the will, or even the consciousness of the animal in which the motion is performed, and are called involuntary motions.

The organs thus controlled belong more directly to the class on which depend the immediate functions of life. The heart and stomach are each active organs, but, in a healthy condition, we neither control nor feel their movements. The wisdom of this arrangement is very obvious, for it would be unsafe to trust such important functions to our voluntary attention.

105. Articulate Language.—Thoughts, sensations, and emotions are communicated to others by muscular motion only. In man this communication is made chiefly by means of articulate language, and is much more extended and perfect than in the lower animals, whose language consists of a few simple sounds, accompanied by certain movements of the body which forcibly express a limited range of thought and passion.

The barking of a dog, the purring of a cat, or the clucking of a hen, each, taken with the motions and attitudes of the body accompanying it, conveys meaning; but the thoughts, however forcibly they may impress us, are not communicated with the clearness of articulate language. The muscles of the human face, which, by contracting, change the features so as to give what is called expression to the countenance, greatly assist in making language impressive.

FI 47.—LARYNX—SIDE VIEW.

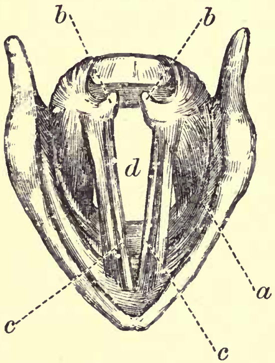
a. Hyoid bone. *b.* Thyroid cartilage. *c.* Cricoid cartilage. *d.* Trachea. *e.* Epiglottis.

106. Anatomy of the Larynx.—Voice is produced in an organ called the Larynx, which is placed on the top of the trachea. It consists of five cartilages, arranged so as to form a most perfect musical instrument, which, by means of air passed through it with more or less force, gives all the varied tones of the human voice. The Cricoid cartilage is a ring, narrow in front and broad behind, and is securely attached to the trachea by its lower margin.

On the front part of this, and overlapping it, is placed the Thyroid cartilage; this is attached to a small U-shaped bone, situated at the root of the tongue, both by a broad ligament and by muscles which move it in swallowing food, in speaking, singing, etc. The thyroid cartilage forms the projection on the front of the neck called Adam's Apple, by the motions of which the movements of the cartilage may be readily observed.

107. Vocal Cords and Glottis.—Two small triangular bodies, called the Arytenoid cartilages, are placed on the back part of the cricoid cartilage, and so joined to it as to admit of considerable motion at the joint; from these are stretched two pairs of ligaments called Vocal cords, which are attached to the upper edge of the thyroid cartilage at the front part. The vocal cords are formed of very fine elastic fibers, inclosed in a delicate mucous membrane. The space between the upper and lower pair of cords is called the Ventricle, and the opening between the cords of each pair is called the glottis. These parts will be better seen in the figure attached.

FIG. 48.—THE GLOTTIS AND VOCAL CORDS.



a. Upper edge of the thyroid cartilage. *b*, *b*. Arytenoid cartilages. *c*, *c*. Vocal cords. *d*. Glottis.

108. The Epiglottis.—The Epiglottis is a thin, cartilaginous valve, which closes the glottis by resting firmly on the upper pair of vocal cords, thus forming a kind of bridge, by which the food and drink are conveyed safely over the glottis into the pharynx and œsophagus, which lie back of the air passage. If we attempt to speak or laugh while in the act of swallowing, the epiglottis will be raised, permitting the food or drink to fall into the trachea, and thereby produce strangling.

In ordinary, quiet breathing, the vocal cords are relaxed, and the epiglottis thrown up, so as to partially close the passage into the mouth, and thus direct the air through the nasal passages. The upper pair of vocal cords serve chiefly as a resting place for the epiglottis, and are but little concerned otherwise in the ordinary production of voice.

109. The Pitch of Voice—its mechanism.—The lower cords are exceedingly delicate, and the edges, which form the glottis proper, are very fine, and when drawn tensely, they present an instrument of vibration more perfect than any that has been produced by art. It is a well established principle, that the pitch of a sound, produced by a vibrating cord, is determined by its length, size, and tension.

Now the vocal cords, fastened firmly at the back to the arytenoid cartilages, and running obliquely upward and forward, are attached to the front of the thyroid cartilage, and if this be drawn upward, it will make the vocal cords very tense. These, being elastic, diminish in size as their tension increases.

We have thus two conditions of elevated pitch, but we have by this movement lengthened the cords which would have a contrary effect. To counteract this, the arytenoid cartilages are drawn closer together, and as the cords are attached to the same point in front, if the back ends are brought closer together, the front part of the cords will touch each other, and thus virtually shorten the cord.

110. The Larynx as a wind instrument.—But the larynx is not merely a stringed instrument; perhaps it has more points in common with wind instruments. In these the notes are varied by the size of the aperture through which the air is forced into the tube, by the length of the tube, and by the velocity with which the air enters it. Now, as the thyroid cartilage is drawn upward, and the vocal cords are made tense and brought nearer to each other by the movement of the arytenoid cartilages, the glottis is diminished in size, while the tube (which consists of the mouth and nasal passages) is shortened by the amount that the thyroid cartilage is elevated.

But when the organs of voice are placed in this condition, more force is required to expel the usual quantity of air from the lungs, and thus the last condition of a high pitch is secured. This explains why it is more fatiguing to speak or sing on a high key than on a lower one.

111. Modulation of Articulate Sounds.—But the utterance of musical sounds, and the performance of most wonderful musical combinations, are not the most important or most difficult functions of the vocal apparatus. The rapid adjustment of the larynx, by the movements of a very complicated system of muscles, in the articulations of a rapid speaker, is one of the most marvelous of all the phenomena of the animal economy.

While all vocal sounds are formed in the larynx, yet voice thus formed is modulated in the mouth and nasal passages. The organs concerned in modulation of voice are chiefly the lips, teeth, tongue, palate, and air passages of the nose. All have observed how the voice is affected by the loss of the front teeth, or by the imperfect palate and lip in persons with harelip. The tongue, though important, is not the sole organ in modulating articulate sounds.

Recapitulation.

The larynx is the organ of voice. It is composed of five cartilages. Voice is produced by the vibration of the vocal cords. These are put in motion by air forced through the glottis from the trachea.

The larynx has the properties of both a stringed and a wind instrument. Various means of modifying pitch, etc. Rapid movement of the vocal organs in speaking. Modulation of sound in the mouth and nasal passages.

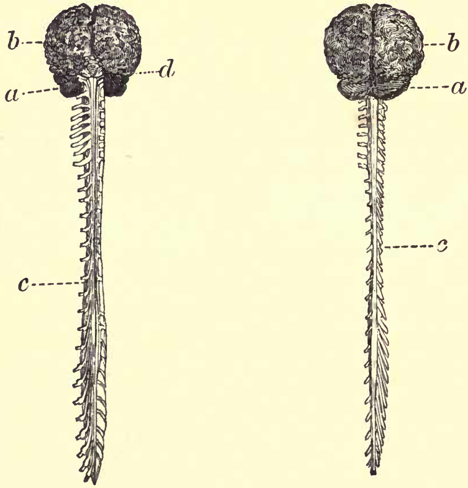
LESSON XIV.

NERVOUS SYSTEM.

112. Distribution of Vital Force, a brain function. — The organs which we have described, with their functions, are simply the machinery of life. We have not yet looked into the engine-room from which the power is furnished to operate this wonderful machinery, enabling it to perform the various functions of the living body. The instrument through which this power is distributed to every organ of the body, is the nervous system.

This consists of the Spinal cord, Brain, and the nerves by which every organ is connected with these great centers of vital force. It has been customary to consider the brain as the primary organ, and the spinal cord and nerves as appendages to it; but we find, in

FIG. 49.—FRONT AND BACK VIEW OF THE BRAIN AND SPINAL CORD.



a, *a*. Cerebellum. *b*, *b*. Cerebrum. *c*, *c*. Spinal cord. *d*. Medulla oblongata.

the lowest class of vertebrate animals (the fishes), that the brain is very imperfectly developed, while the spinal cord, with its nerves distributed to all parts of the animal, is very perfectly formed.

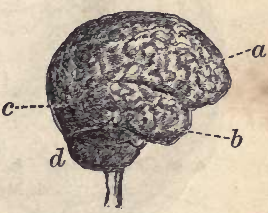
113. Cerebro-spinal and Ganglionic Systems.—Indeed, we find in living bodies this ascending scale: in vegetables we have no trace of anything like a nervous system; in the invertebrate forms of life, we find nerves distributed to the adjacent organs from local nervous centers, called ganglions, but no brain or spinal cord; in fishes, the brain is little more than an enlargement of the forward end of the cord. As we ascend the scale of vertebrate life, however, we find the brain becoming more and more prominent, till we reach the summit of perfection in man.

The spinal cord and brain are generally regarded by anatomists as a single organ, which they call the Cerebro-spinal axis. The existence of this cerebro-spinal axis, in vertebrate animals, does not supersede or displace the system of ganglions, as found in the lower types of animal life. This constitutes what is known as the Sympathetic system.

FIG. 50.—BRAIN—FRONT VIEW.

a. Right hemisphere of the cerebrum. *b*. Left hemisphere of the cerebrum.

FIG. 51.—BRAIN—SIDE VIEW.



a. Anterior lobe of the cerebrum. *b*. Inferior lobe. *c*. Posterior lobe. *d*. Cerebellum.

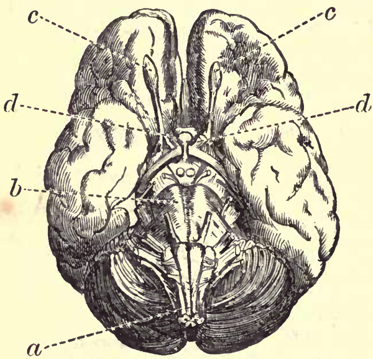
FIG. 52.—CEREBELLUM—BACK VIEW.

114. The Two Hemispheres. — The cerebro-spinal nervous system is symmetrical, being divided into right and left sides, corresponding exactly in number, size, and position of the parts. In accordance with this arrangement, the brain is separated, by a deep, vertical fissure, into the right and left hemispheres. This separation is not quite perfect, for, near the base of the brain, a broad band of fibers extends from one hemisphere to the other, thus forming a connection between them.

Transversely, the brain is divided into the Cerebrum or large brain, occupying the upper and front part of the skull, and the Cerebellum or small brain, situated at the posterior base of the cranium. The spinal cord is divided longitudinally by a deep fissure, both on the front and back, leaving only a narrow bridge of the substance of the cord in its center.

115. Medulla Oblongata—membranes of the brain.—The spinal cord enters the cranium at the large opening in its base, called the Foramen Magnum, and extending upward and forward, forms a connection with the cerebellum backward, and with the cerebrum above. This portion of the spinal cord lying within the skull is called the Medulla Oblongata. It is a kind of bulb, or enlargement of the upper end of the cord, and consists of three pairs of bodies (Pyramidal, Restiform, and Olivary), which are united pretty firmly together.

FIG. 53.—BASE OF THE BRAIN.



a. Medulla oblongata. *b.* Pons varolii. *c.* Olfactory nerves. *d.* Optic nerves.

Both the brain and spinal cord are securely wrapped in membranes. The outer one of these, the Dura Mater, is a dense, firm membrane, adhering strongly to the inner surface of the skull. The Pia Mater is a very delicate membrane, attached to the surface of the brain;

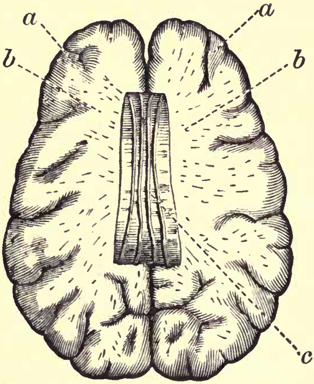
and as this surface is uneven, or convoluted, the Pia Mater dips down between these convolutions, separating them from each other. Between these membranes lies a fine, gauze-like coat, called the Arachnoid membrane. These serous membranes are subject to diseases both dangerous and difficult to cure.

116. Gray and White Matter of the Brain.—The substance of which the brain is composed is very soft, and easily broken down in handling it. Being composed largely of albumen, it may be rendered quite firm by steeping it for some days in alcohol, after which it may be studied very satisfactorily. Like all other life-formed tissues, its ultimate form is the cell, or little globe. These cells, however, change their shape more rapidly in the brain than in any other tissue of the body.

The brain is not uniform throughout in its texture and appearance. In both the cerebrum and cerebellum, the central portion of the organ is nearly a clear white, and appears under the microscope to be fibrous in its texture. Surrounding this, and following the irregularities of the convolutions, we find a layer of gray or ash-colored matter, differing in thickness in different persons, but forming a marked feature of every brain. In the spinal cord, the relative position of these parts is inverted, the gray matter being in the center, and the white surrounding it.

117. Gray and White Matter.—The proportion of gray matter to the white is greater in the cerebrum than in the cerebellum or spinal cord; and the nervous cords distributed from these to all parts of the body are made entirely of white matter, though the gray substance appears again in the center of the ganglions, or little brains attached to the sympathetic system. The gray matter consists of cells, often very irregular in their shape, and constantly changing form. The white part, while it appears to be made of fibers, is really composed of chains of cells, forming continuous tubuli, extending from the gray part of the brain to the extremities of the nerves.

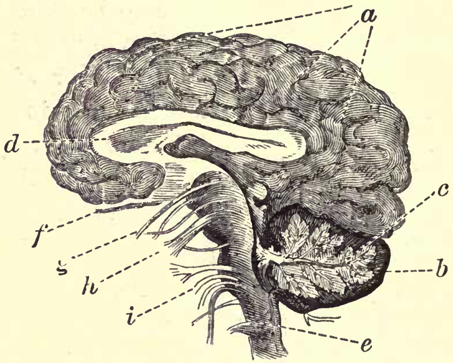
FIG. 54.—TRANSVERSE SECTION OF THE CEREBRUM.



a, a. Gray matter of the brain. *b, b.* White matter. *c.* Corpus callosum.

118. Cranial Nerves.—The nerves are cords composed of a white substance like that of the brain, extending to all the living tissues

FIG. 55.—ORIGIN OF THE CRANIAL NERVES.

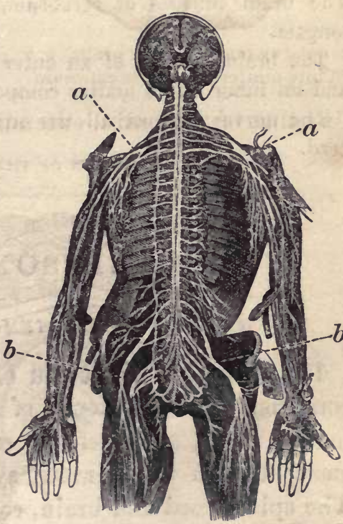


a. Cerebrum. *b.* Cerebellum. *c.* Arbor vitæ. *d.* Corpus callosum. *e.* Medulla oblongata. *f.* Olfactory nerve. *g.* Optic nerve. *h.* Trifacial nerve. *i.* Auditory nerve.

of the body, and connecting all the organs with the gray matter of the brain or spinal cord. These nerves are arranged in pairs, corresponding to each other on the different sides of the body. Twelve pairs of these come off within the skull, and are sent to the different organs on which they are distributed through openings in the bones. These are called Cranial nerves.

The first and second pairs, being the Olfactory and Optic nerves, appear to come off from the lower part of the front lobe of the cerebrum, but their principal fibers have been traced backward to the upper part of the medulla oblongata. The fifth pair, immediately after passing out of the skull, divides into three branches. From this fact it is sometimes described as three nerves. The ninth and tenth pairs, as they leave the skull through the same opening, have been described as one pair by some anatomists.

FIG. 56.—ORIGIN OF THE SPINAL NERVES.



a, a. Brachial plexus. *b, b.* Lumbar plexus.

119. Spinal Nerves.—The spinal cord gives origin to thirty-one pairs of nerves, eight of which come off from the spinal cord in the neck, and are called Cervical nerves; twelve in the back, which are named Dorsal nerves; five from the loins, which are known as Lumbar nerves; and six pairs come from the termination of the cord in the sacrum, and are called Sacral nerves. The four lower cervical and the upper dorsal nerves on each side unite with each other, and separate again to be distributed on the upper extremity. This is called the Brachial Plexus. The last dorsal and the five lumbar nerves form a similar combination, called the Lumbar Plexus.

Recapitulation.

The nervous system is the distributer of vital force. It consists of spinal cord, brain, and nerves. The nervous system is symmetrical, being divided into right and left sides.

The two hemispheres are connected by the corpus callosum. The brain consists of cerebrum, cerebellum, and medulla oblongata.

The brain consists of an outer gray substance made of cells, and an inner white matter composed of fibers, or tubuli.

The nerves connect all the organs with the brain and spinal cord.

LESSON XV.

NERVOUS SYSTEM.—CONTINUED.

120. Complex Function of the Brain.—The organs comprising the systems of nutrition and voluntary motion have, as a general rule, but a single function each; but in the nervous system this rule is violated. The spinal cord and brain, considered as a single organ, performs at least three distinct and independent functions: 1st. it is the source, either directly or indirectly, of all muscular motion; 2d. it is the seat of sensation; and, 3d. it is the organ of thought.

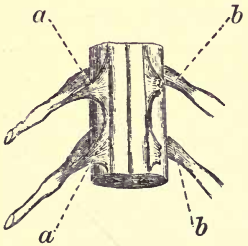
These several functions, if not absolutely independent of each other, are so in a degree that is truly wonderful. The intellectual powers may be deranged so as to produce a true insanity, with scarcely any disturbance of the functions of motion or sensation. On the other hand, in paralysis there may be entire loss of motion or sensation in many of the organs, while the mental activity remains unimpaired.

121. Nerves of Special Sense.—The functions of motion and sensation are carried on by the brain exclusively through the agency of nerves, but the connection of the brain with the intellectual phenomena appears to have no direct association with them.

The first, second, and eighth pairs of nerves are devoted exclusively to special sensations. The first pair are appropriated to the sense of smell, and are therefore called the Olfactory nerves. They are distributed on the mucous membrane of the nasal cavities. The second pair are the Optic nerves, which furnish the eye with the power of vision. The nerves of hearing are the eighth pair. They are distributed on the internal ear, and are the only cranial nerves that do not pass out of the skull. The sense of taste is the function of a branch of the fifth and eighth pair of nerves on each side.

122. Motor and Sentient Nerves.—The nervous trunks which perform the mixed functions of sensation and motion originate by two separate roots, each devoted to its appropriate office. This is more distinctly seen in the spinal nerves, where, at each joint of the spinal column, nerves pass out, right and left, from the spinal cord. These have each an anterior and a posterior root, the first originating from the front, and the last from the back part of the spinal cord. If the anterior root be injured or diseased, the power of motion is lost or impaired in the parts to which the nerve is distributed; but if the injury is in the posterior root, the power of sensation, or feeling, is impaired in the parts supplied by that nerve. The anterior is therefore called the Motor root, and the posterior the Sentient.

FIG. 57.—MOTOR AND SENTIENT ROOTS OF THE SPINAL NERVE.



a, *a*. Anterior or motor root. *b*, *b*. Sentient or posterior root with its ganglion, exposed by removing the motor root.

123. Distribution of Nerves.—The sentient root is slightly larger than the motor, and has a ganglion or enlargement on it just before it joins its fellow. This union takes place before the nerve passes through the opening between the vertebræ, and beyond this the nervous cord appears to consist of but one kind of fibers or tubuli, but at the termination of the nervous branches the distinction of function is again observed.

The nervous trunks, by sending off branches, distribute themselves over the parts they are intended to supply. In this distribution, though the branches of nerves are sent to almost every organ of the body, yet the supply furnished to different organs is not by any means the same.

124. Motor and Sentient Nerves terminate differently.—The nerves of motion and those of sensation differ most widely in their functions, yet the most careful examination with the best microscope fails to reveal any difference in their structure so long as the fibers remain wrapped in the same nervous envelope; but as we trace the nervous trunks toward their extremities, the filaments of different functions separate from each other, and in their terminations there is a very marked difference in their appearance. The nerves of motion continue to divide, until their filaments become so fine that even the microscope scarcely enables us to trace them. They are distributed entirely to the muscular system, and terminate on the ultimate cells composing the muscular fibers, and communicate to them the power by which the fiber is shortened, and, consequently, the whole muscle contracted.

125. Pacinian Corpuscles.—The nerves of sensation, as they approach their extremities, are usually folded back on themselves, so as to form a kind of loop; and sometimes this folding is repeated two or three times, so as to produce a distinct enlargement at the end of the nervous filament. This repeated folding of the nervous tubuli forms what are called Pacinian corpuscles. They are found in the nerves terminating on the hand and foot more frequently than in any other part of the body. They appear to be connected with the special sense of touch, as they are found in the upper lip of the horse, and in the end of the elephant's trunk. Some have supposed them to be organs for producing animal electricity, as they resemble somewhat the organs of certain electric fishes.

126. Sentient Nerves on the Skin.—But the single loop, or simple folding back on themselves, is a mode of termination common to all sentient nerves, whether the sensation is merely feeling, or is some special form of sensation, as seeing, hearing, tasting, or smelling. The surface of the skin is so well furnished with sentient nerves, that it is impossible to put down the point of a needle anywhere on it without touching one of those loops terminating a nervous filament, and thus communicating to the brain intelligence of the

FIG. 58.—NERVES OF SENSATION, WITH THEIR TERMINAL LOOPS GREATLY MAGNIFIED.

injury. By this arrangement, every part of the body that is liable to be injured by foreign substances, is kept in constant communication with the brain, where consciousness resides, and from whence proceed all voluntary motions.

127. Mystery of Sensation.—This power of feeling is a wonderful endowment. An impression is made on a looped extremity of a sentient nerve, in some remote part of the body. Instantly, the filament of nerve thus impressed communicates the impression along the nervous cord, where this particular filament is entangled and interlaced with a thousand similar ones; and yet the impression is not communicated to them, but is confined to the individual filament; it passes through the interior white matter of the brain, and finally reaches the gray substance, where perception or consciousness appears to reside. This perception not only locates the precise spot where the impression was made, but also determines the nature of the impression, and, within certain limits, the character of the substance or agent making it.

128. Injury of a Nervous Trunk.—The office of the nerves is illustrated in the phenomenon of a paralyzed limb. If the great nervous trunks, returning to the brain the impressions made on any particular part of the body, be destroyed, the person has no knowledge of the condition of that part; but if the injury be partial or temporary, the perception will be impaired or confused as to the place of the impression or its nature. Thus, by an improper attitude, we sometimes compress the nervous trunk conveying impressions from the hand or foot, and a peculiar, prickling sensation is felt in the part on which the nerve terminates. This is expressed in common language by saying that the hand or foot "is asleep."

Recapitulation.

The nervous system performs the functions of motion, sensation, and thought. Nerves devoted to sensation alone, have but a single origin; nerves of both sensation and motion, originate by two roots. Nerves of sensation terminate in loops; those of motion by filaments distributed on the muscles. Between their origin and termination the nervous trunks are alike. When impressions are made on the trunk of a sentient nerve, the sensation is referred to the extremity.

LESSON XVI.

SENSATION.

129. Low Sensibility of Bone, Cartilage, etc.—The power of sensation is not distributed alike to all the organs of the body. The bones and cartilages have no feeling when in a healthy condition; but when they are inflamed, they become highly sensitive. This is probably owing to some peculiar condition of the nerves in the solid substance of these tissues, which is not well understood.

The fatty deposits, which often accumulate to a considerable thickness between the skin and muscles, as well as in other parts of the body, are nearly destitute of feeling, having but few nerves distributed on them. The muscles which produce the voluntary motions of the body, while they are the only points of distribution for the motor nerves, are but moderately supplied with nerves of sensation; and consequently the muscles, when in a healthy condition, have but little feeling. The organs of involuntary motion, such as the heart, etc., are entirely insensible, except in a diseased state.

130. Sense of Touch in the Fingers.—The skin, and the mucous membrane lining the mouth and glottis, are the chief seats of sensation. The skin, on different parts of the body, has different degrees of sensibility. The fingers and toes have the largest number of sentient nerves distributed on their surfaces, and, consequently, have the most acute sensibility of any of the organs of the body. Indeed, the surface of the true skin on the ends of the fingers appears to be made up of bundles of sentient nerves, or their loop-like terminations, forming those little elevations, called the papillæ, which cover these parts. So highly endowed with sensibility are these organs, that some have regarded them as special instruments of a local sense, differing from the general sensibility of the body; but the function appears to differ in degree, rather than in kind.

131. The Grades of Sensation—Muscular Sense.—A careful analysis of this subject will reveal at least three distinct grades of sensibility, located in different organs of the body; and, in some of them, the sensation varies in acuteness in different parts of the organ or organs to which the sensation is referred. First in the group of sensations, and lowest in the distinctness of its impressions on the perceptive powers, is the subjective or internal sense, sometimes called the muscular sense. The most obscure manifestation of this is in those sensations which we call weariness, fatigue, faintness, etc. These sensations appear to be rather general than special, and therefore can hardly be referred to any particular locality in the body.

The sensation of weight, or resistance to muscular action, is a little better defined, but still very difficult to locate. If we extend the hand, and place a piece of card-paper on the fingers, we will perceive merely the sensation of touch; but if a two-pound weight be substituted for the card, a very different sensation is felt—a perception of what we call weight.

132. Sense of Touch, of Taste and Smell.—A second class comprises those sensations which are made by contact with external objects, and referred definitely to the point of contact, and also where the perception determines something in relation to the character of the body producing the sensation.

For example, the sense of touch determines where the person is touched, and whether the substance producing the sensation is rough or smooth, hard or soft, hot or cold, etc. But the tongue not only conveys to the brain the sensation of being touched, and the usual knowledge of the physical properties of the body touching it, but also a peculiar sensation which is called taste. It is a special sensation, and is definitely referred to the mouth. So, also, the olfactory nerves convey to the brain the sensation produced by odorous bodies.

133. Organs of the Sense of Smelling.—This second group of sensorial functions ascends, in point of delicacy, from the mere sense of contact common to the whole surface of the body, to the sense of smell, which recognizes odors so exceedingly delicate that no other test can detect their presence. This sense has a pair of nerves especially appropriated to it; and though the sentient extremities of these nerves are distributed on the mucous membrane of the nasal passages, which differs nothing in appearance from the mucous membrane forming the surface of other open cavities, yet the delicacy of the olfactory sense falls but little below that of senses of the third class, each of which has a special apparatus appropriated to its use. In some of the lower animals, such as the dog and the vulture, this sense is much more acute than in man. Many animals which live in the water have the sense of smell greatly developed.

134. Use of the Turbinated Bones.—The nasal cavities have their surfaces greatly extended by the turbinated bones. These are thin plates of bone, rolled up and placed one in each nasal chamber, and covered throughout with the membrane, on which the olfactory nerves are distributed.

These air passages are so placed that the air, in ordinary breathing, scarcely enters them; but when a voluntary effort is made to exercise the function of smelling, it is drawn forcibly through the passages, and made to enter the cavities among the folds of the turbinated bones, and thus greatly to increase the surface in contact with the odors inhaled. There appears to be a strange complication of the sense of smell with that of taste, so that much of what is usually regarded as taste really belongs to the olfactory sense.

135. Simple Nature of the Olfactory Sense.—The sense of smell appears to be the least complicated of all our sensations. When we place our hand on the table, we have, first, a sense of contact with something external to ourselves; then, in quick succession, the sensations which determine hardness, smoothness, temperature, etc., each one of which appears to be the exercise of a special function, but all taken together form the complex sensation which we call feeling. On the other hand, if we inhale a powerful odor, such as musk, for example, we have no distinct sensation of contact, no clear perception of any thing outside of ourselves, no indication of the direction from which the odor came, no ideas of size or shape are derived from the sensation; all we acquire is a knowledge of that indefined property called odor.

A singular fact about the exercise of this sense is that, while we distinguish odors, and identify them as the property of certain substances, yet we have no names for odors, but describe them only by comparison.

136. Ability to suffer Pain, important to our Safety.—These lower grades of sensation are of the utmost importance to the safety and enjoyment of the individual. The senses of taste and smell are the chief guides on which we rely in the selection of our food; and the sense of feeling, which rises to pain when the contact is violent, continually admonishes us of danger from surrounding objects. Our safety depends more on our ability to suffer pain than most persons apprehend. Those who, from disease or accident, have lost the sense of feeling in a limb, often sustain serious injury, from burns or other accidents, before they are aware of danger. These senses may therefore be regarded as body-guards or sentinels, placed on the outposts of the citadel of life to give timely warning of the approach of friend or foe.

Recapitulation.

Sensation is unequally distributed among the organs. Sense of feeling is distributed over the surface of the body generally. Special sense of touch located in the ends of the fingers. Three grades of sensations: 1st, muscular sense; 2d, touch, taste, and smelling; 3d, seeing and hearing. Olfactory sense located in the nasal passages. Peculiar arrangement of the turbinated bones. Smelling the least complicated of all the senses.

LESSON XVII.

ORGANS OF SPECIAL SENSE.

137. Senses which have Special Organs.—The third and highest class of sentient functions have each a special apparatus appropriated to them, by means of which they make us acquainted with properties and conditions of bodies around us, that are entirely beyond the reach of ordinary sensation. The special senses of *hearing* and *seeing* form this class.

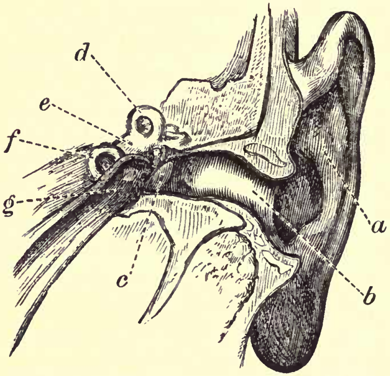
The Ear, the organ of hearing, consists of the external ear, the tympanum or middle ear, and the labyrinth or internal ear. The external ear consists of a tube about an inch in length, which in man and in most mammals spreads out into a broad expansion externally. Both the tube and the expanded rim are formed of a firm, elastic cartilage. In birds and reptiles the external expansion is wanting; and, in fishes, the rudiments of the internal ear are found, but no vestige of an outer ear has been discovered.

138. The External Ear.—In the human subject, the external expansion forms an irregular, semicircular plate, concave on its forward and outer surface, and correspondingly convex on the opposite side. Its purpose is to collect and concentrate the vibrations of the air at a central point, which is the external opening of the auditory tube.

This opening is protected from the intrusion of dust, insects, etc., by a cluster of stiff, short hairs placed near the entrance; but a more effectual protection is afforded by a yellow, tenacious, bitter wax, secreted by a number of small glands on the inner surface of the auditory tube. Across the bottom of this tube is drawn a fine membrane, so as to close it completely, and thus cut off all communication with the middle ear.

139. Drum of the Ear—Eustachian Tube.—The Tympanum, or drum of the ear, is a cavity in the hard portion of the temporal bone. While it is cut off from direct communication with the external air by the drum-head, or membrane of the tympanum, just now described, that communication is indirectly established through the posterior chamber of the mouth, by means of a funnel-shaped canal, called the Eustachian tube. The narrow end of this tube passes through a small opening, or foramen, into the cavity of the middle ear, while the broad end establishes a communication with the upper portion of the pharynx, and by this means the tympanum is kept filled with air. In yawning, the Eustachian tube is compressed, and sometimes the sides temporarily adhere together, occasioning an unpleasant roaring in the head, till, with a crackling sound, the obstruction is removed, and all is right again.

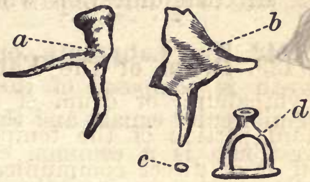
FIG. 59.—THE EAR.



a. External ear. *b*. Auditory tube. *c*. Tympanum, or middle ear. *d*. Semicircular canals. *e*. Vestibule. *f*. Cochlea. *g*. Eustachian tube.

140. Bones of the Ear.—In the cavity of the tympanum there are four small bones, articulated together so as to form a bony chain, stretching from the tympanic membrane to the membrane closing the aperature communicating with the inner ear. These bones are named, from their fancied resemblance to the objects, the *malleus*, or hammer; the *incus*, or anvil; the *orbiculare*, or round-bone; and the *stapes*, or stirrup. The handle of the hammer is fastened to the middle of the drum-head, while the head of the hammer fits into the cavity of the anvil, and the horn of the anvil is attached, by means of the round-bone, to the bow of the stirrup, the base of which rests firmly against the membrane closing the passage into the labyrinth.

FIG. 60.—BONES OF THE MIDDLE EAR, ENLARGED.



a. Malleus, or the hammer. *b.* Incus, or the anvil. *c.* Orbiculare, or the round-bone. *d.* Stapes, or the stirrup.

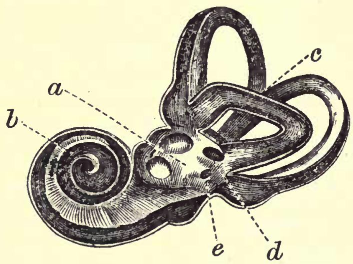
141. Injuries of the Middle Ear—their effect.—This chain of bones is furnished with very delicate muscles, which serve to render it tense, so that the slightest vibration is transmitted along it from the outer to the inner ear. These bones are sometimes destroyed by disease or accident, without the entire loss of hearing, though always with great injury to that function.

The dullness of hearing common to old age is usually the result of the growing together of this bony chain, as well as of the thickening of the membranes at each end of the chain. These changes are often accompanied by the more or less complete closure of the Eustachian tubes. While perfect deafness seldom results from injuries to the middle ear, yet most of the causes which operate to merely impair hearing are located there.

142. The Labyrinth, or Internal Ear.—The Labyrinth is composed of three parts: the vestibule, the semicircular canals, and the cochlea, or snail-shell. The vestibule is a common chamber with which all the other parts communicate. It is a small, oblong, irregularly shaped cavity in the hard portion of the temporal bone, with two small openings looking into the middle ear. These are called *finestræ*, or windows, and from their respective shapes are named the oval and the round windows. These, in the living body, are closed by a dense, firm membrane, but, in the skeleton, appear as openings from one chamber to the other.

143. The Semicircular Canals—their use.—Some idea of the form and relation of the several parts of the inner ear may be obtained from the annexed figure, which represents the internal ear, somewhat enlarged.

FIG. 61.—THE INTERNAL EAR.



a. Vestibule. *b.* Cochlea. *c.* Semicircular canals. *d.* The oval window. *e.* The round window.

The semicircular canals, three in number, are simply curved openings through the bony substance surrounding this cavity, passing out of the vestibule and returning to it. If they serve any other purpose than to extend the surface for the distribution of the auditory nerve, that purpose has not been discovered.

144. The Cochlea.—The Cochlea, or snail-shell, is a double spiral canal, wound around a central pillar. Leaving the vestibule opposite to the oval window, it makes two and a half turns around the pillar and reaches the summit, where it enters the other canal, and by the same number of turns as in ascending, it descends to the vestibule, reaching it at the round window. All these cavities are filled with a limpid fluid, which is nearly pure water; and they are lined by a very delicate membranous expansion of the auditory nerve. In the vestibule and semicircular canals, this nervous expansion is covered with filaments, or loops of nerve matter, floating loosely at one extremity, and attached to the nervous mass by the other. In the cochlea, the nervous expansion presents a smooth, soft surface.

Recapitulation.

Seeing and hearing are senses with special organs devoted to them. The ear consists of the external, middle, and internal divisions. The middle ear communicates with the mouth by the Eustachian tube. It contains a chain of four small bones. Its cavity is filled with air. The internal ear consists of a vestibule, a cochlea, and three semicircular canals. These cavities are filled with water. The auditory nerve is distributed on the membrane.

LESSON XVIII.

HEARING.

145. Nature of Sound. — The complex organ which we attempted to describe in the last lesson, is intended to convey to the brain the sensation of sound, and its several properties and qualities. The sense of hearing takes cognizance of a tremulous or vibratory motion transmitted through a medium (usually the air) from a vibrating body, to the auditory nerve in the inner ear.

All bodies are not capable of emitting sound. Elasticity and hardness are the properties which are commonly assigned to sonorous bodies, but this definition appears to be defective. Two currents of air striking each other will give out sound, without the assistance of any hard substance. Elasticity is an indispensable property of sonorous bodies, and yet but few substances are more elastic than India rubber, and none less sonorous.

146. Transmission of Sound-waves.—A bell is struck with a hammer, and instantly the particles of which it is composed are thrown into a kind of wave-like motion, which is prolonged for several seconds. This vibration can be easily perceived if we bring our fingers into contact with the bell immediately after the stroke. This movement is transmitted to the surrounding air, and waves of motion, exactly corresponding to the vibrations in the bell, roll off in every direction, diminishing, however, in intensity as they recede from the sonorous body, but retaining all the other properties of the original vibration in the bell.

Air is not the only medium of communication between sounding bodies and the organ of hearing. Dense solids, such as the metals, compact wood, etc., are good conductors of sound, and water transmits sonorous vibrations very perfectly.

147. Conditions of the Transmission of Sound.—Sound is not transmitted through a vacuum, hence a bell struck in the exhausted receiver of an air-pump gives out no sound, because there is nothing in contact with it to communicate its vibrations to the outer air. Sound is transferred with difficulty from one medium to another. A bell struck under water gives scarcely any sound to the ear in the air, but if the ear be under water, the sound is almost deafening.

Though wood is an excellent conductor of sound, yet a wooden partition of but an inch in thickness greatly interrupts the passage of sounds. This is because the vibrations have to be transferred to the wood from the air, and after passing the wood, re-transferred to the air again, by which a large proportion of the original intensity is lost. Air contained in a tube transmits sound much more perfectly than when unconfined, because the vibrations are not readily communicated to the surrounding walls of the tube.

148. Reflected Sound.—Waves of sound, transmitted through the air, striking on a solid surface, communicate but a small amount of their motion to the obstructing solid. The greater portion is reflected or turned back again into the same medium. This reflected wave of sound forms what is called the echo, and is always less intense than the original sound, by the amount of vibration communicated to the reflecting surface. Obeying the law of reflection, sound may be concentrated by being reflected from concave surfaces, and diffused when thrown off from convex ones. On this principle ear-trumpets act, to collect at a single point the sonorous vibrations of a large space. The cartilaginous expansion of the outer ear serves the same purpose.

149. Mechanism of Hearing.—The undulations, or waves of sound, thus concentrated by the expansion of the external ear, strike on the tense membrane of the tympanum at the bottom of the auditory tube, communicating to it similar vibrations. But as one end of the chain of bones in the middle ear is attached to the tympanic membrane, whatever state of motion is induced in it will be transmitted along the bony connections to the stirrup, the base of which presses firmly against the membrane of the oval window.

The arrangement of these bones is such as to slightly magnify the movement, and to limit it to a single direction. The stirrup-bone moves to and from the membrane with which it is in contact, and can have no lateral or side motion. But the inner ear, in all its parts, being filled with fluid, has the vibration of the membrane communicated to it throughout, by the well-known law of the transmission of impressions through fluids.

150. The Qualities of Sound.—The expansion of the auditory nerve being every-where in contact with this fluid, and its sentient loops floating loosely in it, transmits to the brain the intelligence of the vibration.

The sensation thus conveyed to the seat of perception is an exceedingly complex one, embracing, beside the simple impression of sound, the almost innumerable qualities and modifications of it.

The chief of these may be comprised in the intensity or force, the pitch, and the direction of sound. The force or loudness of a sound is often mistaken for its pitch, because a sound on a high key produces the jarring sensation of a much louder sound on a lower key. The length of the undulations, or what is the same thing, the number of vibrations in a given time, constitutes the pitch of a sound, without any reference to the force by which the vibration is set in motion.

151. The Direction of Sound, how determined.— The power to determine the direction from which a vibration proceeds, is not the least of the wonders of this wonderful sense. If we were to reason from the mechanical arrangement of the ear, we would infer that all sounds, when communicated to the auditory nerve through the tube of the external ear, the chain of bones in the middle ear, and the fluid of the labyrinth, would be converted into waves in a uniform direction; but this is not the case. As the wave of sound rolls out in every direction from the vibrating body, it is evident that a line drawn from that body must cut the wave at right-angles, at whatever point it may strike it. That which the auditory sense determines, therefore, is the direction of a line that shall be at right-angles with the undulations. In a practiced ear, this delicate task is performed with amazing accuracy.

152. Musical Faculties.—But the nice discriminations of a well disciplined musical ear, are even more wonderful than the measurement of the angle necessary to determine the direction of sound. This is a special faculty, and does not depend alone on the acuteness of hearing. Many persons who hear accurately even very feeble sounds, and judge correctly of their other properties, yet distinguish the pitch of sounds very imperfectly. Many eminent physiologists have referred this faculty to the cochlea or spiral canals, and there appears to be plausible reasons for such reference. However, in the present state of anatomical knowledge, it would be hazardous to affirm any thing on the subject. The power to distinguish the voice of a particular person, is really as strange as the most wonderful musical powers.

153. The Sense of Hearing—how far it is voluntary.—The sense of hearing is properly an involuntary function, though there are several modifications, subject to the will, which have an important bearing on the exercise of this faculty. For example, if the attention be directed to a certain sound, we can, by a voluntary effort, transmit that sound to the perceptive center, and practically exclude all others, though they may be more forcible.

There is also a voluntary power of increasing the tension of the tympanic membrane, thus rendering the ear more sensitive, and capable of hearing very feeble sounds. The sense of hearing can be educated, in its several departments, to an almost unlimited extent, as is witnessed in the trained musician, and the telegraph operator.

The organs essential to hearing being located in a bony cavity, are subject to fewer accidents than most of the other organs; but a long continued exposure to loud and constant noises, as in machine-shops and factories, greatly impairs the acuteness of hearing.

Recapitulation.

The ear acquaints us with sound and its qualities. Hard, elastic bodies, when vibrating, communicate their motion to the air, or other medium with which they are in contact. This vibration is transmitted to the inner ear through the drum by means of the bony chain, and a similar motion is set up in the fluid of the internal ear. The auditory nerve transmits to the brain the knowledge of this vibration. The brain recognizes the sound—its force, pitch, direction, etc. Hearing is involuntary, but may be modified by volition.

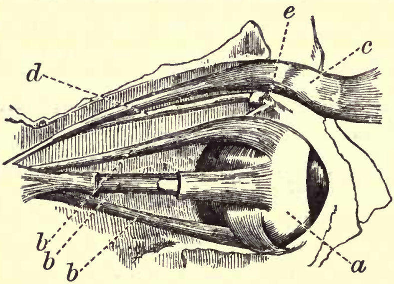
LESSON XIX.

THE EYE.

154. Muscles of the Eye.—The Eye, the organ of vision, consists of the globe or ball of the eye, the adjusting machinery, and the protecting organs. The two last-named divisions, however, are merely auxiliary organs, and not absolutely essential to vision. The adjusting machinery consists of six muscles, which arise from the back part of the bony socket in which the ball of the eye is placed. Four of these are called straight muscles. They are inserted into the back part of the orbit, about equal distances apart, so that while two serve to roll the eye upward and downward, the other two give it a lateral motion to the right and left.

The remaining two are called oblique muscles. They are inserted into the outside of the eyeball, and operate to roll it inward and downward. One of these has a peculiar contrivance for this purpose. It arises with the straight muscles from the back of the orbit, but is

FIG. 62.—MUSCLES OF THE EYE.



a. Globe of the eye. *b, b, b.* Straight muscles. *c.* Muscle to raise the upper eyelid (*Levator Palpebræ*). *d.* Upper oblique muscle. *e.* Loop and tendon.

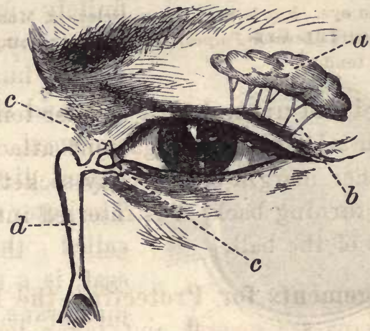
carried forward and upward by a slender tendon, which passes through a loop of firm ligament attached to the upper and inner margin of the bony socket of the eye, from whence, turning back, it is inserted into the outer and back part of the ball.

155. Arrangements for Protecting the Eye.—The protecting organs are several, and, taken together, constitute a very perfect system of protection to a very delicate organ, whose function requires that it shall have a large external exposure. The ball of the eye, the true organ of vision, is placed in a deep, bony socket, the margin of which is guarded above by a heavy ridge of bone in the form of an arch. The eyeball, in this cavity, rests on a soft, elastic cushion of fatty matter, which entirely fills the back part of the socket.

The eyelids are a pair of curtains, with each a thick, cartilaginous edge fitting accurately to its mate, and thus completely excluding the eye from the outer world. These margins are lined with short, curved hairs, the eyelashes, which serve as a screen to protect the eye from dust. The bony ridge above the eye is also covered with a line of short, thick hairs, inclining toward the outer angle of the eye, so as to carry the perspiration around that organ.

156. Tears — their use — the Lachrymal Duct. — That it may perform its function correctly, the eye

FIG. 63.—LACHRYMAL GLAND AND DUCT.



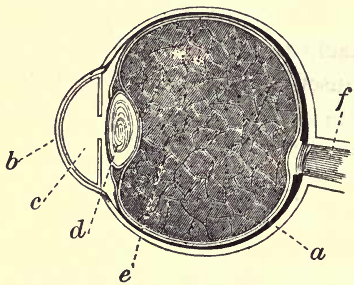
a. Lachrymal gland. *b.* Ducts leading from the gland to the upper part of the eye. *c, c.* The lachrymal points. *d.* Nasal duct.

requires to be kept constantly moist. To accomplish this end, a gland, called the Lachrymal gland, is placed in a depression of the orbit immediately back of the arch, at its upper and outer part. This gland secretes the fluid called tears, and, from its situation, this secretion is very readily distributed over the front part of the ball, by the motion of the eyelids in winking.

The inner surface of the eyelid is covered with a very delicate and highly sensitive membrane, called the conjunctiva. This is reflected off from the eyelid to the ball, and covers the front part of it, one layer of it passing entirely over the transparent cornea in front of the eye. The tears, after having performed their office, are conveyed into the nose by the lachrymal duct, which opens into the orbital cavity near the inner angle of the eye.

157. Coats of the Eye.—The ball of the eye is a complete optical instrument, a camera of the same kind used by artists in making sun-pictures, but infinitely more perfect than any instrument which human ingenuity and skill has yet produced. The eye has three distinct coats. The outer one of these, called the Sclerotic coat, is a dense, tough membrane, approaching nearly to the firmness of cartilage.

FIG. 64.—THE EYE.

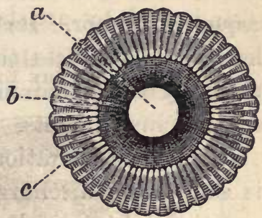


a. The three coats of the eye. *b*. The cornea. *c*. The aqueous humor. *d*. The crystalline lens. *e*. The vitreous humor. *f*. Optic nerve.

On the front part of the ball, this coat changes its character, becomes transparent and slightly thinner, but preserves its hardness. This transparent portion is called the Cornea. It is more convex than the sclerotic coat elsewhere, as if it were a segment cut from a smaller sphere. The Choroid coat is a highly vascular membrane, lying in immediate contact with the inner surface of the sclerotic coat. It contains numerous cells filled with a dark brown or black pigment, which gives its color to the membrane.

158. Iris, Pupil, and Ciliary Processes. — That portion of the choroid coat which lies back of the cornea, is separated from it by a considerable space, and in this part it takes the name of Iris. The iris is a colored curtain, with a circular opening in the center called the Pupil.

FIG. 65.—IRIS, PUPIL, AND CILIARY PROCESSES.



a. Pupil. b. Iris. c. Ciliary processes.

On the back of the iris, and attached to the outer margin of it, is a series of firm, ligamentous bodies, arranged like rays around the iris. These are the Ciliary processes. To the inner end of these is attached a number of very fine, muscular fibers, with their opposite ends inserted into the margin of the pupil. When these contract, they draw the curtain back, and thus enlarge the pupil.

There is also a set of circular fibers, the contraction of which serves to draw the curtain forward, and thus diminish the pupil. These motions are produced, involuntarily, by the effect of light.

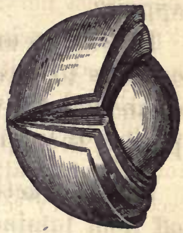
159. The Retina.—The Retina forms the third coat of the eye, and lies directly in contact with the vitreous humor which fills the greater portion of the ball. This is a very delicate membrane, made up of a net-work of nervous filaments interwoven with minute blood-vessels, so as to form a continuous membrane. These filaments are expansions of the optic nerve, which, though it is the largest nervous trunk in the body, is confined in its expansion exclusively to the inner coat of the eye. It is limited in its function to the special sense of sight, and though so sensitive to the effect of light, it is incapable of feeling the grosser impressions, when in a normal or healthy condition; but when inflamed, it becomes very sensitive.

160. Aqueous Humor—its position.—The space between the cornea and iris is filled with a transparent fluid, which is nearly pure water. It is called the Aqueous humor. Its shape is that of a plano-convex lens, and it affects the rays of light that enter it in precisely the same manner that such a lens does in optical instruments.

In surgical operations on the eye, the aqueous humor is sometimes discharged; but if the opening be closed, and the light carefully excluded from the eye, the water will be reproduced in a few days. This fluid fills not only the space between the cornea and the iris, but also that back of the iris, to the suspensory ligament of the crystalline lens.

161. Crystalline Lens.—The Crystalline Lens is the principal organ in the apparatus of vision. It is situated immediately behind the pupil, and is held in place by a thin suspensory ligament, attached to the outer margin of the ciliary processes. It is a soft solid, very transparent, and, in shape, a double convex lens, with the posterior surface more convex than the front. It is capable of being separated into concentric layers, somewhat like the coats of an onion, the layers becoming constantly denser as we penetrate toward its center.

FIG. 66.—CONCENTRIC LAYERS OF THE CRYSTALLINE LENS.



The muscular bands attached to the ciliary processes have the power of adjusting the crystalline lens, so as to accommodate the vision to objects at different distances from the eye. Back of the crystalline lens, the ball of the eye is filled with a transparent semi-fluid, somewhat resembling the white of an egg. It is the vitreous humor, and is in contact with the retina at all points.

Recapitulation.

Provisions for protecting the eye. Eyebrows, their use. Tears secreted by the lachrymal gland, and distributed over the eyeball in winking. Conjunctiva covers the inner surface of the eyelid. The eyeball has three coats—the sclerotic coat, the choroid, and the retina. The front projection of the sclerotic coat is transparent—it is the cornea. The front part of the choroid coat is the iris; the opening through it, the pupil. The retina, the inner coat, is a nervous membrane. The aqueous humor lies between the cornea and iris. The crystalline lens lies behind the pupil.

LESSON XX.

VISION.

162. Mechanism of Vision.—The Eye is an optical instrument which, by the most perfect adaptation of its parts, produces an image of external objects, and casts it on a sensitive screen in the back part of a darkened chamber. It is, therefore, a true camera obscura with two lenses, and a very transparent medium between the last lens and the retina, where the image appears.

In order to understand how the mechanism of the eye operates to produce vision, it will be necessary to state a fundamental law governing the movement of light in passing through mediums of different density.

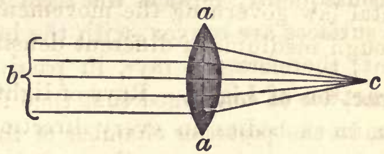
163. Refraction of Light.—Rays of light are thrown off from luminous bodies in every direction, and move in straight lines so long as they continue to pass through the same medium. When light passes from one medium into another, as from air into water, the ray is bent out of its course, unless it enters on a line perpendicular to the surface.

This bending of a ray out of a straight line is called the *refraction of light.* Different substances have different refractive powers. A ray of light passing from the air into water, on a line oblique to its surface, is bent downward, or refracted toward a line perpendicular to the surface of the water; and a ray passing from water into the air, is refracted in the opposite direction—that is, from the perpendicular.

164. Reflection of Light from Opaque Bodies.—A lens is a transparent medium bounded by curved lines. These may make the surfaces either concave or convex, and the effect of the lens on rays of light will correspond to the shape. A convex lens converges or brings the rays together, while the effect of a concave lens is to cause the rays to diverge from each other.

Rays of light are thrown off, not only from luminous bodies, but from all substances which afford any obstruction to light in passing through them. The latter reflect the rays of light, which thus appear to come from the reflecting surface as though it originated there. Most bodies are visible, therefore, only by reflected light.

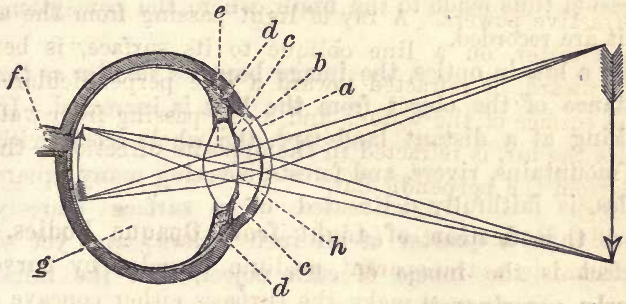
FIG. 67.—A DOUBLE CONVEX LENS, SHOWING THE REFRACTION OF LIGHT.



a, a. A double convex lens. *b.* Parallel rays of light. *c.* The focus, or point where the converging rays meet.

165. Aqueous Humor and Crystalline Lens.—The transparent cornea, forming the front of the eye, re-

FIG. 68.—FORMATION OF IMAGES IN THE EYE.



a. The cornea. *b.* The aqueous humor. *c, c.* The iris. *d, d.* The sclerotic coat. *e.* The crystalline lens. *f.* The optic nerve. *g.* The vitreous humor. *h.* The pupil.

ceives the rays of light on a convex surface; and it, with the aqueous humor lying back of it, being denser than the air, causes the rays to converge. Now rays coming to the eye from objects near it, do not reach the cornea parallel with each other, but are diverging. This first lens (the aqueous humor), therefore, serves chiefly to correct this divergence, and bring the light to the crystalline lens in parallel rays. This lens is denser than the aqueous humor, and consequently refracts the light conveyed to it. Both its surfaces are convex, with the back more so than the front; therefore the rays, in passing into the vitreous humor, are so converged that they form a focus on the retina, in the posterior chamber of the eye.

166. Place and Size of the Image.—Rays of light thrown off divergent from every point of an object, would therefore be converged to a focus, and form an image; and when the eye is properly adjusted, this image will be in direct contact with the sensitive surface of the retina. This surface transmits the impression thus made to the brain, where the perceptions of it are recorded.

By a law in optics, the image becomes smaller as the distance of the object from the lens is increased. In looking at a distant landscape, the whole scene, with its mountains, rivers, and forests, covering many square miles, is faithfully delineated on a surface scarcely more than a quarter of an inch square; and yet so perfect is the image of each object, that the mind clearly perceives it.

167. Images on the Retina are Inverted.—But the rays of light coming from the lower part of an object, will form their focus at the upper part of the image; and those from the upper part of the object, crossing the first, will form the lower part of the image, so that the picture will be inverted.

This is well known to be the position of the image formed in a camera obscura, an instrument constructed on the principle of the eye; and it has been further proven by actual experiment. If we take the eye of an ox, and carefully dissect the sclerotic and choroid coats away from the back part of it, and fit the eye thus prepared into an opening in a shutter, so that the cornea will look outward, and then place ourselves behind the eye, in a dark room, we shall see the images of external objects in an inverted position on its retina.

168. How Objects are seen Erect.—Many physiologists have been greatly puzzled to explain why objects appear erect, when the images by which we see them are inverted; but if we remember that vision is an acquired function, and that we learn the position, size, and form of things seen, only by habit, the difficulty disappears at once.

Universal experience teaches us that the part of the image impressed on the lower portion of the retina, answers to the upper part of the object; and, reversely, impressions on the higher parts of the eye answer to the lower portion of objects. Indeed, none of the special senses give us knowledge instinctively, but all require to be trained and educated, till the perceptive powers become familiar with their modes of communicating intelligence.

169. Adjustment of the Eye.—But there is another difficulty connected with the mechanism of the eye, more serious than this. Rays coming from distant objects are nearer parallel than those radiating from a less remote point, and rays entering the eye least divergent will come to a focus soonest; consequently, if the distance between the crystalline lens and the retina were always the same, and the shape of the lens unalterable, we would be able to see objects distinctly only in one place.

If they were nearer to us, the image would fall behind the retina; if farther from us, it would be formed in the vitreous humor in front of that surface. This difficulty is remedied by accommodating the position or shape of the crystalline lens to the distance of the object from the eye. The muscular fibers of the ciliary processes (§ 161), draw the lens forward when we look at things near us, which movement also compresses the lens, so that its focus is shortened; and these joint movements throw the image on the sensitive surface of the retina.

Recapitulation.

Images are formed in the eye by the refraction of light. Self-luminous bodies, and those reflecting light, are objects of vision. The aqueous humor corrects the divergence of light; the crystalline lens is chiefly concerned in forming the image. The distance of the object diminishes the size of the image. Perfect vision requires that the image be in contact with the retina. Images in the eye are inverted. Position, size, and place of an object are determined by habit. The eye adjusts itself to the varying location of objects.

LESSON XXI.

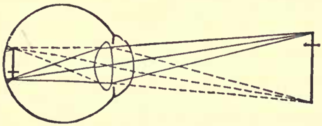
VISION. — CONTINUED.

170. Spherical Aberration — its cause and effect. — The quantity of light admitted into the eye is measured by its intensity. In a strong light, fewer rays are required to form a distinct image; and accommodating itself to this condition, the pupil is diminished by the circular fibers of the iris contracting, and drawing the edge of the curtain forward. In a dim light, this movement is reversed, and the radiating fibers of the iris draw the edge back, and thus enlarge the pupil. But in using the eye with an enlarged pupil in a dim light, objects become indistinct, with their outlines no longer sharply defined.

This results from a well-known principle in optics. The rays of light which fall near the edge of a convex lens are bent more, and consequently have a shorter focal distance than those falling near the axis of the lens, thus making the focus a line, rather than a point. This is called *spherical aberration.* The contraction of the iris covers the edges of the crystalline lens, and thus avoiding spherical aberration, leaves the image sharply defined when made by a bright light.

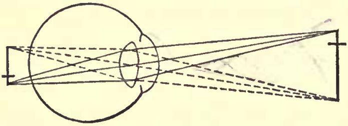
171. Short-sightedness. — Short-sightedness is generally attributed to a too great convexity of the cornea. In a majority of cases of this kind, the defect in vision arises from this cause, but it evidently may be produced by a too great convexity of the crystalline lens, as well as by the same deformity of the cornea; or there may be too great a distance between the lens and the retina. This may be owing to a defect in the power of adjustment in the eye. If the cause of near-sightedness lies in the cornea, age will cure it; if it is from either of the other causes, it will remain. Long-sightedness arises from the opposite conditions. This is seen in the subjoined figures.

FIG. 69.—SHORT-SIGHTEDNESS.



The image formed forward of the retina.

FIG. 70.—LONG-SIGHTEDNESS.



The image formed back of the retina.

172. Size and Distance of Objects—how determined.—The ability to determine the distance and size of objects seen is acquired only by practice. The size of an object would very naturally be inferred from the space occupied by the image on the retina; but a small object near the eye will make an image covering as much of the retina as a large one at a distance. From this it will be seen that size and distance are intimately related in vision.

If we know the distance of an object, we may form a pretty accurate judgment of its size; and, on the other hand, having determined the size of any thing, we readily refer it to the proper distance. Painters avail themselves of this law by introducing into pictures of buildings, landscapes, etc., figures of men or animals whose size is well known, and by this means they enable us to judge correctly of the distance of the objects, which the perspective may, perhaps, have failed to determine positively.

173. Transparency of the Atmosphere affects the Judgment of Distance.—The degree of distinctness in the outlines and general form of bodies, furnishes another means of determining distance. This is modified very much by the intensity of light and the transparency of the air. In the clear atmosphere and strong light common in mountainous regions, the distance of objects is apparently much diminished.

When we look at objects near to us, the eyes are rolled inward, so that the lines drawn through the center of each eye will form a greater angle where they meet in the object, than they would if it were distant. The muscular sense estimates the extent of this inclination of the eyes toward each other, and thus materially aids in determining distance.

174. Why Objects are seen Single, when an Image is made in each Eye.—When we see objects with two eyes, it is evident that two distinct images are formed, and yet the mind perceives but one object. This depends on our ability to adjust the axis of vision, so that the image will occupy exactly the same point on the retina in each eye. Any thing that interferes with the action of the muscles which roll the eyeballs, or that hinders our adjusting the eyes to objects at a particular distance, will produce the phenomenon of double vision.

When we attempt to arrange three or more objects at different distances from us, so that they shall be in a line, we use but one eye, otherwise all the objects but one would be seen double. If we press one of our eyes so as to hold the ball firmly in the socket, we see all objects double, because we interfere with the adjustment of the angle of vision.

175. The Advantage of two Eyes.—The advantage of two eyes in seeing is not merely that we double the impression made on the nervous center, but we are enabled to see more of objects with two eyes than with but one. If we place a card before us, with its edge directed to the space between the eyes, we will see both sides of the card; but if we close one eye, the side of the card corresponding to that eye will disappear. From this simple experiment, it is evident that the images in the two eyes are not alike, but they must occupy the same point on the retina to make vision perfect.

When we look at a plane surface, each eye has exactly the same image in it; but if the surface is irregular, curved, or angular, each eye will picture its own side of these irregularities; but out of the two pictures, the mind perceives one perfect image.

176. The influence of the Mind on Vision.—In cross-eyes, the mind recognizes the image formed in but one eye, and thus objects are seen single which otherwise would evidently appear double. But it is true of ordinary vision, also, that the mind has no perception of many images that must be formed on the retina. Indeed, the whole process of sight is very much influenced by the mind, and often the things spoken of as objects of sight are really the results of our judgment about the sensation.

Distance, size, and, to a great extent, shape, are rather complex judgments than simple sensations. Another source of false vision is, that the image is not perceived at the instant it is made, nor is its absence observed the moment it disappears. The separate spokes of a wheel in rapid motion blend together and appear continuous. So if a burning coal be whirled rapidly in a circle, it appears as a continuous line of light, because the eye retains the first impression till it is reproduced.

177. Subjective Sensation. — The mind performs an important part in all our sensations, as well as in vision. What are commonly known as "delusions of the senses" are really mental phenomena — morbid actions of the perceptive faculties. They are more properly called subjective sensations.

In certain conditions of the skin, there is a perception of something creeping on the surface. In many diseases, the patient is constantly harassed with certain disagreeable tastes or odors. These are perceptions from internal conditions, and not from external impressions on the organs of sense. Many persons are troubled with perceptions of sound, without any external cause; but the most wonderful exhibition of subjective sensation is to be seen in patients laboring under delirium tremens, when the most frightful objects are pictured to the mind with great distinctness and in minute detail.

Recapitulation.

Spherical aberration, the effect of enlarging the pupil in a dim light. Short-sightedness may be the effect of several causes. Distance of an object determined chiefly by its known size, and the sharpness of its outline. Objects are seen singly by the image in each eye falling on the same part of each retina. More of an object can be seen with two eyes than with one. Vision is influenced by the mind. Certain conditions of the brain produce false perceptions, or subjective sensations.

LESSON XXII.

MOTOR FUNCTION.

178. The Motor Functions of the Nervous System.—We have already said (§ 120) that the nervous system has a three-fold function; or, rather, it performs three distinct and nearly independent functions. Sensation is but one of these. By it we become acquainted with the external world, and acquire the material for thought—that on which the mind exerts its creative powers of imagination, comparison, judgment, etc. Sensation is thus intimately connected with our rational enjoyment; but the power of motion, communicated to the muscles through the motor nerves, is essential to life itself.

When the heart and the respiratory muscles cease to move, death ensues instantly. But the motor functions have an important bearing on the mental action. While the mind receives the thoughts of other minds by the sentient nerves, it is able to communicate its own thoughts only through the motor nerves.

179. Voluntary and Involuntary Movements.—Muscular motion has been generally considered as of two kinds, voluntary and involuntary; or those motions that are immediately under the control of the will, and those over which we are able to exert little or no control by our volitions. The involuntary movements belong to the functions immediately connected with life, such as digestion, circulation, secretion, etc. Respiration is a mixed function, controlled to a limited extent by the will, but beyond that, becoming involuntary.

The involuntary motions of the body, when in a healthy condition, are carried on without our knowledge, as well as without our consent. We therefore never feel fatigued from the constant action of the heart, or the movements of the stomach during digestion. The wisdom of placing these important functions beyond the reach of the will, as well as beyond our consciousness, is apparent at the first glance.

180. Ganglions of Involuntary Motion.—The nerves supplying power to the involuntary muscles, do not come directly from the brain or spinal cord, but are derived from a system of ganglions, or little brains, located in the vicinity of the great organs they are intended to supply, and these connect with two nervous cords extending nearly the whole length of the spinal column, and occupying positions on each side of it. This double cord is known as the Great Sympathetic nerve. These cords are really chains of ganglia, or little knots of nervous matter arranged like the spinal cord, the gray matter occupying the center, with the white matter on the surface. These ganglia are opposite to the space between the vertebra. They are connected together by a nervous cord, and each ganglion receives a filament from the corresponding spinal nerve at its origin, and sends off branches which, uniting together, form the ganglia of the involuntary organs.

181. Importance of Ganglionic Nerves. — The branches of this sympathetic system accompany the blood-vessels even to their capillary extremities, and seem to exert an influence on those mysterious changes which take place in connection with this class of vessels, such as the secretion of fluids by certain glands, direct nutrition of the different tissues, etc.

This is demonstrated by the effect of injuries to the branches of this nervous system distributed to the different organs. For instance, if the great semi-lunar ganglion, from which the diaphragm derives its nerves of involuntary motion, be injured, breathing is so impaired that the patient frequently dies suddenly, as if from suffocation. This system has no true sentient nerves, but certain mental emotions are referred to the larger ganglions, producing peculiar sensations familiar to every one.

182. Passions and Emotions — how expressed. — This indirect or sympathetic connection between the mental condition and the involuntary organs, gives rise to all the common manifestations of emotion or passion, such as tears of grief, the paleness of fear, the flush of rage, or the blush of confusion or shame. These being produced involuntarily by the several mental conditions of which they are the exponents, can be artificially induced only by exciting in the mind the actual condition of which they are the proper representatives.

The actor on the stage, by the long training of, perhaps, an originally active imagination, throws his mind into the actual condition of that expressed in the character he is personating, and the involuntary expressions of these conditions follow, by sympathy, as truly as if the emotions were real.

183. The Physiological Law of Sympathy.—But the sympathetic action does not end here. Watching the expression of the actor's emotion, our own minds become similarly affected, whether we will it or not, and that condition is expressed by the invariable action of the involuntary nerves. In this power to voluntarily call up the mental condition present in the exercise of any of the passions, and thus induce the true expression of the emotion through involuntary functions, consists the chief control of the orator over his hearers.

The speaker who can so impress his own mind as to produce the mental state of grief, will find the lachrymal glands responding at once in as copious a flow of tears as if his grief were real; and his audience, unless they, by a voluntary effort, withdraw their attention, and thus sever the cord of sympathy, will find themselves weeping too. Such are the mental associations of the involuntary nerves.

184. Degree of Sensibility in the Involuntary Organs.—The organs which perform involuntary functions have, in their healthy condition, no sensibility, or, at least, they are sensitive only as they are supplied with nerves from the cerebro-spinal system. In certain forms of disease, however, the stomach, intestinal canal, and heart become exceedingly sensitive to the touch of any solid substance.

Though the will has no direct control over these functions yet the activity of the voluntary organs produces a decided influence on the rate and force with which they act. Brisk exercise, short of the point of violence, and not continued to fatigue, will accelerate all the involuntary actions in sympathy with the voluntary functions. If, however, the exercise be violent, and be carried forward till a sense of fatigue is felt, the vital force will be expended on the voluntary organs, leaving the involuntary functions in an impaired condition.

185. Effect of Sleep.—This sympathy of the involuntary with the voluntary movements of the body is further seen in the diminished force and activity of circulation, digestion, and secretion during sleep, which, as we shall see in the proper place, is a suspension of the voluntary functions.

Though the involuntary muscles are not capable of feeling fatigued, yet they are subject, at least in some degree, to the rapid exhaustion which so soon succeeds to the forcible contraction of a voluntary muscle. Though the heart may continue to perform its function incessantly for its "three score and ten" years, yet we must remember that its intervals of relaxation are equal to its periods of contraction; in other words, the heart rests half its time.

Recapitulation.

The motor functions are essential to the maintenance of life. Muscular motions are of two kinds, voluntary and involuntary. The cranial and spinal nerves govern voluntary motion. Involuntary movements are connected with the brain through ganglions. The sympathetic nerve, with its connected ganglions, controls the circulation, secretion, etc. Passions and emotions are expressed through the sympathetic nerve. Voluntary motions effect involuntary functions indirectly.

LESSON XXIII.

NERVOUS FUNCTIONS.

186. Special Functions of the Spinal Cord.—In the anatomical description of the brain and spinal cord, it was observed that the proportion of gray matter, compared with the white, was smaller in the cord than in either the cerebrum or cerebellum. As we come now to inquire into the motor function of the spinal cord, it will be well to note the relative position of these two substances. As is shown in the subjoined figure, the gray matter occupies the center of the cord, and is nearly surrounded by the white substance.

FIG. 71.—TRANSVERSE SECTION OF THE SPINAL CORD.

a. Anterior fissure. *b.* Posterior fissure. *c, c.* Gray matter.

Both roots of the spinal nerves communicate first with the white matter of the cord, but do not terminate there. Many of their filaments dip downward through the external white envelope of the cord, and terminate on the gray matter at its center. This arrangement gives to the cord a twofold function: 1st. It is, by its white matter, a part of the continuous chain of communication between the gray substance of the brain and the motor and sentient extremities of the nerves; and, 2d. Under certain circumstances, it assumes the functions of brain proper, and carries forward its actions unconsciously.

187. Complex Nature of Voluntary Motion.—Voluntary motion, however simple it may appear, is a very complicated matter. If the hand comes into contact with a hot poker, an impression is made on the extremities of the sentient nerves; this is immediately transmitted to the spinal cord by the brachial nerve, and, through the white matter of the cord, is conveyed to the gray substance of the brain, where the sense of heat is perceived, and immediately an impulse is transmitted to the proper motor nerves by the same route through the spinal cord, the appropriate muscles are called into action, and the hand removed from its dangerous contact with a hot surface. That these actions take place consecutively can be clearly demonstrated by experiment, and yet the touch, the sensation, and the motion appear to occur at the same instant.

188. Reflex Motions originate in the Spinal Cord.—But the greater number of voluntary motions do not originate directly from sensations transmitted to the brain, but spring from independent volitions. A voluntary motion, which at first requires a specific action of the brain and a clear consciousness of the volition which produced it, will, after being often repeated, become habitual, and be produced without any consciousness of the volition commanding it.

These are called *reflex* motions, and are supposed to originate in the gray matter of the spinal cord, which, in these instances, performs the true functions of brain without our being conscious of its action. A great majority of the movements of the body belong to this class of reflex or unconscious action.

189. Unconscious nature of Reflex Motions. — Movements thus performed fatigue us much less, and are usually performed with greater accuracy, than those which demand our conscious attention to every volition and every motion resulting therefrom. In illustration of this, take the example of a walk. At every step the foot is carried forward by the contraction of a great number of muscles; but the attention is diverted to the scenery around us, or to the particular objects along our pathway; or, if not to these, the mind is engaged with some train of thought, or in the solution of some abstract problem, and at the end of our walk we are unable to recall the volition which produced any one of the thousands of separate motions we have made, or the consciousness of a single step we have taken.

190. Reflex Motions less exhaustive than Voluntary ones. — When we begin a kind of work to which we are not accustomed, our motions are awkward and clumsy, and each movement requires our undivided attention. They are cerebral motions. But after we establish the habit of these motions, however complex they may be — or, in common phrase, after we have acquired the handicraft — the movements are made gracefully, with ease, and without our attention or consciousness. These are spinal or reflex actions.

It is a matter of common observation, that a kind of labor to which we are not accustomed, fatigues us more than heavier labor to which we have habituated ourselves. This is because cerebral action is more exhausting than spinal or reflex action.

191. How the Nerves convey Impressions.—We have spoken of the impressions made on the looped extremity of a sentient nerve, and of their communication along that nerve to the seat of perception in the brain, and of the transmission of an impulse or force from the same center of influence, along the motor nerves to the muscles to produce motion; but our closest scrutiny does not detect any matter, however subtle, as traversing the nerves in either direction.

The nervous tissue, like other tissues of the body, is made of cells, and those in the white matter of the brain, and in the nervous cords, are elongated into tubuli, and what is transmitted is probably the mere motion or undulation of the molecules of which these tubuli are formed.

192. Communication with the Brain essential to Sensation or Motion.—A continuity of nerve structure from the brain to the muscles of motion, and from the organs of sensation to the brain, is absolutely essential to motion or sensation. If the nerve be divided, or if the communication with the brain through the spinal cord be broken, all the organs to which that nerve is distributed will lose the power of either sensation or motion.

From the fact that the spinal nerves originate by separate roots from different tracts of the spinal cord, (§ 122,) and these roots each performs a different function, it is possible to lose the power of feeling in a part while the function of motion remains unimpaired, and the reverse. Both the power of motion and sensation may be lost in a limb, while the circulation in it will be scarcely disturbed, this being under the control of the ganglionic nerves.

193. Effect of Injury to the Nervous Trunks.—If the trunk of a nerve, at any point between its origin and its sentient extremity, be irritated or injured in any way, the pain will be referred to the part on which the sentient extremities of the nerve are spread. When a limb has been amputated, and the ends of the divided nerves left in a condition exposing them to injury from compression or irritation, the patient will complain of pain in the lost limb; and these unpleasant sensations will frequently continue for years. The practical lesson to be learned from this is, that sensation is not to be received as infallible evidence that the cause producing it is located at the point where it is felt. It may be at any point along the trunk of the nerve.

194. Motions Classified.—The motor functions of the nervous system may be arranged in three classes: 1st. Those motions which originate in the gray matter of the brain, and proceed from a conscious impulse of the will; 2d. Those which at first are voluntary and conscious, but by frequent repetition come to be performed unconsciously, under the control of the spinal cord; 3d. Those which are purely involuntary, and of which we are entirely unconscious. These motions originate in the ganglions, and the organs thus acting are supplied chiefly with nerves from this source.

Recapitulation.

The spinal cord consists, like the brain, of gray and white matter, but their relative positions are inverted. Voluntary motions are complex. Reflex motions originate in the spinal cord. They are performed unconsciously, and are less fatiguing than motions of cerebral origin. Sensation and motion require unbroken nervous connection with the brain. Injuries of nervous trunks produce sensation which is referred to the extremities.

LESSON XXIV.

MENTAL FUNCTION.

195. Thought — dependent on the Brain. — The third function of the brain is thought. In what manner the brain acts when one thinks, we may, perhaps, never know; and yet we are as certain that it is the instrument of thought, as we know its connection with sensation and motion. Compression of the brain suspends consciousness and thought, as certainly as compression of the spinal cord arrests motion, and destroys sensation in the parts beyond the compression.

Certain diseased conditions of the brain derange the function of thought, and produce the different forms and grades of insanity corresponding to the character and intensity of the disease. Malformation of the brain may be regarded as a constant accompaniment of idiocy; and, as a general rule, the extent of the malformation measures the loss of mental power.

196. Development of Brain measures Thought. — To suppose that the power of thought belongs alone to the human race is, perhaps, the most common mistake on this subject. There is unmistakable evidence that the inferior animals think, and that in them the power of thought is more or less perfect, according to the degree of brain development.

In the vertebrate animals, as we ascend the scale from fishes to reptiles, from reptiles to birds, from birds to mammals, and finally to man, we find at every step an advance in the perfection of the nervous system; but this advance affects chiefly the cerebrum. Fishes have a very perfect spinal cord, the rudiments of a cerebellum, but nothing that deserves to be called a cerebrum. With them, thought is little more than an instinct of self-preservation. In reptiles, the cerebrum, though very small, can be clearly distinguished; and so the advance continues, intelligence keeping pace with it, till it culminates in man.

197. The Cerebrum, the Organ of Thought.—But even in the mammalia, the class to which man, as an animal, belongs, the proportion of the cerebrum to the cerebellum varies very much. In the lower orders of this class, such as the sloth, the ant-eater, and the opossum, the cerebrum is but little larger than the cerebellum; but, in man, it is from seven to ten times as large. This fact has led physiologists to infer that the cerebrum is the proper organ of thought, and the inference is probably well founded.

There is another feature in which the human brain differs from that organ in inferior animals. The proportion of gray matter is much greater in the brain of man than in that of any of the lower animals. But here, again, we find an ascending scale corresponding to the degree of intelligence in the animal. This is so uniform, that it may be regarded as establishing a general rule, that the proportion of gray, as compared with the white matter in the cerebrum, measures the sagacity of the animal.

198. Voluntary and Involuntary Thought.—Within certain limits, thought is an involuntary function, but beyond these, the intellectual phenomena appear to be, to a great extent at least, under the control of the will. Thoughts which arise. immediately from impressions made through the senses are not voluntary, but appear to spring up spontaneously. Another source of involuntary thought is found in the appetites and desires connected with the maintenance of life and health, such as hunger and thirst.

In the higher and more purely intellectual regions of thought, the will exercises at least a directive power over the mental action, selecting the subject of thought, and determining the direction of the investigation, and how far it shall be prosecuted.

199. Voluntary Thought modified by Training.—The power to maintain complete control of the mental functions varies materially in different individuals. To some extent this variation is natural, but to a great extent it is the result of training and education. Every student has observed how much more readily and perfectly he can command his attention to the subject of his studies, after his mind has been trained for years in the daily business of study, than he could when he first made his acquaintance with books.

The relation existing between the voluntary and involuntary departments of thought, gives rise to many curious and interesting phenomena. The power to concentrate the thoughts by a voluntary effort, and fix them on any line of investigation, is often so strong as to completely suppress the involuntary powers for the time being. This in common language is called absent-mindedness. It may arise from the great force of the directive faculty, or from the feeble effect of the sentient power on the brain.

200. Life in the Ascending Scale.—Modern philosophy assumes that motion, every-where in this world, is the result of *force*, operating on and through matter. Gravity, the chemical, electrical, and thermal forces pervade the entire material world. In addition to these, we find the force of organic life manifesting its presence in the vegetable world by the phenomena of nutrition, and through the mysterious process of cell growth, molding each individual into a specific form. Superadded to this, we have animal life manifested in the three-fold function of the nervous system—sensation, voluntary motion, and thought. Besides these phenomena, man also possesses the power of abstract thought, giving him the faculties of imagination, moral and religious perceptions, etc.

201. The Human Powers.—In the possession of these human powers, man differs from all the lower animals as really as they differ from the vegetable world. As the formation of cells and the construction of organs, etc., are functions of organic life, and sensation, motion, and thought are functions of animal life, so abstract reasoning, moral sensibility, the creative faculty of imagination, with all its high powers of examining and comparing things which are not, as though they were, are functions of spirit.

As animal life differs from the organic, not in degree merely, but also in kind, so the power of abstract reason differs from animal sensation and intellection — it is of another kind. Man manifests all the life forces of the vegetable and animal worlds, and in addition to these, functions which belong to a higher force, which we call Spirit.

202. Man, compared with the Lower Animals. — Of the nature of any force, abstractly, we know nothing. Its existence, and the law governing its activities, we know only by a careful study of what it does. The lower animals have all our senses, and some of these are much more acute than in man. They have memory, in some instances amazingly perfect; they manifest emotions and desires; and to gratify these desires, they adopt means to that end, limiting their reasoning to objects of sensation, however, and circumscribing their efforts to the securing of pleasurable emotions, and the avoidance of painful sensations. But they manifest no power to separate and examine, abstractly, the qualities of either actions or objects. These are functions of the spirit, and in the exercise of these powers man is a moral agent: he knows right and wrong; has a conscience, and feels his accountability, and is, therefore, a religious being; he reasons on *form* and *number* as abstract qualities of things, and is, therefore, a mathematical being. These are attributes of spirit.

Recapitulation.

Thought is a function of brain. This faculty is not confined to man, but is manifested in the lower animals in proportion to brain development. The cerebrum is probably the organ of thought. The sagacity of animals may be measured by the proportion of gray matter in the cerebrum. Thought is an involuntary function, but the directive power is voluntary.

Abstract thoughts, such as relate to the moral qualities of actions, the mathematical properties, form, number, etc., are functions of spirit, and belong exclusively to man.

LESSON XXV.

SLEEP.

203. Sleep, as it affects the Vital Functions.—The constant activity of the brain, in its triple function, rapidly exhausts its power, and, like other living organs, it requires rest. But the rest of the brain, necessary to restore its wasted energies, like rest in other organs, is the suspension of its function. To suspend the functions of the nervous system, is to induce a state of entire unconsciousness. This is sleep, and is a necessity in all animals, as well as in man.

It is proper to say, however, that the complete suspension of function does not extend to the whole nervous system. It begins with and belongs properly to the cranial brain, extending, by a kind of secondary influence, to the spinal cord, and modifying but slightly the great sympathetic nerve and its ganglions. Therefore, all the involuntary movements of the body continue during sleep, but they are performed more slowly and with less force.

204. The order in which Sleep affects the Senses.—The transition from a waking to a sleeping state, though often very rapid, is a process consisting of several consecutive steps. The progress toward a state of sleep appears to begin with impaired sensation, the senses of smell and taste being first to feel the effect; after this the eyes close, and vision ceases. The sense of touch is early impaired, but does not entirely disappear until all the other faculties are locked in sleep.

The sense of hearing maintains its function unimpaired as long as consciousness remains; and there are good reasons to believe that, though unconscious of it, the auditory sense is constantly reporting to the perceptive center, though no notice may be taken of these reports. A man falls asleep in the middle of a sermon, but as soon as the voice ceases he wakes, from the auditory nerve ceasing to report to the perceptive center.

205. Cerebral and Spinal Functions differently influenced. — While sleep is thus stealing on our senses, the power of voluntary motion is early suspended, especially those motions which demand the attention, and which requires each a special volition for its performance. The habitual motions, or those which are performed by the reflex action of the spinal cord, are continued longer, sometimes even after consciousness is entirely suspended, as in case of persons walking.

Somnambulism, or sleep-walking, is but the waking state of the functions under the influence of the reflex action of the spinal cord. The involuntary functions, such as respiration, circulation, digestion, etc., as soon as the voluntary movements of the body are suspended, feel the effect at once. The breathing is not so deep, and the number of inspirations in a given time is reduced; the pulse is generally diminished in frequency and force, and the temperature of the body falls sensibly.

206. Effect of Sleep on the Mental Faculties.— In the mental department of brain action, sleep first impairs the directive power of the mind. By this we mean the faculty which determines the course which our thoughts shall pursue. Next follow the powers of abstract reasoning, imagination, and memory; and last of all, the mind ceases to respond to the impressions made on the senses, and consciousness of our personality, or even existence, is lost.

Just before consciousness becomes extinct, there sometimes supervenes a curious intermediate state, which in common language is called *dozing.* We are still conscious, but unable to discriminate between impressions made by external objects through the senses, and those made from within by our own thoughts. This state is near akin to dreaming.

207. Sleep is Brain rest.—In a healthy state of the body, after about fifteen hours, more or less, spent in brain activity, the nervous system demands rest, to recuperate its powers and restore its exhausted energies. Sleep is the only true brain rest. We can temporarily repair an exhausted faculty by suspending its action, or exchanging it for some other form of brain activity; as, for example, when fatigued with study, we take a brisk walk, thus transferring the action to the motor nerves; yet the brain, as a whole, is suffering an exhaustion of its force, which can be restored only by sleep.

We may, by a voluntary effort, postpone from hour to hour the demanded rest, but, finally, it supervenes involuntarily, or inflammation of the brain will ensue. Well authenticated instances are on record of persons falling asleep on the battle-field, or in the midst of a terrible storm at sea, the presence of death itself not being able to keep them awake.

208. How much Sleep is Necessary.—The demand for sleep differs materially in different persons. Children require more hours of sleep than do adults, and their sleep is more profound, and the suspension of all the brain functions is more perfect. As a general rule, women endure loss of sleep better than men, and the nervous better than sanguine or lymphatic temperaments.

Of the three functions of brain, the mental is the most exhaustive. Next to this stands the function of sensation; and that which demands the least sleep is the motor function, or muscular activity. No rule can be laid down, with any degree of certainty, prescribing a given number of hours for sleep in the twenty-four. Age, sex, temperament, kind of employment, condition of health, etc., will materially modify any rule we may adopt.

209. How far Sleep is Voluntary.—Though sleep can not be voluntarily induced, yet we may place ourselves in such a condition that it will be invited, and will almost invariably supervene. Silence, darkness, and the absence of any object of sense, together with a state of muscular repose, will place the brain in a condition where no external demand on its powers can be made. In this state of repose, it falls very naturally into unconscious sleep, unless this is prevented by the activity of the representative faculties, or the creative powers of the imagination. These, in persons of active minds, often become troublesome, inducing a state of wakefulness which is always exhaustive of the vital force, and sometimes causes dangerous disease of the brain.

210. Coma—how it differs from Sleep.—Coma is a condition of the brain which, in its external manifestations, resembles very much a profound sleep. But in this state, consciousness can not be restored by or through impressions made on the organs of sense. Natural sleep may be regarded as an objective condition; one by one the senses suspend their functions, and cut the brain off from the external world, and thus secluded, it sinks into a state of insensibility. In coma, the brain suffers from mechanical compression, from an engorged state of its blood-vessels, from the presence of alcohol or some other narcotic, till unconsciousness supervenes, and impressions made through the senses can no longer arouse it to action. It is in a state of subjective sleep.

Recapitulation.

Sleep is brain rest, and is common to all animals. It affects the involuntary functions only indirectly. Sleep approaches by successive steps, affecting the senses in a regular order.

Somnambulism is the waking state of the spinal cord in its reflex functions. Of the mental faculties, the directive power first sleeps, and afterward the power to perceive sensations, etc. Sleep is involuntary, but may be invited or repelled by circumstances. Sleep is an objective condition. Coma is subjective sleep.

PART II.

HYGIENE.

LESSON XXVI.

HEALTH.

211. Hygiene defined—the Importance of Health.—The art of preserving health is merely the application of correct physiological principles to our daily life. As we have seen, the human body in living action is a very complex piece of machinery. Though wisely contrived and admirably constructed for the performance of its very complicated functions, yet it is liable to derangements both of structure and force.

The causes leading to these derangements, and the circumstances under which they occur, and the mode of preventing their occurrence, constitute the science of Hygiene; and its correlate art is the observance of such rules of life as will most effectually avoid the causes of derangement and disease. The importance of this knowledge in practice is so obvious to all, that not one word is necessary on that subject. Without good health, there is neither enjoyment or profit in life; therefore, to secure good health is the first duty of every human being; nor can we neglect this duty without incurring a fearful responsibility.

212. Relation of Physiology to Hygiene. — In the first part of these lessons we attempted to give the student a correct idea of the form and structure of the several organs of the human body, and their action in a normal or healthy condition. This knowledge has two important practical applications: the first of these is to preserve health while we have it; the second is to restore it when it is lost.

If by accident, neglect, or violation of the physiological conditions of vital actions, whether from ignorance or willful inattention, these actions are impaired, deranged, or disturbed, great skill and knowledge are required in the physician, in order to restore them to the normal condition; but the knowledge and observance of a few simple laws constitute the art of maintaining health, and these are within the reach of all.

213. False Ideas of Disease — their Influence on Health. — The study and practice of hygiene has been very much impeded by false notions of the nature of disease. In ancient times, diseases were regarded as the inflictions of malignant spirits, who entered into the living body, deranged the delicate machinery, and disturbed its harmonious action. This superstition has long since been dispelled by the light of science, but there lingers still, in the common mind, the error which supposes that disease is a *thing* — an undefined and indefinable something—which has somehow gained a lodgment in the body, and is to be driven out by medicines. Such notions as these are very unfavorable to the introduction of healthful observances in our daily life. When the mind has once fully settled in the conclusion that disease occurs by a kind of fatal necessity, which no precautions can avail to prevent, and all that remains is for the physician to find some specific which has the mysterious power of expelling it, but little care will be taken to prevent it.

214. Health and Disease defined.—From a careful study of the living body, we learn that vital force, if not resulting from chemical change, is, at least, its constant accompaniment; and the development and maintenance of animal power are dependent on vital transformations. The lungs are in constant action, supplying oxygen to the blood; and the heart keeps that blood in incessant motion through all the parts of the body. But these sensible and visible motions are only accessory to the chemical changes effected by the oxygen thus transmitted.

These changes take place in the tissues of the body, and in the combustible elements of our food, evolving from the change both heat and vital force. This active change and constant renewal of the particles constituting the body, is HEALTH; the disturbance, obstruction, or perversion of this transformation of the tissues, or the imperfect elimination of its products, is DISEASE. It is not a malignant entity, but a morbid action.

215. Diminished Transformation, a diseased condition.—A disease may, however, consist in diminished or suspended action, as well as in its perversion. In all diseases of debility, the transformation of the tissues takes place too slowly; and nutrition, in all its processes, from the first action of the mouth on the food to its final deposition, is impaired, resulting in prostration of all the vital forces, and general emaciation of the body.

On the other hand, in febrile diseases the tissues are rapidly transformed, and the force evolved from this change appears in the correlate form of heat, while the tissues thus wasted are not replaced, as nutrition is almost entirely suspended. All narcotic substances, such as tobacco, opium, alcohol, etc., produce a really diseased condition, inasmuch as they diminish the amount of chemical change in the system in a given time. Quinine, iron, and kindred substances, though they disturb the normal rate of vital action by increasing the amount of change, can hardly be said to produce disease, as the nutrition is augmented in the same proportion.

216. Disease from Perverted Action. — But disease may consist in a perverted chemistry of the body, resulting in the formation of compounds not found in the healthy state of the system. Such are the concretions found in and about the joints in gout, the gall-stones found in the gall-bladder under certain circumstances, and the gravel found in the urinary organs. But whatever may be the characteristics of disease, it will be found to consist in diminished, accelerated, or perverted *action*, in reference to the chemical change going on in the living body.

The disturbing causes, which thus derange the vital action, may not always be within the reach of human knowledge, or, if known, may not be under our control, yet, in a great majority of cases, we can discover and avoid the course of life inducing these derangements, and thus escape disease. At least, it is easier to maintain the normal action than to restore it when impaired.

217. Influence of Hygiene on the Duration of Life. — The influence of a knowledge of hygienic laws, were that knowledge generally diffused, would greatly increase the average duration of human life. It would also add very much to the efficiency and value of life, both to the individual and to the community, by the maintenance of uniform good health, protracting the vigor and efficiency of manhood to what we now call extreme old age.

Of the average life of man, deducting infancy, sickness, and old age, scarcely more than half is available for the purposes of active life. Nor should we be surprised that men and women are so frequently sick, and so often unfit for the duties or even the enjoyments of life. When we observe the almost constant violations of the laws of health, so common in every community, we wonder that people live at all; we are surprised at the leniency and long-suffering of Nature, in so slowly and tenderly exacting the penalty of her violated laws.

218. Hygiene in relation to the Cure of Disease. — But the rules, by the observance of which health is maintained, have an important bearing on the cure of disease; and it is in this relation that hygiene becomes almost as important to the physician as to the patient. The persistent violation of a sanitary law finally wears out the powers of resistance inherent in the vital force, and disease follows. No sensible physician would even hope for a cure of that disease without first restoring an enforcement of the violated laws: these being restored and carefully observed, health will generally follow with but little aid from medicine. The most perceptible change in the practice of medicine, within the last fifty years, is the diminished confidence of enlightened physicians in mere medication, and their increased confidence in sanitary and hygienic measures for the cure of disease.

Recapitulation.

Hygiene is the art of preserving health. Disease is deranged physiological action. To restore health is a complex and difficult work, but to maintain health is comparatively simple and easy. Vital force is in the ratio of the chemical changes taking place in the body. This chemical action may be too rapid, too slow, or it may be perverted. Duration and value of life dependent on the maintenance of health. Disease arising from violations of the laws of health is incurable while these violations continue.

LESSON XXVII.

FOOD AND DRINK.

219. Division of the Subject—purposes of Food.—In investigating the subject of hygiene, we find it convenient to follow the same division which we adopted in the first part of the work. We will therefore begin with the hygiene of the Nutritive system.

This will embrace the subjects of Digestion, Circulation, Respiration, and the Transformation of the tissues.

The subject of digestion includes food and drink, with regard, 1st, to quality and quantity; 2d, to the time and manner of taking them; and, 3d, to the condition of the system. As it is the purpose of food to supply material to repair the wastes of the system from the wear of its incessant activities, it is evident that it must contain the elementary substances out of which the tissues of the body are formed; for the vital and chemical forces, however strangely they may change and modify the forms of matter, can create nothing. Therefore our food must furnish the material for growth and repair.

220. Organic and Inorganic Substances. — In general terms, we may assume that all digestible food is derived from the organized forms of matter, vegetable or animal. It is true that a number of substances, such as water, common salt, lime, etc., enter into both the fluids and solids of the body; but these undergo no change by digestion. They enter the circulation by absorption, maintaining their true forms, and are never vitalized in the same manner that muscles, nerves, and membranes are. Yet we must not suppose that these are therefore unimportant in the animal economy.

The inorganic elements of the body are, indeed, indispensable for its growth and health. Of these, water is by far the most abundant, and, we may safely say, of the most immediate importance. It is the solvent of all that goes into or is carried out of the system. It is present in all the tissues, and permeates even the firmest solids, carrying nutrition to them, and bearing from them the waste material.

221. Sources of Impurity in Water.—Water, to be fitted for the purposes of the body, should be as nearly pure as possible; but absolutely pure water can be obtained only by distillation. Rain-water, in falling through the air, absorbs carbonic acid, ammonia, and other gases, which are mixed in minute quantities with the air; afterward, in percolating through the earth, it dissolves variable amounts of lime and other mineral substances which are found in solution in the water of our springs and wells.

But, fortunately, the gases from the air or the minerals from the earth are not often in such quantities as to greatly impair the healthfulness of water as a diet drink. Much has been said of the unhealthfulness of what is called *hard water*, but a comparison of limestone and freestone districts shows much less difference in the health of the people living in them, than we might expect.

222. Lime, how held in Solution—Rain-water.—Water holds lime in solution chiefly by aid of the carbonic acid dissolved in it; but on raising the temperature of the water, the carbonic acid escapes as a gas, and the lime is consequently precipitated. It is probably from this cause that limestone water is comparatively harmless. As soon as it enters the stomach, the temperature rises till it reaches blood-heat, the carbonic acid escapes, and the lime is precipitated, and, being indigestible, is carried off by the intestines.

Iron is frequently found in spring and well waters, but it is seldom in such quantity as to materially affect its healthfulness; and when such is the case, it imparts to the water an offensive taste, which will commonly prevent its use for drinking purposes. Rain-water, well filtered through alternate layers of coarsely pulverized charcoal and clean silicious sand, furnishes a diet drink sufficiently pure for all practical uses.

223. Organic Impurities in Water. — But organic impurities, derived from decomposing animal and vegetable matter, are much more injurious than the ordinary mineral impurities in water. Unfiltered rain-water, especially if it has been collected from a wooden roof, is generally unfit for drinking or culinary purposes; and river water is seldom so free from organic substances, in solution, as to render it fit for table or kitchen use.

Rivers, springs, and shallow wells often become impure from sewage which is mixed with them in the vicinity of large cities. Sickness is sometimes induced by the use of such water, when neither the taste nor smell of it betrays the presence of the impurities. It is hardly necessary to add that surface water, though derived from recent rains, and drawn from the surface of clean meadows or woodlands, is unfit for use until it has been very thoroughly filtered.

224. Proper Temperature of Drinks. — For drinking purposes, water should have a temperature ranging between fifty-five and sixty degrees Fahrenheit. A temperature above sixty is not palatable, and a lower temperature than fifty-five degrees is injurious to the stomach, and often dangerous. Especially is this true of ice-water used at meals. Food requires a temperature varying but a few degrees from blood-heat (ninety-eight), to insure its rapid and perfect digestion; but if the drink used at meals be either ice-cold or boiling hot, digestion will be suspended until the contents of the stomach has acquired nearly the natural temperature of the body.

Both ice-water and hot drinks at meals are unhealthy, but of the two, the former is the most injurious. In warm weather, when heated from exercise, ice-cold water should never be used, and even water at the proper temperature should be taken slowly and with caution.

225. Tea, Coffee, and Chocolate.—The diet drinks, tea, coffee, and chocolate appear to have been misunderstood until very recently. They have generally been classed with stimulants and narcotics, but careful experiments have established the fact that their action is to hasten the transformation of the tissues, as is indicated by the increased volume of carbonic acid exhaled from the lungs in a given time, when under their influence. The active principle in each of these belongs to that family of vegetable alkaloids of which quinine is the representative.

But it is not to be inferred from this that every indulgence in these beverages is harmless. Tea and coffee, besides the active principle, contain a large amount of astringent matter (tannic acid) which acts unfavorably on the mucous membrane of the stomach and intestines. This is, however, modified to a great extent by the action of milk, which should always be used with these beverages.

226. Fermented Drinks—their effects.—Beer, ale, wine, and other diet drinks produced by fermentation, and consequently containing alcohol, should be unconditionally rejected by every one who wishes to maintain good health. It is the characteristic action of alcohol to prevent or arrest chemical change in organic substances. But digestion is chemical change, and so long as the alcoholic mixture is mingled with the food, that change is suspended.

The absorbents of the stomach, however, soon remove it into the circulation, but the effect of its specific action on the nerves of the stomach remains, diminishing and perverting the sensibility of that organ, so that the food in a half-digested state is hurried into the intestines, and the nutriment is lost, if nothing worse occurs. The glass of wine at dinner is merely a bribe to deaden the sensibility of the stomach, overloaded by gluttonous indulgence, so that it may not complain.

Recapitulation.

The subject of digestion, as it relates to food, embraces quantity, quality, time and manner of taking, and the condition of the system when food is taken. Inorganic substances undergo no change by digestion. Impurities in water, and the sources from which they are derived. Mode of purifying rain-water. Extremes of temperature in drinks—their effect on digestion. Tea, coffee, and chocolate—their true character. Fermented drinks are always injurious.

B. P. 14.

LESSON XXVIII.

CLASSIFICATION OF FOOD.

227. Animal and Vegetable Food—their essential identity.—The classification of food into animal and vegetable, which appears so obvious and which, a few years ago, was so generally admitted, is found, on careful examination, to be without any real foundation. Animal substances are all derived from the vegetable kingdom, and most of the proximate principles entering into the composition of animal bodies are found already formed in vegetable organisms. The prejudice against animal food is therefore without foundation, so far as the chemical constituents of the food is concerned.

Animal food is only a more concentrated state and differently organized form of the same substances we find in vegetables. The vegetable world, however, contains many proximate elements that are not transferred to the animal kingdom. No one substance, whether produced in the vegetable or animal kingdom, contains all the material of healthful, nutritious food; nor do all persons require the same proportions of the various kinds of food, nor does the same person under different circumstances.

228. The Three Groups of Food.—Food may be conveniently divided into three groups, according to their resemblances in composition, and the general purpose which they subserve in the animal economy. These are, 1st. The Proteine or flesh-forming group; 2d. The Amylaceous or starchy group; 3d. The Oleaginous or fatty group.

In their office as food, the second and third group, though not identical, are nearly allied to each other. The old division of food into the carbonaceous or heat-producing substances, and the nutritious or flesh-forming materials, is found to be faulty, inasmuch as the latter, in its chemical changes, also gives off heat, and the changes in both are connected with the evolution of vital force.

229. The Proteine Group—its several substances.—The proteine group consists chiefly of *gluten*, *fibrine*, *albumen*, and *caseine*. These all contain nitrogen, and closely resemble each other in their chemical composition, though they differ materially in the form of their organization and in their general appearance. They decompose by putrefaction, and give off in that process the disagreeable odor familiarly known as accompanying that kind of decay.

Gluten is found in various kinds of grain, in fruits, and in numerous vegetables, such as asparagus, cabbages, etc. It is easily obtained by washing the starch from flour with cold water. It is a tough, elastic substance, of a light gray color, without odor, and with a slightly sweetish taste. Its composition is the same as that found in the lean flesh of animals, the two differing only in the manner in which they are organized.

230. Fibrine, Albumen, and Caseine.—Fibrine is found in solution in the blood of animals, and is precipitated when the blood is cooled, forming the essential part of the coagulum, or clot, from which it may be obtained by washing with cold water. It is the substance from which most of the fibrous tissues of all animals are formed.

Caseine is the curd or solid part of milk, which is separated by coagulation, and therefore forms the chief ingredient in cheese, as it is the chief element of nutrition in milk. It is found in the seeds of many plants, such as peas, beans, etc. Albumen is found nearly pure in the white of eggs. It dissolves, to a limited extent, in cold water, but coagulates and hardens in water a little below the boiling temperature. It occurs in nearly all the fluids of the living body, and forms a large proportion of the brain. It has also been detected in the seeds of many vegetables.

231. Gelatine—its properties and use.—Gelatine, a substance often associated with this group, differs essentially from those just described, both in chemical composition and in material form. The animal matter in bones, the substance of tendons, ligaments, etc., is gelatine. Glue is the form in which it is most familiar. While the true proteine compounds are convertible into one another in the animal economy, gelatine can not be appropriated to any purpose but the formation and repair of bone, tendon, ligament, etc.

It is sparingly soluble in cold water, but dissolves readily in that fluid at or near the boiling point. It is the essential ingredient in soups and animal jellies. The fact that it can not be appropriated to the repair or growth of the soft tissues of the body, corrects a popular mistake in regard to the very nutritious quality of soup.

232. The Tissues—whence derived.—All the tissues of the body are derived from the proteine group of alimentary substances and from gelatine; consequently their growth and constant repair depend on a sufficient supply of these, in such form and condition as will enable the stomach most readily to digest them, and place them in favorable circumstances to be assimilated. It is of but little consequence whether they are derived from their original forms in the vegetable world, or from the secondary forms of animal organization, but it is of the first importance that these be in a sound condition, entirely free from any taint of decomposition or putrefaction.

Animal food is usually preserved from decay by an excess of salt (chloride of sodium), which requires to be dissolved out by the fluids of the stomach before digestion takes place. Salt meats are therefore not so readily digested as fresh.

233. The Amylaceous Group — its office. — The second group of alimentary substances comprises starch and the several forms of sugar, gums, etc. From this group is derived by far the largest bulk of our food; and in whatever form it comes to us, it is the product of vegetable life. All the members of this group contain the same chemical elements, and differ only in the proportions in which these are combined. They are especially rich in the two combustible substances, carbon and hydrogen. This fact indicates the office of the starch and sugar, which, in the form of bread, potatoes, fruits, and other vegetable productions, enter so largely into our daily bill of fare.

In combining with the oxygen inhaled by the lungs, these undergo a true combustion. From this source, and from the oxidation of the waste matter of the tissues, are derived the animal heat and working force expended by the body.

234. The Oleaginous Group — the use of Oils and Fats. — The oleaginous group consists of various oils and fats, derived both from the vegetable and the animal world. Like the members of the other groups, they are closely allied to each other in composition, and are convertible each into the other in the vital economy. The oils are non-nitrogenized bodies, made of the same elementary substances as those composing the second group, but containing much less oxygen. They therefore form the highest grade of heat-producing food, and are in demand in cold temperatures and with those exposed to the winter climate of the temperate zones. Fatty matter is also found in the brain, and is probably an essential constituent of that important organ.

Recapitulation.

Animal and vegetable forms of food contain the same proximate elements. Food is divided into three groups — the proteine, the amylaceous, and the oleaginous. The tissues are derived from the proteine forms of food. The proteine elements are formed in vegetables and transferred to animals. The amylaceous group supplies the largest portion of our daily food. Both the amylaceous and the oleaginous groups furnish heat-producing food. They consist chiefly of combustible elements.

LESSON XXIX.

QUALITY OF FOOD.

235. Volume of Food important. — Before we proceed to name the several articles of food which go to make up our bill of fare, it may be well to say that the value of any particular article does not depend altogether on the amount of nutritious matter it contains. Nutriment may be so concentrated or so combined as to render its digestion difficult, if not impossible.

The stomach requires a certain degree of distention for the ready and perfect performance of its function. To secure this distention, volume or bulk in the food is required, at least to a certain extent. An ounce of concentrated nutriment mixed with half a pound of inert, indigestible matter, will generally be digested much more readily than if it were taken unmixed. The nutritious elements of food may be so combined as to render their separation difficult, and consequently their digestion slow and imperfect.

236. Milk as a perfect Diet. — Milk comes nearer supplying all the demands of a complete nutrition than any other substance. It has, therefore, been generally regarded as the perfect type of food, and other articles have been measured by this standard. This, however, is true only of young or growing persons; but in adults engaged in active and laborious employments, it fails to furnish a necessary proportion of combustible or heat and force-producing elements.

Milk from different animals varies considerably in its composition, and even from the same animal, under different circumstances of food, exercise, temperature, etc., a considerable variation in quality is observed. The average of a number of specimens of milk, taken from several cows, gives, in a hundred parts, 4.48 parts of caseine or cheesy matter, 3.13 of butter, 4.47 of sugar of milk, .60 of saline matter, and 87.32 of water.

237. Milk, by what circumstances modified.—In most stomachs, milk is more digestible when quite fresh, but there are conditions of that organ in which the lactic acid, formed when milk coagulates, is required to supplement the deficiency of acid in the gastric fluid. This relates, however, to a morbid and not to a normal condition of the digestive organs. Milk, when used as a diet drink, should have a temperature not lower than sixty degrees.

Iced milk, taken at meals, suspends the digestion of the food till the whole mass has acquired the natural temperature of the body; and sometimes this interruption so disturbs the whole process, that the work is very imperfectly done. Milk is much affected by the food of the cow producing it, and certain odors, such as clover-bloom and others less agreeable, can readily be detected in the milk when fresh. From this cause, decaying or putrescent food and slops should never be fed to cows giving milk.

238. Cheese and Butter — their dietetic value.— Cheese is a product from milk, and contains, when properly made, the caseine and most of the butter, together with a considerable proportion of the milk sugar. It is a highly concentrated form of food, and therefore it should never be eaten alone, but always with the more crude and bulky forms of vegetable diet. Mixed in this manner, cheese digests readily, and furnishes a large amount of material for repairs in active bodies. Taken by itself, it is hard of digestion, and often produces serious disturbances of the stomach.

Butter is a true fat, but more complex in its character than the other oils, whether animal or vegetable; and from this cause it is more liable to chemical changes, producing certain acids which give the rancid character to it, and greatly impair its dietetic value. It is purely a heat and force-producing article, and furnishes nothing to growth or repair.

239. Eggs very nutritious—how to cook them.—Eggs consist chiefly of albumen and the mineral salts, especially those whose acids are derived from phosphorus and sulphur. They are, therefore, a very perfect but a very concentrated form of food. However, albumen is the most digestible form of all the proteine group, and eggs, if properly prepared, seldom fail to be digested, though taken alone.

Mixed with a proper measure of food containing starch, so as to increase the bulk and furnish an additional supply of the heat-producing material, there is no more nutritious and healthful diet than fresh eggs. Those of barn-yard fowls are always to be preferred to the eggs of water fowls. Eggs, though very nutritious in themselves, are often so injured in cooking as to render them almost indigestible. By whatever method they are cooked (and boiling is the best), the white should be merely coagulated and the yolk left soft.

240. Animal Flesh — kinds and value. — Animal flesh furnishes a concentrated and highly nutritious food. In most of its forms it is easily digested and readily assimilated. There is quite a wide margin, however, between different kinds of meat, in regard to the amount of available nutrition, as well as to the ease with which they are digested and incorporated into the living tissues.

Beef, pork, and mutton are the most common forms in which animal flesh is met with on American tables. Of these, mutton is the most digestible, but beef contains the highest per cent of nutriment. Pork is of value chiefly for the large amount of oil it furnishes, and its consequent high, heat-producing quality. It is therefore well adapted to use in cold climates and in the winter season. The animal fats should be used with caution and sparingly in warm weather, but never in hot climates.

241. Necessary Precaution in Fattening Animals for Food. — The flesh of young animals is more easily digested than that of the more mature. An important exception to this rule may be mentioned: beef is more digestible than veal. The good quality of meat depends much on the manner in which it is fed and prepared for the market. The best beef is fattened on fresh pastures, with but little grain. This mode of fattening tends to develop the muscular or fleshy part of the animal, and diffuse the fat through the flesh, rather than to accumulate it in masses, as is done in stall-feeding.

Animals fattened on the slops of distilleries and the wastes of breweries are entirely unfit for food, and should not be offered in the markets. Animals taken to market by long journeys, whether on foot or in crowded cars, are not suitable for food till they have fully recovered from the journey.

242. Wholesome Meat—how distinguished.—The flesh of good beef, pork, or mutton should be a light red, approaching toward the scarlet hue. A pale color indicates an immature animal, and dark red meat shows an animal too old and tough to be savory, or that it had been suffering from the effects of a long journey to market.

Wholesome meat should be entirely free from even a tendency to putrefaction. This can not always be detected by the odor, for meat kept on charcoal or on ice will frequently be far advanced in the first stages of decomposition, and yet emit no unpleasant gases. If, on cutting the flesh, the surface appears mottled, or marbled with pale spots, and if the fibers be easily torn across, it will be safe to reject such meat. The fat of pork and mutton should be white and firm, even in warm weather, and that of beef but slightly tinged with yellow.

Recapitulation.

Concentrated food is difficult of digestion. Milk is a perfect food only for growing persons. The composition of milk. It varies with the circumstances of the animal from which it is derived. Cheese is a very concentrated form of food, and therefore should never be taken alone. Butter belongs to the oleaginous group. Eggs form a very nutritious diet, and when properly cooked, are easily digested. Animal flesh—difference in the several kinds. The kind of food on which animals are fattened affects the quality of their flesh.

LESSON XXX.

QUALITY OF FOOD — CONTINUED.

243. Flour—its composition—different varieties.— The amylaceous or starchy group is represented chiefly by the cereal grains, such as wheat, rye, Indian corn, barley, etc. Of these, wheat is the most important, as it approaches nearer to a perfect diet than any other product of the vegetable world. Different samples of wheat vary somewhat in the proportions of the different proximate elements entering into its composition.

This arises from the many varieties of wheat cultivated, and from the quality of the soil on which it is grown. The average may be stated at twelve per cent of gluten, seventy per cent of starch, and ten per cent of water; the remaining eight per cent consists of sugar, oil, and phosphates of lime, potash, and magnesia. These proportions are seldom found, however, in fine flour. The central portion of the grain consists almost entirely of starch, while the outer part, near the cuticle or bran, is rich in gluten and the mineral salts. In the common methods of manufacturing flour, these are chiefly lost, by not being made fine enough to pass through the bolting cloth.

244. Adulteration and Deterioration of Flour.— From this cause, very fine flour is less nutritious than that of a coarser grade. Brown bread, made of unbolted flour ground closely, contains all the nutriment of the grain in a very digestible form; and for persons of feeble digestive powers, it is always to be preferred to fine bread. Flour is sometimes adulterated by mixtures of carbonate of lime or chalk. This can be detected by a grittiness in chewing the flour or the bread made from it.

Adulterations from mixture of cheaper grains are difficult to detect, but, fortunately, they are of less consequence, as they but slightly diminish the nutritive value of the food. Flour becomes whiter by age, but this improved appearance is at the expense of its sweetness and real value. The richer flour is in gluten, the more rapidly it deteriorates.

245. Rye and Corn as Bread Materials. — Rye furnishes a wholesome bread, though it is much darker than that made from wheaten flour. It contains more sugar and oil than wheat, has a heavier bran and a smaller proportion of starch. In the gluten, the nitrogenized matter resembles caseine from milk, while that from wheat flour more nearly resembles fibrine. In delicate stomachs it is not easily digested; and it is much more difficult to make good bread from rye than from wheat flour.

Indian corn contains a larger proportion of oil than any other grain known. This, however, differs very materially in the different varieties of corn. Those known as *flint corn* yield more than double as much oil as the varieties with large, spongy grains. The quantity of sugar, also, is far from being constant. It is very rich in starch, but in the nitrogenized or flesh-producing element, it is poorer than any bread material in use, excepting, perhaps, buckwheat. This is not in the form of gluten, as found in other grains, but in a peculiar form called *zeine*.

246. Preparation of Corn for Food.—From these peculiarities it lacks the adhesive qualities of dough from wheat or rye flour, and therefore the bread is made light by fermentation, with difficulty. In preparing articles from corn meal, a longer time is required to cook them thoroughly than is necessary when other bread materials are used. But when properly cooked, corn meal furnishes a palatable, highly nutritious, and easily digested food.

Barley and oats are but little used as bread material in this country, though in some parts of the world they form an important part of the daily food of a large population. They are rich in sugar and gluten, but poor in starch and the phosphates, as compared with wheat. Rice is seldom used for bread. It is very digestible, consisting of nearly pure starch, with the smallest quantity of gluten and oil.

247. Beans and Peas—their dietetic value.—Peas and beans can hardly be classed with this group, as they contain from twenty-five to thirty per cent of nitrogenous matter, in the form of vegetable caseine; but as there appears to be no more appropriate place for them, we have assigned them here. They are highly nutritious, but, like most other concentrated forms of nutritive matter, they are hard to digest, and if not readily digested, they are apt to produce flatulency and other derangements of the digestive apparatus. Taken in the unripe state, they are less objectionable in this respect.

As a substitute for animal food, to laborers and others following active employments, there is no form of vegetable food so well adapted as peas and beans. They are rich in sulphur and the phosphates, and contain sufficient starch to furnish heat-producing material even for winter food.

248. Potatoes — their composition and use as Food. — There is a class of succulent vegetables extensively used as food, which is allied more or less remotely to this group of starchy foods. The potato properly stands at the head of this list. Well matured potatoes contain, in one hundred parts, seventy-four parts of water, twenty-three parts of starch, one and one-half parts of gluten, and one part earthy salts, with but a small fraction of oil. It will be observed, the proportion of flesh-producing material is very small. They should, therefore, always be associated with animal food to supply this defect, as well as that of the oily matter.

Potatoes, when properly cooked, are easily digested; and being a bulky form of food, are well adapted to accompany the more concentrated articles of diet, not merely to give distention to the stomach, but to promote the digestion of those highly nutritious articles that are often difficult of digestion.

249. Other Succulent Vegetables. — Turnips, beets, carrots, and parsnips, constitute an important group in this class of succulent vegetables. They contain even more water than potatoes, and the solid part consists largely of sugar, instead of starch, and the proportion of nitrogenous elements is somewhat larger than in the potato. They are rather hard of digestion, and should be used sparingly by persons whose habits of life are not very active, or whose digestive powers are feeble.

Asparagus, onions, and cabbage contain but little starch. They are, however, well supplied with the flesh-forming elements, and are therefore very nutritious when properly prepared. Onions contain an essential oil, on which their peculiar odor depends. This oil is indigestible, but being volatile, it is absorbed from the stomach, and passing to the lungs, is exhaled, giving the disagreeable odor to the breath. Thorough boiling removes the greater portion of this, and leaves a very nutritious food.

250. Fruits — their importance as diet. — Fruits consist mainly of water, with variable quantities of starch, sugar, and gum. Many kinds of fruit furnish a fair supply of gluten, and are on that account highly nutritious. Their chief value, however, as diet, is in the various forms of vegetable acid which they contain, in such combination with the alkaline and earthy carbonates, as supply an important want in the process of digestion, as well as furnish the lime and potash which they contain for the use of the animal economy.

Most of these acids are laxative, and are therefore well adapted to persons predisposed to habits of constipation. This is especially true of the malic acid, which abounds in apples, peaches, pears, etc. The tartaric acid, so abundant in grapes and berries generally, is not only a laxative, but tends to increase the secretion of the skin and kidneys.

Recapitulation.

The amylaceous group is represented chiefly by the cereal grains. Wheat is the most important of these. Fine flour is not so nutritious as coarse. Flour deteriorates by age. Rye contains more sugar and oil than wheat, and a smaller proportion of starch. Indian corn is rich in oil and starch. Its nitrogenous element has a peculiar form. Beans and peas are very nutritious, but hard to digest. Potatoes are rich in starch, but deficient in the proteine elements. Asparagus, onions, and cabbage are lacking in starch, but abound in proteine elements. Fruits are important on account of the acids they furnish to assist digestion.

LESSON XXXI.

MODE OF PREPARING FOOD.

251. Cooking Food—what is gained by it.—The natural quality of the different articles of food is scarcely less important than is the mode of preparing them for the table. But few articles of diet are fit for food without some preparation. This is usually done by the aid of heat. Cooking, when properly performed, accomplishes two objects: 1st. By rendering the substances soft, they are easily masticated, and more readily dissolved in the gastric fluid; and, 2d. The peculiar flavor of the food is developed, so that it is more agreeable to the taste.

This is generally the result of cooking, though there are some very well marked exceptions to the rule. For example, cabbage cut fine, and dressed with diluted vinegar, is more digestible than when cooked in any form. The flavor of some kinds of fruit is so volatile that it escapes in cooking, and thus the fruit is rendered insipid. Long continued boiling produces this effect on nearly all kinds of vegetables.

252. Meat—general rule for cooking it.—Meats are prepared for the table by several methods, such as boiling, roasting, baking, broiling, frying, etc. One general rule applies to all these methods, and its observance is indispensable if we would preserve the good qualities of flesh.

All wholesome meats contain a good proportion of albumen. This substance is familiar to us in the white of eggs. It dissolves readily in warm water, but if the temperature be raised to near the boiling point, it is instantly hardened, and becomes entirely insoluble in water. To preserve this property of meat is essential alike to its nutritive quality and good taste. A high heat should therefore be applied to meat at the beginning, and as the cooking proceeds, the heat may be reduced. This coagulates the albumen on the outside, and thus prevents the escape of the nutritive juices.

253. Boiling Meat — the Rules. — When meat is cooked by boiling, the pieces should be large, and the water raised to the boiling point before the meat is put in. By this means its flavor may be preserved nearly perfect, and the loss in weight greatly diminished. This, in the ordinary method of boiling meat, amounts to nearly one-third of the original weight. After boiling rapidly for ten minutes, the heat should be lowered to about one hundred and seventy degrees, or to a point below any perceptible boiling, and should be retained at that temperature till the fiber is fully softened and tender.

If the object is to make soup, the meat should be put into cold water, and the temperature of about one hundred and fifty degrees maintained for two or three hours, when a few minutes of rapid boiling will complete the process. Soft water is a better solvent than hard, therefore soup should be made with soft water, and the salt should not be added till the last stage of the process. The opposite course should be followed when meat is boiled for other purposes.

254. Roasting, Broiling, Baking, and Frying Meat.—Meat is cooked with a direct application of heat by roasting, broiling, or baking. By either of these methods the flavor of the meat is better retained than when cooked by boiling, but care must be taken not to overdo the cooking, and thus render the fiber hard, insipid, and indigestible. The same rule should be observed in the application of heat when cooking meat by these methods as by boiling (§ 253).

Frying is in all respects the worst method of cooking meat. It expels the natural fluids from the flesh fiber, and substitutes oil for these. When meat is cooked by frying, the fat should be heated very hot before the meat is put in, and it should be cooked rapidly, and removed as soon as it is tender.

255. Cooking Vegetables.—Vegetables are usually cooked by boiling; potatoes, however, are often prepared by baking; and when it is carefully done, the result is very satisfactory. When vegetables are boiled, care must be taken that the process be not carried too far. As soon as the vegetable is soft it should be removed at once from the boiling water. If the cooking be continued beyond this point, the structure will be broken down, and much of the vegetable will be dissolved in the water and lost.

Potatoes, especially, should not be suffered to remain in the water a moment after boiling has ceased. While boiling, the pores of the vegetable are filled with steam, but as soon as the temperature falls below the boiling point, the steam begins to condense, and the surrounding water is drawn in to fill the vacuum, and the potato is water-soaked and indigestible. To a less extent, the same is true of beets, carrots, and parsnips.

256. Bread — its importance as a diet. — The preparation of farinaceous food in the form of bread is at once the most difficult and the most important part of the culinary art. In civilized countries bread is a constant diet, a part of every meal; and if it be badly made, unwholesome, and indigestible, the mischief will be in proportion to its universal use.

The method of preparing bread by fermentation has undergone no material change since the days of the oldest monuments of Egypt; and yet fermentation is not essential to the production of a wholesome and digestible bread. Indeed, fermentation is incipient decay, and all substances are less wholesome and nutritious after decomposition than before. So we find crackers, and kindred forms of unleavened bread, more digestible and nutritious than the ordinary form of fermented bread. In fermentation, flour loses all the sugar it originally contained, and this loss amounts to from six to ten per cent of the whole weight.

257. Fermenting Bread — rules to be observed. — In making fermented bread, the chief secret lies in producing a rapid action; and to secure this, good, undamaged flour and fresh, active yeast must be used, with a temperature of about one hundred degrees steadily maintained. If fermentation begins slowly, or if it be arrested after it has commenced, either by too high or too low a temperature, the first products of fermentation will pass to the second stage, acetic acid will be formed, and the dough thus soured will be spoiled.

There is much more danger of fermentation going too far, and the bread being sour, than there is of arresting it at too early a stage by baking it. A very palatable and wholesome bread is made by forcing carbonic acid into the dough, under a high pressure, as it is being mixed. But this "aerated bread" can be produced only by expensive machinery, and therefore can not be made in common domestic establishments.

258. The Qualities of Wholesome Bread. — By whatever method bread is produced, rapid and thorough baking is indispensable to a palatable and digestible article. The bread should not shrink on cooling, and there should be no clamminess on cutting a loaf. Several kinds of "baking powders" are in use to produce spongy bread without fermentation. These consist of carbonates of soda or potash, mixed with some of the vegetable acids, or with phosphoric acid. The last is the least objectionable, as the salt resulting from the combination is comparatively harmless.

Perhaps the best method to obtain carbonic acid, to lighten bread without fermentation, is to mix good bicarbonate of soda with dry flour, and a weight of pure muriatic (chloro hydric) acid equal to the soda, with the fluid used to moisten the mass. The gas will be set free, and nothing but common salt will be formed.

Recapitulation.

Cooking renders food more easily digested and develops its flavor. Meat is cooked by boiling, roasting, baking, broiling, and frying. There is one general rule for applying the heat, to be observed in all these methods. Danger of boiling vegetables too long. They should be removed from the water while it is yet boiling. Importance of bread as an article of diet. Antiquity of fermented bread. Fermentation not necessary to wholesome bread. Aerated bread is a substitute for the fermented article.

LESSON XXXII.

AUXILIARY FOOD.

259. Oils and Fats — their dietetic value. — The group of oils and fatty substances forms an important element in the diet of the inhabitants of cold climates. The animal tissues containing fatty deposits are usually subjected to the same cooking processes as the fibrous meats, but the oil undergoes no change whatever in the operation. This class of food, however, is not confined to animal substances, but is found extensively distributed through the vegetable kingdom.

Oil is the most concentrated form of heat-producing food; therefore most appetites demand it in cold weather, even in our temperate latitudes. Its rapid combination with the oxygen inhaled by the lungs is also an important source of vital force, and it is on this account that persons engaged in severe labor in the open air demand oily food.

260. Oily Food for Consumptives. — Of late it has been maintained that a deficiency of oily food predisposes to consumption, and a careful observation of the early habits of consumptive persons shows that a very large proportion of this class were not in the habit of eating fat meats, many of them declining even butter. Dr. Carpenter says: "There is a strong tendency and increasing reason to believe that a deficiency of oleaginous matter, in a state fit for appropriating by the nutritive processes, is a fertile source of diseased action, especially that of a tuberculous character; and that the habitual use of it in large proportions would operate favorably in the prevention of such maladies."

It is, however, an unsettled question, whether this abstinence from fatty food is the *cause* or the *effect* of the consumptive tendency. Care should be taken that oils, fats, and butter used for food be fresh and sweet. Rancid fat or butter is always unwholesome.

261. Salt—its use in the Animal Economy.—There are many substances which enter into our daily bill of fare which are not properly food, and yet they affect our health in a very important degree. Common salt (chloride of sodium) may with propriety be placed at the head of this list. It has been held by some writers that salt is not necessary to the maintenance of good health, and even that its use is injurious.

It is true that many savage tribes, living almost exclusively on animal food, have maintained good health without the use of salt; but extensive observation proves that persons living on a mixed diet, or chiefly on vegetables, lose their health when salt is withheld from their food. Both chlorine and sodium, the two elements of which salt is formed, are essential to the digestion of food, the former furnishing the acid for the gastric fluid, and the latter the alkaline properties of the bile. In flesh-eating tribes, these are furnished in sufficient quantity from the animal food on which they subsist.

262. Salt retards Transformation. — Salt has another office in the animal economy. It appears to be a kind of governor, regulating the rate at which the changes in the body proceed. Salt is an antiseptic, and therefore retards the transformation of the tissues. Lean persons of active habits have an instinct for salt, and generally use it freely with their food; while persons of full habit, or tending to corpulency, use it but sparingly, the transformation being already too slow.

Pepper and other condiments, such as mustard, horse-radish, etc., are direct stimulants, both on the local surfaces with which they come in contact, and on the general circulation. By their local action they increase the flow of saliva and gastric fluid; but the quality of these secretions is impaired nearly in the proportion that their quantity is increased, so that really little or nothing is gained in the digestive process.

263. Effect of Highly-seasoned Food. — The continued and habitual use of highly-seasoned food vitiates the secretions of the mouth and stomach, and thus impairs digestion; and worse even than this, such stimulants impair the sense of taste and pervert the appetite, the natural faculty of selection, and the power of determining both the quantity and quality of food which the necessities of the system demand. In a healthy condition, the digestive organs will not require condiments to assist them in the performance of their work.

If this is true of pepper and kindred stimulants, it is more intensely important in regard to wine, beer, and other alcoholic drinks used at meals, under the pretext of creating an appetite. Such beverages not only act as a local irritant on the mucous membrane of the stomach, but the effect of the alcohol is to impair sensibility in the nerves of that organ, and to disturb if not suspend digestion by its well-known power of preserving organic substances from decomposition or change.

264. Vinegar — its effect on Digestion. — Vinegar is extensively used as an auxiliary food. It furnishes no nutriment; indeed, it is not digestible; but when nitrogenous food is taken in large quantities, or in such form as to be difficult of digestion, the secretion of the stomach frequently fails to furnish the acid quality of the gastric fluid sufficiently to complete digestion before putrefaction takes place. Vinegar more nearly supplies this defect than any other substance which could be used with safety.

Nitrogenous vegetables, such as cabbage, etc., are rendered more digestible by vinegar. Two precautions, however, are necessary in the use of vinegar: 1st. We should be sure that it is vinegar that we are using, as many dangerous compounds of cheap mineral acids are sold for vinegar; 2d. The vinegar for the table should be largely diluted with water.

265. Soda — its use in Cooking. — Much has been said of the use of soda in the different culinary processes, and considerable alarm has been manifested over the constantly increasing use of this article. While it admits of no doubt that caustic soda is a dangerous poison, and that even the milder carbonate is unfit to be taken into the stomach in that state, yet it must be remembered that, in cooking, the use of soda is confined almost exclusively to the neutralizing of acids which it is desirable to get clear of, or as a means of obtaining carbonic acid to lighten bread artificially. In either of these instances the soda becomes a neutral salt, and nearly all the salts of soda are harmless.

But it may be well to say that, though no bad effects result from the use of well neutralized soda, yet the practice of using it to mitigate the acid of sour fruits, in cooking them, has the effect to impair their flavor and ultimately to render them insipid.

266. The Appetite — when it is safe to follow it. — Before closing the subject of the quality of food as affecting health, it will be proper to state, in general terms, that the most reliable guide in selecting our bill of fare is an unperverted appetite. This, however, is very rarely to be found in civilized communities. The false and often pernicious theories of nurses and mothers too frequently establish wrong habits and perverted tastes, long before the unfortunate victim learns to form a proper judgment by his own reasoning from physiological laws; and even then it too often happens that wrong habit is stronger than right knowledge.

Children naturally prefer plain, simple, nutritious food, but if they are fed on that which is highly-seasoned and stimulating, accompanied with wine or other narcotic beverages, plain food will soon fail to gratify their desires. The appetite is then an unsafe guide.

Recapitulation.

Oils and fats are demanded in cold climates, and in the winter season of temperate climates. Their necessity in the diet of those predisposed to consumption. Salt furnishes the chlorine and soda necessary for healthy action of the system. It retards transformation of the tissues. Highly-seasoned food and stimulating condiments are injurious. Vinegar hastens the digestion of nitrogenous food. Soda, when used in cooking, should always be neutralized by an acid. An unperverted appetite is the best guide in the selection of food.

LESSON XXXIII.

QUANTITY OF FOOD.

267. Quantity of Food. — The quantity of food necessary to the maintenance of good health has been variously stated by different authors. Indeed, there are so many modifying circumstances connected with this question, that no definite statement can be made that will be in any degree reliable. Age, sex, temperament, occupation, state of health, and previously established habits, each exerts a greater or less influence on the demands of the system for support.

Dr. Dalton says that a man in full health, living on a diet exclusively of bread, butter, and meat, with coffee and water for drink, and exercising in the open air, will require, in each twenty-four hours, nineteen ounces of bread, three and one-half ounces of butter, and sixteen ounces of meat, with fifty-two ounces of drink. The army rations of the United States soldier exceed Dalton's estimate by about twenty per cent, besides adding rice, sugar, and beans to the bill of fare. The rations in European armies are somewhat less than this.

268. Digestion modifies Food.—The more or less perfect manner in which the digestive process is performed, is a modifying circumstance to which too little importance has been attached. Two persons, each in good health, of the same age, and following the same occupation, will eat equal quantities of the same kind of food, and yet derive nutriment from it in very different proportions.

It is not the quantity of food taken, but the amount digested, which ministers to the support of the living body. This defective digestion may depend on a natural debility, a lack of vital force in the organs concerned in the work; but more frequently it is the result of bad habit, the habit of overeating, formed in early life. As the digestive process will seldom take from the food more nutriment than the demands of the system require, so when that amount is obtained the work is suspended, and the residue is passed off as waste matter.

269. Use of Tobacco.—Persons addicted to the use of tobacco require a larger amount of food to furnish the same nutrition than persons who do not use the narcotic. The saliva, being rendered unfit for its office, is wasted, and the starchy part of the food, which should have been converted into sugar by this fluid, remains to a great extent unchanged. The saliva is less important in the digestion of animal food, and for this reason those who use tobacco instinctively become largely flesh-eaters, or the habit induces dyspepsia.

Alcoholic drinks produce similar effects, by impairing the sensibility of the stomach, and diminishing its vital force. By these derangements the stomach permits the imperfectly digested food to pass the pyloric orifice, and so but a small amount of its nutriment is made available. The appetite demands more food, and this morbid and pernicious effect of the "bitters" is often mistaken for an evidence of increased nutrition.

270. Temperature — its influence on Food. — A few general principles, judiciously applied, will be found more effectual in regulating the quantity of food than any special rules that can be laid down. In childhood and youth, the nutrition must not only supply the waste of the system — which is greater in a given time than in adult age — but also a surplus, to be applied to growth.

In cold weather the transformation of the tissues is more rapid, and a greater amount of heat-producing food is consumed to maintain the temperature of the body. The amount of this increase will be modified by circumstances. Persons well provided with warm clothing, living in comfortable houses, and spending their time chiefly in well-warmed apartments, will scarcely require any increase of food; but the poorly clad and housed, and those engaged in out-door occupations, will require their food to be greatly augmented in cold weather.

271. Exercise and Ventilation vary the quantity of Food.—Active muscular exercise draws largely on the vital force; but the evolution of force is intimately connected with the wastes of the body, the oxidation of the food we digest, and of the worn-out particles of the body. These wastes must find an appropriate compensation in an increase of food. If the exercise be in the open air, the atmosphere pure, and the breathing free, the increased demand for food will be much greater than if the same exercise had been taken in a close, ill-ventilated room.

But the force furnished to perform the exercise or labor will be in the exact proportion of the wastes to be supplied, and if the demand for food is not increased, the ability to perform the exercise will soon fail. From this cause persons are capable of performing more severe and longer protracted labor in the open air than in badly-ventilated rooms.

272. Change of Habits demands change in Food.—In altering their habits of life, persons should be careful to adapt the quantity of food to the modified condition. If the change be from sedentary, in-door occupation to active, open-air labor, the appetite will generally point out the proper alteration in diet; but changes in the opposite direction are not so promptly indicated, or, if so, the indications are not always heeded.

Pupils leaving the active employments of the farm, and confining themselves to the school-room, often injure their health by continuing the same diet, both in quantity and quality, which they found necessary when engaged in daily labor. After a careful attention to this subject for the first week of school life, it may be safely intrusted to the appetite. Persons making such a change of habits are frequently alarmed at their failing appetite, and resort to medicines to provoke a desire for food. This is all wrong.

273. Mental Labor — the diet it demands. — Pupils at school, and other persons engaged in mental labor, need a plain, liberal diet. The amount of food devoted to muscular repair and the production of animal heat should be reduced proportionally to their diminished physical exercise, yet it by no means follows that it is necessary to starve the body to invigorate the mind. This hypothesis, so popular a few years ago, has been superseded by more rational views.

Brain is exhausted by activity even more rapidly than muscle, and the waste of its material is proportionally great. To replace this wasted matter requires a full supply of food, rich in albumen and the phosphates. Eggs, fish, oysters and other shell-fish, the lean part of mutton and beef, and wheat bread, are all articles rich in brain elements, and may be used liberally if cooked plainly, with no other seasoning than salt. Fruits, either raw or cooked by stewing or baking, may be introduced as dessert.

274. Bribing the Appetite. — The appetite is the only measure to determine the quantity of food to be taken, but many devices have been invented to bribe the appetite to take more food than the demands of the system require, or to take it when none is needed. Highly-seasoned food perverts the appetite, and renders it an unsafe guide. A great variety of dishes at the same meal has the same effect.

A single course, consisting of one kind of meat or eggs, one variety of vegetables, with bread and butter, and some palatable, unstimulating diet drink, in very moderate quantities, will furnish a meal which may be supplemented by a dessert of fruit. Of such a repast, the appetite will determine very accurately when to desist from eating. A person should never suffer himself to be decoyed into taking food when there is no desire for it.

Recapitulation.

The quantity of food demanded to supply the wastes of the system depends primarily on its perfect digestion. Tobacco and alcohol impair digestion. Temperature modifies the demand for food. A change of habits of life requires a corresponding variation in diet. Exercise and good ventilation increase the demand for food. Brain labor needs a generous diet. The use of highly-seasoned food renders the appetite an unsafe guide.

LESSON XXXIV.

TIME OF TAKING FOOD.

275. Intervals at which Food should be taken.—Food should be taken at such intervals as will permit the stomach to perform the labor of digestion, and enjoy a period of rest about equal to the time of its active work. An ordinary meal, in a healthy stomach, will be disposed of in about three hours; and if we allow the same time for rest, this will make an interval of six hours between meals.

Nearly all civilized nations have adopted the rule of three meals per day—a few, more than this, and some, less. But individuals are found, in all communities, who depart from the general usage of society in one direction or another.

Whatever rule is adopted, it should be made a uniform habit, which should not be violated except under the most urgent necessity. When a habit is fully established, the quantity of food will not depend on the number of meals. A person eating but once in twenty-four hours will take as much food at that one meal as he would take if it were divided into three meals.

276. Early Breakfast—why required.—When three meals are taken, the morning one should come early, or at least before we enter on any of the active duties of the day. The long interval between supper and breakfast is or should be an interval of rest, yet the active absorbents have carried into the circulation, in this time, all the nutritious matter derived from yesterday's food, and the stomach is now in an empty condition, awaiting a fresh supply. Any heavy drafts on the vital force in this condition can not fail to seriously disturb the equilibrium of that force, and derange important functions.

In this state, the system demands that the digestive apparatus should be early set at work to prepare nutriment sufficient to meet the heavy drafts of a day of active exertion. This view of the subject demands that breakfast should be a substantial meal of good, nutritious food.

277. Dinner—its proper time.—Dinner should not be delayed much beyond six hours after the morning meal. Late dinners require that the interval between them and the evening meal be too short, or that the latter be crowded too close to the hour of retiring for sleep. If the meals be taken at regular intervals of six hours, beginning at about seven o'clock in the morning, they may all be made full meals of substantial food; but if the dinner be delayed till four o'clock in the afternoon, the evening meal, if not entirely dispensed with, should be very light both in quantity and quality, and should be taken not later than eight o'clock.

Late suppers of heavy, indigestible food are a fruitful source of dyspepsia, and that long train of nervous diseases which render life an intolerable burden to so many. No food should be taken nearer than two hours to the time of retiring, and that time should not be later than ten o'clock.

278. Eating between Meals—its pernicious effects.— The practice of eating "pieces" between meals is a most pernicious habit, and one that is the prolific cause to which may be traced the ruin of so many constitutions, even in childhood. When food is taken, a full meal should be made, and the stomach should then be permitted to digest it without disturbance. But if fresh portions of food be introduced when the stomach has half finished its work, the result is that neither portion is properly digested; for the process is thereby prolonged, the stomach is virtually kept at constant labor, and its powers are so enfeebled and exhausted that it fails to provide the means of nutrition sufficient to supply the demands of the system, or to compensate for its daily waste.

Loss of appetite and general debility ensue, followed by a train of nervous derangements that disturb all the vital functions. Half the ruined constitutions, that are not traceable to alcohol and tobacco, may safely be referred to the habit of eating between meals.

279. Meals should not be interrupted. — Eating should be done slowly and deliberately, but it should also be done continuously. By this we mean that, when a meal is begun, it should proceed without any considerable interruption to its termination. The stomach does not begin the process of digestion till eating is finished; but if, after the first course at a fashionable dinner, there is an interval of ten minutes, a healthy stomach will go promptly to work on the food already taken. But this will be interrupted by the second course, and the stomach, thus disturbed, will return to its task tardily, and will be likely to do its work imperfectly.

Extremes of temperature in our food should be avoided. Food, to be promptly digested, must vary but a few degrees from blood-heat. Hot food and drink, or ice-water, ice-cream, etc., taken into the stomach, suspend all action till the mass has acquired the temperature of the body. (§ 224.)

280. Importance of thorough Mastication. — Good health depends not alone on what we eat, and when we eat it, but the manner of taking food is of the first importance in this relation. Eating, as we have said, should be done slowly and deliberately, and the mastication should be thorough. This is demanded more especially with regard to the starchy forms of food.

Saliva is the immediate agent by which starch is changed into sugar, and thus rendered soluble and transformed into available nutriment.

But if the food be hurried through the mouth, and but imperfectly mixed with saliva, the digestion will be equally imperfect, and much of the nutriment lost. A worse defect in mastication than this occurs when, by the use of tobacco, the saliva is poisoned and rendered unfit for the purposes of mastication; or the salivary glands, goaded to constant overaction, secrete a fluid which contains none of the essential properties of saliva, and therefore can not aid in digestion.

281. Good Teeth necessary to Mastication.—The grinding of food, the mechanical work of mastication, is performed by the teeth; and in order that the work should be well done, the machinery should be kept in good order. But, in this country, a good, sound set of teeth, in a middle-aged person, is rare. Many things have, each in their turn, been charged with causing the premature decay of teeth, so common and so damaging to good health.

It is pretty clear that the mischief is traceable to a combination of causes rather than to any one agent. The teeth are covered with an enamel which, if properly taken care of, will protect them from the chemical action of any thing proper to be taken into the mouth; but this enamel may be broken, either by mechanical means, or by taking food too hot or too cold, and decay will inevitably follow.

282. Rules for preserving the Teeth.—The preservation of the teeth is a subject of too much importance to be passed over lightly; we therefore submit a few general rules for their care. After eating, the teeth should be thoroughly cleaned, removing, by means of a tooth-pick of wood, quill, or ivory, whatever has lodged between them, and washing the mouth with tepid water. Never use a metallic instrument of any kind to clean the teeth, for in its use there is always a liability to fracture the enamel, which is, of all things, most to be guarded against.

All tooth-powders and dentifrices are to be avoided, for even the constant rubbing of the teeth with powdered charcoal will ultimately wear through the enamel, and expose the teeth to decay. A soft brush, a little fine soap, and soft water about blood-heat, will cleanse the teeth more thoroughly and more safely than the most expensive dentifrice.

Recapitulation.

Three meals a day generally adopted in civilized countries. Meals should be taken at intervals of at least six hours. Breakfast should be eaten before commencing the day's labor. Late dinners bring the evening repast too near the hour of retiring. The pernicious effects of late suppers. Eating between meals is a fruitful source of indigestion. The digestive apparatus must have time to rest. Meals, when once begun, should not be interrupted. Care of the teeth important to good health.

LESSON XXXV.

CONDITION OF THE SYSTEM.

283. Do not eat when fatigued. — The condition of the system, at the time of taking and digesting food, is a matter not to be overlooked in the hygiene of nutrition. To digest a full meal, is an operation which draws heavily on the nervous system for the force necessary to maintain the constant motion of the stomach, by which its contents are moved about so that every part of it may be brought in contact with the surface secreting the gastric fluid, as well as to keep up a full flow of this secretion.

Now if labor of muscle or mind has been carried to fatigue, and a feeling of exhaustion is experienced, it would be very improper to take food until the exhausted vital force has been restored by rest. Persons engaged in active labor, or in hard study, should allow themselves at least half an hour for rest of body and mind before assigning to the stomach its task of digesting a meal.

284. Rest should follow Meals. — It is equally important that an interval of rest and relaxation should follow each meal. The action of the stomach is involuntary, and proceeds without our knowledge or consent; yet, if a strong effort be made to carry on any voluntary function, the vital force will be directed to the organs concerned in that work, and being thus turned away from the stomach the work of digestion can not proceed for want of power.

It is not merely vigorous muscular exertion which produces this effect, but it may be even more certainly induced by brain labor. Some of the most inveterate cases of indigestion are traceable to the habit of spending the dinner hour in reading and hard study. This is a habit which laboring men, anxious both to acquire knowledge and economize time, are apt to fall into, and against which they should be warned.

285. Cheerfulness during Meals.—A lively, cheerful state of mind, as far as this can be commanded, should accompany all our meals; and if the surrounding circumstances force on us the melancholy mood, our meals should consist of light, digestible food, in small quantities. Under such circumstances the appetite will seldom demand food; and care must be taken that we are not decoyed into the mistake of attempting to create an appetite by local stimulants, or of escaping from the cares that oppress us by a resort to alcoholic exhilarants.

At least half an hour should be spent in sprightly conversation or amusement after a meal is taken. Light reading, which will amuse and entertain, will furnish a safe means of passing this interval between eating and business. But works of fiction which appeal strongly to the imagination or rouse emotions should be carefully avoided.

286. Rest after Meals—objection to the Siesta.—The half hour of rest after meals, which we have recommended, will be sufficient, in most persons, to start the process of digestion; and when the stomach has become fully engaged in its work, it will not be easily diverted from it. But on resuming business we should begin moderately, and not tax our powers to their full capacity for at least the first hour of labor. When the time can be spared, it will be safer to lengthen the period of rest after eating to an hour, which could be economized by devoting it to some easy task that will but lightly tax either muscle or brain.

To the Spanish siesta, or hour of sleep after dinner, there is a physiological objection. All the vital powers are depressed during sleep, and the stomach feels this lowering of vital force in common with all the other organs, and consequently digestion can not be perfectly performed.

287. Food not to be taken when there is no Appetite.—We have, in a previous lesson, intimated that food should be taken at regular intervals, and this regularity should be maintained till it grows into a habit. This, however, is to be accepted under certain restrictions. There are conditions of the system in which the appetite does not ask for food, and in which to take food into the stomach would only add a new source of irritation, which might, with existing disturbances, prove a cause of serious sickness.

These conditions may be reduced to two general divisions, to wit: Those in which the loss of appetite springs from derangements in the digestive apparatus, so that food, if taken, could not be properly digested, and, by becoming either acid or putrid in the stomach, would not fail to seriously irritate that organ; and those in which the loss of appetite arises from diminished wastes of the system, reducing the demand for nutrition.

288. Abstinence — when necessary. — The first of these conditions, resulting in a loss of appetite, usually has its origin in improper eating as to the quantity of food, its quality, or the time of taking it. Under these circumstances nothing more is necessary than to abstain from eating and await a return of appetite. If there be no serious disease approaching, abstinence from food for twenty-four hours will correct the disturbance and bring a renewed appetite.

The second condition may generally be traced to a lack of active exercise in the open air. When the change or transformation of the tissues is retarded, the demand for new material is proportionally diminished, and the digestive organs refuse to prepare nutrition beyond the healthy demands of the system.

289. Efforts to create an Appetite. — The habit of urging food on invalids when there is no desire for it, is only equaled in absurdity by the opposite error of denying food to convalescent persons when the appetite imperiously demands it. In these conditions of the system, which disqualify the digestive apparatus for the performance of its proper office, it is a very grave mistake to resort to medicines to create an artificial appetite.

When we look at the formidable catalogue of tonics, and bitters, and other nostrums, with which the public regularly doses itself, and all for the purpose of provoking an appetite against the wiser instincts of the system, it is surprising that comparatively so little mischief is done by all this war on nature. Out of this injudicious tampering with the digestive organs grow most of the chronic diseases, which make so many invalids, and induce premature old age in so many cases.

290. Habits measure the quantity of Food. — The condition of the system, with regard to activity or rest, must modify our diet both as to quantity and kind; and it will be wise to depart even from the general rule of following the appetite when changes in manner of life are suddenly made, especially if the change be from active labor to absolute rest. Under these circumstances, it will be prudent to leave the table while there is still a desire for more food.

The changes of the season demand a corresponding change in our bill of fare. Oils and animal flesh may be taken freely in winter, if we follow out-door occupations, but when the relaxing days of spring come, we should keep lent, for health, if from no other motive. Never take food late at night when the system is oppressed with a feeling of drowsiness or languor.

Recapitulation.

Food should not be taken when there is fatigue of either muscle or brain. Meals should be followed by rest. Cheerfulness and mental relaxation at meals are important. Sleep should not be indulged in during digestion. Food is not to be taken when there is no desire for it. Abstinence from food — when proper, and to what extent. Efforts to create an artificial appetite are injurious. Change of habits or of season demand a corresponding change of diet.

LESSON XXXVI.

CIRCULATION.

291. Sympathetic Relations of the Heart and Blood-vessels.—The circulatory apparatus has an extensive range of sympathies, being affected, more or less, by every change which takes place in any of the important organs of the body; but the circulation is subject to fewer direct disturbances than any other function of the living body.

The heart, the central organ of the circulation, is so situated that it is removed from liability to injury by external accidents; and being an involuntary organ, the will exerts no direct control over it, and therefore it is not, like the stomach, liable to be overworked for any present gratification, or neglected in the hurry and press of other business. Nearly all the diseases to which the heart and blood-vessels are subject, have their origin in their sympathetic action with the digestive or respiratory functions, or with the brain and nervous system.

292. Pressure on the Veins.—The veins perform the work of returning the blood to the heart, and are therefore an important link in the process of circulation. These are largely distributed on the superficial parts of the body, and are therefore peculiarly subject to external influences, such as change of temperature, mechanical pressure, etc. Moreover the veins, unlike the arteries, have soft and yielding coats, affected by the lightest pressure; and as the current of blood flowing through them is not impelled by any direct active force behind it, therefore it is more liable to disturbances from external causes.

If the clothing is so tight as to produce any sensible pressure, it will retard the return of venous blood, and will to that extent disturb the circulation. Tight garters are a fruitful source of cold feet, which so many complain of. The return of blood from the feet being interrupted, the supply will be diminished in proportion.

293. Compression of the Jugular Veins. — A more dangerous compression of the venous circulation is that occasioned by tight collars or neckties. The jugular veins, which return the blood from the head, are situated immediately under the skin, on each side of the neck, and are therefore very liable to compression from dressing the neck tightly. Compression of these vessels produces engorgement of the whole vascular system of the brain, manifesting itself by dizziness, a sense of fullness in the head, or severe headache.

This will derange the mental machinery, and disturb all the functions of the nervous system. If the compression is considerable, and any active exertion is attempted, the engorgement of the brain is liable to terminate in apoplexy; but if the compression be moderate and long continued, the consequence will be that less blood will be sent to the brain, and the whole nervous system will be correspondingly weakened.

294. Muscular Exercise and the Circulation. — But the circulation is affected indirectly by nearly all the activities of the body. Every contraction of a muscle makes momentary pressure on the veins in contact with it, and thus their contents are forced forward in the direction of the heart, the valves preventing the flow in the opposite direction. The relaxtion of the muscle permits the veins to fill again, and thus the action of the muscular system increases the quantity of blood returned to the heart in a given time.

This demands a more vigorous action of the heart, and, under this influence, the pulse becomes fuller, stronger, and more frequent. This increase of circulation by exercise is a healthy action, and with it an increased respiration is demanded for the full supply of oxygen, in order to break down and render soluble the old material of the tissues, that it may be removed by the absorbents.

295. Changes of Temperature. — The temperature of the body and the circulation of the blood mutually affect each other. Whatever excites the circulation, and induces a greater transmission of blood through the capillaries, increases the temperature in the same proportion; and, on the other hand, if any part of the body be exposed to a very low temperature, the vessels will be contracted, and the circulation in that part diminished.

This may be general, as in a cold bath; or local, as in the application of ice to any part of the body. But when there is a depression of the circulation from sudden exposure to cold, there is always an effort of the system to overcome the obstruction by augmenting the force of the circulating current. Under these circumstances, if the depressing cause be removed, the temperature suddenly restores itself and even rises above its former standard; and the increased action of the capillary circulation will be maintained for several hours.

296. Change from Cold to Heat, most dangerous.— But in feeble health this reaction does not always take place, especially if the low temperature be long endured. Persons, therefore, of feeble vitality should be cautious in exposing themselves to a low temperature, whether in the bath, or in a cold atmosphere; and they should bear in mind that the reactive force diminishes with the length of the exposure.

The increased force of the circulation, whether from a high temperature of the surrounding medium, or from violent and long-continued exertion, is more to be dreaded as a cause of disease than exposure to a low temperature. Changes of weather from cold to warm are more unfavorable to health than those in the opposite direction. By the increased vascular action there is induced a tendency to inflammatory diseases.

297. Influence of the Mind on the Circulation.— The action of the heart is readily influenced by the mental condition. A powerful exertion of the purely intellectual faculties, as in the solution of some intricate problem, reduces both the force and fullness of the circulation, while the action of the heart becomes more frequent, and often irregular.

Anger and the other exciting passions increase the force of the heart's action sometimes to an alarming extent. The depressing passions, such as sorrow or grief, render the pulse empty, slow, and feeble. Under the influence of these depressing passions, the power to resist disease is greatly diminished, as was demonstrated when cholera visited our cities a few years since.

The condition of the circulation is the best measure of the vital force which is in our reach. A heart-action which maintains its uniformity, and is but little disturbed by the various exciting causes, indicates a powerful life force which will resist all ordinary causes of disease, and restore health under circumstances that, with a feeble circulation, would be hopeless.

298. Bleeding from Arteries or Veins. — Though the heart and larger arteries are well secured from injury by ordinary accidents, yet the superficial vessels are often injured, and it is frequently of the first importance to be able to distinguish the bleeding of an artery from that of a vein, as this discrimination will decide what must be done. (§ 48.)

When an artery is divided, the bleeding can be arrested only by tying the vessel; but the immediate danger can generally be met by compressing the vessel above the wound, or on the side next to the heart, till a surgeon is obtained.

Recapitulation.

The circulatory organs are in sympathy with all the functions of the body. Danger from compression of the veins by tight clothing. Nearly all the activities of the body affect the circulation indirectly. Temperature and circulation mutually influence each other. Reaction from exposure to cold — necessary precautions. Mental exercise and the influence of the passions affect the circulation.

LESSON XXXVII.

BREATHING.

299. Breathing — its complex character. — The organs concerned in respiration are intimately connected with a long train of dangers to health, both from the defective performance of their functions, and from the unwholesome condition of the air used in breathing. Foremost among these dangers stand prominent the restrictions on the respiratory movements from improper dressing.

We have already described (Lesson VII) the process of breathing as being carried on jointly by the diaphragm, the muscles between the ribs (intercostals), and the muscles forming the front part of the abdomen. Now, breathing may be imperfectly carried on by the diaphragm alone, but perfect breathing requires the joint action of all these organs, operating without restraint and with the utmost freedom. But our modern style of dress defeats this end so completely, that we rarely see a person breathing naturally.

300. Movement of the Ribs in Breathing. — Much that has been written on the subject of tight lacing has been misunderstood, or the statements have been so indefinitely made that they have rather served to mislead than to instruct those for whose benefit they were written.

The motion of the ribs in expanding the chest increases as we descend in the series. The first rib is a fixed point, and the second one is moved upward a given amount; the third moves twice as much as the second, the fourth three times as much, and so on through the whole series, so that the twelfth rib should have eleven times as much motion as the second one. At a glance it will be seen how much more injurious it is to compress the lower than the upper part of the chest, yet our modern styles nearly relieve the true ribs, and put all the compression on the false and floating ribs.

301. Injurious effect of Compression. — But the compression of the chest is not the only thing to be guarded against in this relation. In healthy breathing there is a free motion of the abdominal muscles, and if this motion be in any way interfered with, the breathing will be imperfect.

To suspend the lower garments by a band passed around the loins, will prevent all free motion of the muscles on the front and sides of the abdomen, and to that extent impede respiration. And this remark applies not merely to women's clothing; the habits of dress common among men confine the abdomen by too tight a waistband, so as to materially interfere with the freedom of breathing. The lower garments, whether in male or female dress, should be suspended from the shoulders, so as to leave the most perfect freedom of motion to the lower part of the chest and abdomen. Compression need not be violent in order to be injurious. A very moderate pressure, constantly kept up, will be sufficient.

302. Compression — when most injurious. — Improper clothing is much more injurious to young persons than to those of mature age. In youth the cartilages are soft and yielding; a compression, therefore, which in older persons would hardly be felt, will in a short time produce permanent distortion of the ribs, and entail on the unfortunate and, perhaps, unconscious subject of it, a feeble vitality, which will constantly invite all the ailments that flesh is heir to.

Mothers, in the dressing of their children, have a great responsibility resting on them. We can not be too often reminded that vital force is measured by the amount of chemical change going on in the body, and that these changes are limited, at least on one side, by the supply of oxygen furnished by the respiratory process. Free breathing is therefore a prime condition of vigorous health.

303. Too frequent Breathing.—To one who understands the mechanism of breathing, it is an instructive lesson to watch the respiration of a company quietly seated in a room. Not one in ten breathes correctly. Many persons breathe with the diaphragm alone; others use the upper part of the chest almost exclusively; and but few bring into requisition all the means of inflating the lungs.

This imperfect filling of the air-cells compels the breathing to be more frequent, in order to supply in some degree the deficiency of fullness. But this increased frequency not only exhausts the few muscles on which the whole labor is imposed, but the air is not retained in the pulmonary cells long enough to impart its oxygen fully to the blood, and receive, in turn, its charge of carbonic acid from it. A healthy person with well-developed lungs, breathing quietly, will fill them about fifteen times per minute; but persons, from a bad habit of breathing, or from ill-developed or compressed lungs, frequently respire twenty or twenty-five times per minute.

304. Exercise of the Vocal apparatus.—A free exercise of the lungs in singing, declaiming, or reading aloud, with careful attention to the method of breathing, is the best means of correcting vicious habits in the use of the lungs and their associated apparatus. In these exercises, care must be taken that the diaphragm, ribs, and abdominal muscles are all brought into use and act in concert.

Many public speakers and singers, when they suffer somewhat from embarrassment, are in the habit of rigidly contracting the abdominal muscles, and holding them firmly in that attitude during the whole performance. This compels more frequent breathing than is convenient, deprives the voice of volume and force, and gives it the appearance of coming from the upper part of the throat only. Much of the throat disease in public speakers may be traced directly to this vicious habit of breathing.

305. Imperfect Breathing, source of Feeble Health.—Imperfect breathing, from whatever cause it may arise, is more to be dreaded as inducing feeble health than almost any other cause, for the reason that it is seldom suspected either by those who suffer or by their friends. Though a compressed chest and undeveloped lungs, with a bad habit of breathing, may not immediately lead to any actual disease, yet the diminished vital force, which is an inevitable result of breathing imperfectly, will greatly impair the powers of endurance—the ability to sustain protracted efforts either of muscle or mind.

With this diminished vital force comes the enfeebled power to resist the encroachment of disease, or to restore the healthy action of the system after disease has supervened. The chances of recovery from sickness are always augmented by a well-developed respiratory apparatus and a good habit of breathing. Much of the feeble health that is complained of in this country, especially among women, is traceable to imperfect breathing as its remote cause.

306. Breathing directly connected with Life.— Eating, drinking, sleeping, and exercising are conditions of life and health, yet they are only remotely so; but breathing is an immediate and indispensable condition on which life depends directly; it is therefore the most important of all the voluntary functions we perform. Indeed, respiration is so immediately connected with life, that beyond a certain point of voluntary control, the Creator has wisely removed it from our personal management, and placed it among the involuntary functions.

In this view of its importance, it is surprising to observe how little attention is usually paid to the whole matter of respiration, both with regard to how we breathe and what we breathe. Persons are often very particular to have their food scrupulously clean, but will not hesitate to breathe the air of a crowded, ill-ventilated hall, or to inhale volumes of second-hand tobacco smoke.

Recapitulation.

Breathing is a complex function, carried on by the joint action of several organs. Compression of the lower ribs is more injurious than that of the upper ones. Bad effects of compression on the abdominal muscles. Tight clothing is most injurious to the young. Too frequent breathing defeats the object of respiration. Use of the vocal organs as a means of correcting bad habits of breathing. Imperfect breathing is a source of feeble health.

LESSON XXXVIII.

PURE AIR.

307. Composition of the Atmosphere.—A healthy respiration demands that pure air be supplied to the lungs at appropriate intervals and in proper quantities. This question of pure air is the more difficult to solve because many of the most objectionable impurities give to our senses no evidence of their presence. The atmosphere consists of seventy-nine parts of nitrogen and twenty-one parts of oxygen. These are not chemically combined, but in a state of intimate mixture; or, more properly, the nitrogen acts as a solvent, and the oxygen is held in solution in it. This accounts for its uniformity in every place where it has been examined.

Besides these two gases, the atmosphere holds a variable quantity of watery vapor, carbonic acid, ammonia, and other volatile substances, which it receives from a thousand sources. These impurities, however, where the air is allowed a free circulation, seldom exceed one part in a thousand. It is only where the air is confined that they accumulate so as to be dangerous to those who breathe them.

308. Natural means of Purifying the Air.—One of the most beautiful economies in nature is that by which the air is purified of the pollutions that are constantly poured into it from the breathing of animals, the burning of fires, the decomposition of vegetable and animal matter, etc. Like a great ocean, the air receives from all these sources constant streams of carbonic acid and ammonia, which, if there were no counteracting agency, would soon render it utterly unfit to be breathed. But these noxious impurities are readily dissolved in water, and the showers, as they fall from the clouds, wash the air and purify it.

To assist this process, the vegetable world spreads its broad, leafy surface to the breeze, where myriads of mouths on every leaf are open to drink up the carbonic acid from the air, and appropriate it to their own use. In this same leaf the impurity is decomposed, and its oxygen returned to the air to supply the constant waste of it by animals.

309. Sources of Impure Air.—The influence of growing vegetation in purifying the air suggests the importance of trees and shrubbery about our dwellings, and of lawns and parks in the vicinity of large cities, where they will serve as reservoirs of pure air. What we are able to do, locally, to purify the air for our use, may be but a small matter, but much may be gained for health by carefully shunning the sources of impure air. Ponds of stagnant water, marshes, and other accumulations of decomposing vegetable and animal matter, should be studiously avoided.

Large assemblies in imperfectly ventilated rooms are most fruitful sources of mischief to the health of those who visit them. Air that has been once breathed is unfit for use until it has mingled with the great atmospheric ocean, and its original composition has been restored. By a wise provision, to prevent re-inhaling our own breath, it is rarefied by heat, and caused to rise above our heads as soon as exhaled from the lungs.

310. Oxygen — its diminution by Breathing. — It has been ascertained by careful experiment that air exhaled from healthy lungs has lost about one-fourth of the oxygen it originally contained, and that the volume has been maintained by the substitution of carbonic acid for the oxygen abstracted. Some might infer from this that breathing the same air four times would rob it of all its oxygen. This is not the case. Air that has lost one-fourth of its oxygen by a first inhalation, will lose less than one-eighth the second time it is inhaled; and when the oxygen has been diminished one-half the original quantity, the air will no longer support life.

On the other hand, the capacity of air to dissolve carbonic acid diminishes in a rapid ratio by the amount dissolved. Now, when we bear in mind that breathing performs the double function of supplying oxygen to the blood and removing carbonic acid from it, we shall perceive the importance of having the first use of all the air we breathe.

311. Importance of thorough Ventilation. — The proper ventilation of rooms is a subject involving more of health and comfort than has been generally apprehended. Public halls, churches, school-rooms, private apartments, and especially sleeping-rooms, should at all times have a free supply of pure, fresh air, and a constant removal of that which has been vitiated by breathing.

It is not necessary that air should be cold in order to be pure. Air may be warmed to any desirable temperature by a proper apparatus, and yet retain its healthy proportions unchanged. The only advantage in breathing cold air is, that heat expands air largely, and consequently a given volume of cold air contains more oxygen than the same volume of heated air. In warming apartments by a supply of heated air, we must guard against passing the air over red-hot surfaces of iron, as a portion of its oxygen will combine with the iron, and thus the amount available for breathing will be diminished in the same proportion.

312. Care necessary in Warming Rooms.—When stoves or furnaces are used for the purpose of heating apartments, great care must be taken that the gases resulting from combustion of the fuel do not escape into the air being warmed by it. Dr. Nichols, of Boston, has demonstrated, by a series of careful experiments, that cast-iron, when highly heated, will permit carbonic oxide to pass through its pores, and render the air thus heated unsafe.

An open grate or wood fire with a strong draft, though not a very good method of economizing heat, is an excellent ventilator and a safe way of warming small rooms; but when large halls or suites of rooms require heating, currents of warm air should be constantly introduced, which will demand that means be provided for the discharge of a corresponding current of vitiated air. This warm air should be supplied either from a wrought-iron furnace or from a chamber heated by coils of steam or hot water pipes.

313. Bad effects of ill-ventilated School-rooms.— In large manufacturing establishments, where unhealthy gases are generated, provisions should be made for carrying these away, by means of a high ventilating stack, in which a rapid current is made to ascend constantly by the aid of proper machinery, thus effecting a thorough renovation of the air.

The imperfect ventilation of school-rooms is an evil whose consequences can hardly be measured; and they are the more to be dreaded because their effects are of such a character as seldom to occasion immediate alarm. The direct consequence of breathing air containing a mixture of carbonic acid below the point producing a sense of suffocation, is to oppress the brain with a feeling of languor and dullness, followed by an almost irresistible tendency to sleep. In this condition neither teachers nor pupils are fit for duty. In a room twenty-five feet square, fifty pupils will breathe all the air it contains in a little more than two hours. After the first hour, the time spent in such a school-room is worse than wasted.

314. Alcohol and Tobacco—influence on Respiration.—It is important, in the relation of acquiring and maintaining vigorous health, that the lungs be preserved in such a state that the air will freely enter the whole of each lung, and that the air-cells be in such a condition that the oxygen from the air, and the carbonic acid and watery vapor from the blood, may be freely transmitted through the walls of the cells.

It is a familiar fact, that when spirituous liquors are taken into the stomach, the alcohol begins directly to pass off by the lungs, and may be detected in the breath. But so delicate a membrane as that of the air-cells can not be subjected to the action of alcohol without serious injury. The same may be said of inhaling an atmosphere foul with tobacco smoke. The narcotic effect of tobacco smoke in its second use is worse than the first use of the fumes, as in that instance the poison is carried to the lungs, instead of merely affecting the mucous membrane of the mouth.

Recapitulation.

Healthy respiration requires pure air in proper quantities. Decaying animal and vegetable matters vitiate the air. Rain and growing vegetation are means of purifying the air. Large assemblies corrupt it. Air once breathed is unfit for use till it is purified. In exhaled air, the oxygen is reduced and carbonic acid increased. Ill ventilation affects brain functions. Narcotics diminish the quantity of oxygen retained from the air inhaled.

LESSON XXXIX.

ANIMAL HEAT.

315. Uniform Temperature of the Body.—Animal heat, being so intimately connected with the respiratory function, will be appropriately considered in this place. The temperature of a healthy adult is about ninety-eight degrees; in infancy it is a little greater, and in old age somewhat less. It is astonishing to observe with what regularity the general temperature is maintained in all climates, and under extreme vicissitudes of season. When persons are exposed in extremely cold weather, the temperature of the extremities and of the exposed parts of the face often sinks to near the freezing point; but, even at this time, a delicate thermometer, placed in the arm-pit or under the tongue, will show little or no variation from the uniform standard of ninety-eight degrees.

Dr. Kane, in his Arctic explorations, was often exposed for hours to a temperature between sixty and seventy degrees below zero, without materially affecting the heat of his body; and in a number of well-authenticated cases, persons have subjected themselves for hours to a temperature above the boiling point of water, and still the thermometer under the tongue marked ninety-eight degrees.

316. Evaporation and Temperature.—These astonishing results can be explained only by understanding the relations existing between the pulmonary and cutaneous surfaces of the body. If the proper amount and kind of food be taken and digested, the temperature will be measured by the quantity of oxygen received through the lungs in respiration; but the evaporation of water is a cooling process, and reduces temperature in proportion to its rapidity.

The rapidity of evaporation depends, to a very great extent, on the temperature of the air. In a low temperature, the evaporation from the surface of the body is virtually suspended, and the heat evolved in the system is retained only as it is conducted away by exposure of the surface to the cold air. When the body is exposed to the other extreme of temperature, the evaporation of perspiration from the surface is sufficient to keep the temperature down to ninety-eight degrees.

317. Conditions of a uniform Temperature.—The power to maintain this constant equilibrium of temperature depends directly on the healthy action of the pulmonary surface—that is, the inner surface of the air-cells; and on the external, or perspiratory surface—the skin; and indirectly, on the supply of oily, starchy, or saccharine food, and the perfect digestion of the same. The failure of either of these conditions will be followed by a corresponding disturbance in the power to maintain an equal temperature under changes in the heat of the atmosphere.

In cold weather, the first condition of security against suffering is full and free breathing of pure air into healthy lungs. Many persons, on leaving a warm room and going into a cold atmosphere, feel a sense of chilliness, which induces a short, shallow breathing, as though they feared to fill the lungs with cold air. A few full inspirations will relieve this chilly sensation and restore a feeling of comfortable heat.

318. Precautions against a Cold Atmosphere.—But if there is an inability to fill the lungs, whether from temporary disturbance or from permanent disease, care must be observed in making sudden transitions from a warm to a cold atmosphere. Persons who have naturally small lungs, or who dress so that the larger part of the pulmonary surface is rendered useless, or those who, from present or previous disease, have the full use of only a small part of the breathing apparatus, generate heat feebly, and should not be exposed to low temperatures. But even if the lungs supply a full amount of oxygen, the stomach may not have furnished the supply of combustible material with which this is to unite; there will then be a corresponding inability to maintain the temperature on exposure to cold.

319. Overheated Rooms — ill effects.— Dyspeptics, and those who are suffering from pulmonary disease, or have a predisposition to it, while they are careful to avoid sudden transitions from one extreme of temperature to another, should be equally careful to guard against the too common error of constantly living in overheated rooms.

Let invalids remember that the chemical action which goes on between the air we breathe and the food we digest is not only the source of animal heat, but of vital force. That uncomprehended, and perhaps incomprehensible power also, by which all the movements of the living machinery are performed, is more or less directly connected with the same chemical changes; and whatever diminishes the amount of these changes, impairs the life-force in the same ratio. In a room heated to near the natural temperature of the body, there is but little demand for food, because there is very little chemical change required to supply the small deficiency of heat; but the vital force is also diminished in like proportion.

320. Proper Temperature of Rooms.—This accounts for the relaxing effect of external heat — the languor and lassitude of those who spend their days and nights in heated apartments. This effect is often heightened by imperfect ventilation, suffering the air to become loaded with carbonic acid and other impurities. The stomach seldom digests food when there is no demand for it in the system; and if food be taken under these circumstances, indigestion must follow.

Living-rooms, school-rooms, offices, etc., should be maintained as nearly as possible at a temperature between sixty and sixty-five degrees. This will leave some thirty-five degrees of temperature to be supplied by the vital apparatus, and that will insure, as a consequent, sufficient force to give energy and efficiency to the life-functions. Sleeping apartments may safely have a lower temperature—say fifty degrees.

321. Means of reducing Heat.—In the artificial heat produced by the burning of fuel, we have a means of guarding against low temperature, that may be made available in all in-door occupations; and proper clothing, exercise, breathing, and food will render out-door employments comparatively comfortable in any ordinary temperature. But the other extreme, the high temperature of summer, is not so readily controlled; much may be done, however, in this direction that has hardly been attempted yet.

Buildings with thick walls, or with an air-chamber between the outer and inner surface, will maintain a much more uniform temperature than can be secured by the walls in common use. The evaporation of water is the method employed in nature to mitigate extreme heat every-where. The three great oceans which stretch across the tropics present a broad evaporating surface, which serves to cool the trade-winds that sweep over the continents. If the entire surface of the globe within the tropics were land, neither animal nor vegetable life could be sustained on it.

322. Exposure to currents of Air.—Evaporation may be made available, to some extent at least, to cool down the intensity of summer heat in and around our dwellings. While our clothing should allow the air to penetrate freely, that the perspiration may evaporate easily from the surface of the body, yet care must be taken lest currents of dry air produce such rapid evaporation as to arrest or obstruct the perspiration by a sudden reduction of the temperature.

It is always safer to have the evaporation take place from the surface of our clothing rather than directly from the skin. The influence of even a rapid breeze, when we are perspiring freely, may be borne with little danger if we continue in active exercise; but when the exercise is suspended, currents of air should be avoided, and additional clothing should be put on.

Recapitulation.

Temperature of the healthy body is uniform. Evaporation is a regulator of temperature. Proper breathing, appropriate food, and a healthy condition of the skin are necessary to a uniform heat. Precautions should be taken against a cold atmosphere by those who have weak or diseased lungs. Overheated rooms are to be guarded against. Proper temperature of living-rooms is between sixty and sixty-five degrees Fahrenheit. Evaporation is the natural means of reducing temperature. When heated, avoid currents of air.

LESSON XL.

BATHING — CLOTHING.

323. Bathing necessary. — In order to maintain a uniform temperature of the body, the skin must be kept in a healthy condition, so that when the heat of the body rises above ninety-eight degrees, perspiration will be increased, and evaporation will reduce the temperature to the healthy standard; or, on the other hand, if the heat of the body falls below that standard, the action of the skin will be proportionally diminished, and the animal heat thus preserved. But in order that the skin may thus act as a regulator of animal heat, it must be kept clean. It is one of the channels through which the waste material of the body is carried away.

When the perspiration evaporates, it leaves on the surface of the skin the saline and animal matter which it held in solution. But the skin secretes oil, also; and this, with the residuum from the evaporation and the natural waste from the surface of the cuticle, forms a gummy substance which is liable to obstruct greatly the natural outlets through the skin.

324. How to Bathe.—To remove this accumulation, as well as that which is added to it from external sources, the whole surface of the body should be frequently and carefully washed. Bathing, as a means of cleansing the skin, should be resorted to, during the warm seasons, at least as often as twice a week. The bath should be of soft water, and the temperature between ninety and one hundred and ten degrees. In order to dissolve the oily accumulations more certainly, fine soap should be used moderately, and the surface briskly rubbed with a soft sponge, and dried with a coarse towel.

Care must be observed in the use of strong potash soap, in bathing, lest the oil should be so completely removed from the cuticle that its surface will be exposed to the air, and become dry and chapped from its action. If soft, warm water be used, nothing but the mildest soaps will be necessary to cleanse the skin effectually.

325. Bathing for other Purposes.—Bathing may be resorted to for other purposes than that of cleansing the skin. Where the cutaneous circulation is feeble, and the temperature of the surface habitually too low, a hot bath may be taken for the purpose of inviting the circulation to the surface. For this purpose the temperature of the bath may range between one hundred and twenty and one hundred and thirty degrees. Those who resort to the use of the hot bath must be careful not to suffer its use to grow into a habit.

What we have already said (Lesson XXXIX) on the subject of overheated rooms, applies equally to any other habitual substitution of external heat for that which is produced by the chemical changes going on in the living body. If the vital force be not very feeble, the circulation may be attracted to the surface as certainly and more permanently by a cold bath—or, rather, by the reaction which follows a cold bath—than by the direct application of heat. To secure this object, the bath should have a temperature of about seventy degrees, and should not be continued more than two or three minutes, being followed by brisk friction on the surface with a coarse towel or hair-cloth.

326. The Plunge-bath and Shower-bath. — The bath may be used for the purpose of rousing up the sluggish action and torpid sensibilities of the body. To accomplish this end, the whole body should be plunged at once into water of a temperature between sixty and seventy degrees, and immediately wiped dry, and wrapped in a soft blanket or clothed in flannel. The same purpose can be accomplished as effectually and sometimes more conveniently by a shower-bath. But in the use of both the plunge and shower-bath we must be careful not to mistake an exhausted vitality for a merely torpid condition of the system.

In general it will be safer to begin either the plunge or shower-bath with a temperature of eighty degrees, and if the bath is followed by a glow of heat on the surface, we may safely venture to reduce the temperature; but if not, we should at once desist. Medicated and vapor-baths are frequently used, but, being remedial agents, they do not belong to the subject of hygiene.

327. Clothing, as related to health. — To enable the skin to perform its office in such a manner as to regulate effectually the temperature of the body, careful attention must be paid to the subject of clothing. This embraces both the material used in the fabrics worn, and the adjustment of it to the body.

So far as the subject is related to health, the prime object of clothing is to protect the surface of the body from vicissitudes of temperature, by interposing between it and the external air a non-conducting substance, which will transmit the heat of the body but slowly when the air is colder than blood-heat, and which will arrest the scorching heat of the sun, when his rays have a temperature above the natural heat of the body. Substances differ widely in their conducting properties; but in the fabrics used for clothing, the chief difference consists in the porous texture of the cloth, or the amount of air in the fabric.

328. Qualities of Good Clothing. — Wool, when carded and spun in the ordinary manner, forms an elastic, soft, and porous texture, and is therefore an excellent non-conductor of heat; but the same wool, if combed so that the fibers will lie parallel, will form a firm, hard, worsted thread, which, when woven, will be almost as good a conductor as linen. Cotton spun with a slack twist, and softly woven, will conduct heat but little better than flannel; but if hard twisted and firmly woven, cotton goods conduct heat freely.

Another important property of a good material for clothing is, that it shall not absorb and retain moisture to any considerable extent. A good clothing material, while it will not permit a current of air to pass through it directly, yet it must be so porous as to transmit the insensible perspiration without obstruction.

329. Variations of Clothing. — Clothing should be varied with the climate and season, but this variation should have regard more to quantity than quality of clothing. In hot climates, and in warm weather in all climates, fewer garments should be worn, and those of lighter fabrics; but still a non-conductor is needed, to prevent the injurious effects of sudden changes of temperature, from currents of air, or transitions from sunshine to shade. The direct rays of the sun in the summer months frequently give a temperature far above blood-heat, and persons exposed to this require the protection of the best non-conductors they can command.

The materials of clothing in common use are fur, wool, silk, cotton, and linen; and their value as clothing material is in the order they occupy in this list. For protection against intense cold, fur is the best dress material known. Its high price and the difficulty with which it is cleansed are the principal objections to its general use as winter clothing.

330. Wool, Silk, Cotton, and Linen.—Fine wool, made into loose, soft fabrics, is the best substitute for fur, and, indeed, meets all the demands of comfort, health, and beauty in dress material. Silk is a good non-conductor of heat, and absorbs very little moisture, but its high price has hitherto prevented its general use in dress. Cotton has a wide range in its conducting properties, depending on the mode of its manufacture. Cotton flannels are nearly equal to woolen fabrics as non conductors, while the hard-twisted, closely-woven shirtings differ but little from linens in this respect.

From the round, hard character of the fiber, flax and hemp, in all the forms of their manufacture, are good conductors of heat, and consequently the worst material for clothing in use. White linen, worn as an outer garment, is a good reflector of sunshine. This, to some extent, counteracts its defect as a conductor. Under-clothing should be changed frequently and kept scrupulously clean.

Recapitulation.

A healthy action of the skin is important in maintaining a uniform temperature. To secure this, frequent bathing is necessary. Bathing may be used as a means of influencing the circulation of the blood. Caution in the use of warm baths. Rules for using the plunge-bath and shower-bath.

Clothing is directly related to health. A good clothing material must be an imperfect conductor of heat. Mode of manufacture has much to do with the conducting property of clothing materials.

LESSON XLI.

HYGIENE OF BONES.

331. Bone Nutrition — its demands. — The apparatus of voluntary motion is much less complicated than that of either of the other systems, and consequently less liable to derangements and disturbances of its functions. The osseous or bony frame-work of the body, for its proper development and the maintenance of its healthy action, demands attention to food, exercise, and security from external injuries.

The food necessary to supply the material for the formation and repair of bone, consists of those articles which are rich in phosphate of lime, such as fish and other forms of animal flesh, eggs, wheat bread, etc. Many vegetables and fruits, which are otherwise very nutritious, are nearly destitute of bone-earth, and persons living on these exclusively can not develop and maintain a healthy bony system. Potatoes, for example, while they are rich in the starchy elements of food, and contain a fair proportion of the nitrogenous or muscle-forming material, are deficient in bone-earth; and the bones of persons living exclusively on such diet become soft and often distorted.

332. Oversupply of Bone-earth — its effects. — Persons who are very fond of what they please to call good living — that is, a diet rich in animal food — frequently suffer from an oversupply of bone-earth. The bones become hard and brittle, and even slight accidents result in fractured bones, often seriously endangering life. This redundancy of phosphates in the food may give rise to gouty concretions about the joints, resulting in a disease alike troublesome, painful, and difficult to cure.

These two conditions frequently mark the opposite extremes of society. Rickets and other bony deformities indicate the poor diet of the children of want, while fractured bones from slight accidents, and gouty ailments, are the results of affluence and ease. The remedy for both lies in a rational diet and proper exercise.

333. Distortion of Bones — how produced. — Both the size and strength of the bones composing the frame of the body will depend much on the judicious use of them. Like every other organ of the body, the bones during the period of growth require regular exercise, in order to their full development both in regard to their perfect organization and their proper size. But at this period all occupations which require a constrained or unnatural attitude of the body, or which demand hours to be spent in the standing position, should be carefully avoided.

The bones of growing persons are quite soft and flexible, and will yield to a constant pressure; and if that force be applied in an unnatural direction, the bones will be permanently curved, and the body misshapen and deformed. Scholars at their desks should be required to sit upright, so that the weight may be supported vertically on the spinal column.

334. Freedom of Motion necessary. — Persons following sedentary employments should so arrange their work that they will not be required to assume a stooping attitude. With all persons, such positions of the body are injurious to health, but, to the young, permanent deformity is almost certain to be added to the present injury. This mischief results not so much from assuming improper attitudes as from the continuance of them. Children at natural, healthful play throw the body and limbs into almost every conceivable position, but they change their attitudes every moment, and no harm results.

In childhood, the symmetrical development of the bony skeleton requires perfect freedom of motion, and such active employments or plays as will give a great variety of motions to the body, and a constant change of position. The perfect play of all the organs in mature life demands, as a first condition, that there be no malformation of the bones by careless or improper treatment in youth.

335. Compression from Clothing. — The clothing of young persons should be adjusted with special reference to the fact that, while the bones are yet flexible from the large proportion of animal matter they contain, even a very gentle pressure, continued from day to day, will curve and distort the bones, and thus produce permanent malformation.

In this manner the Chinese practically render their women cripples for life; and a tribe of savages in the Rocky Mountains, by a similar process, deform the head in childhood so as to produce a nation of monstrosities; and thousands of children in this country, by a very moderate pressure on the floating ribs, continued through the growing period, have the chest so narrowed at the base as practically to diminish the breathing power at least one-half, and, as a consequence, reduce the force of all the vital functions in the same ratio.

336. Deformed Feet—how produced.—Multitudes thus deformed in infancy drag out a miserable life, under the false impression that their daily suffering from feeble health is a mysterious visitation of Divine Providence. In childhood and youth, the dress of either sex should be so loose as to admit of the fullest inflation of the lungs without obstruction or constraint.

In dressing the feet there is great liability to distort the bones of the toes and the metatarsal bones. But few feet can be found in this country which retain the natural form of the human foot, as seen in the statuary of the Greeks. Though this is a minor evil compared with the deformity of the chest, yet activity and gracefulness of movement is greatly impaired by every departure from the natural form of the foot, and the ability to participate in that most healthful of all forms of exercise, walking, is proportionally reduced.

337. Spinal Curvature — its origin. — Next to the ribs, the spinal column is most liable to permanent deformity from compression. We have already spoken of the stooping attitude, acquired at study or in following sedentary employments, but a greater danger is to be apprehended from a lateral or sidewise curvature, induced by working at occupations which employ but one hand and arm.

The constant action of the muscles on one side, while those of the other remain inactive, will naturally tend to draw the dorsal portion of the spine toward that side. This tendency is often aided by an elevated position of the elbow of the active arm, or, in many instances, merely by a habit of drawing the shoulder of that side upward. This deformity is very common, to a greater or less extent, among needle-women, and is frequently seen among clerks who write at high desks. The deformity is often so slight as to escape the notice of those suffering from it, or their friends, and yet it always impairs the powers of endurance.

338. Exercise — its effects. — In adult age the bones become firm and solid, and are much less liable to be distorted or deformed by pressure than in early life; they are, however, subject to the general law of waste and repair common to all parts of the living machinery. This transformation takes place more slowly in bone than in the soft parts, but the health of the bone requires that it be carried on steadily and at a uniform rate. This demands active exercise in a good atmosphere.

It has been demonstrated that the bones actually diminish in size, when persons accustomed to active labor suddenly change their habits of life and abandon their activities. But exercise may be carried to exhaustion, and both bone and muscle may be diminished in size and impaired in strength by overwork.

Recapitulation.

Bone nutrition demands food sufficiently rich in phosphate of lime. Oversupply renders them brittle. Deformity of the skeleton may result from unnatural positions long continued. Freedom of motion and frequent change of attitude are necessary to secure a well-developed frame. Deformities are more easily produced in childhood than in mature age. Spinal curvature — how induced, and its effect on the general health.

LESSON XLII.

MUSCULAR EXERCISE.

339. Muscular Motion. — The system of muscles, with their tendons and attachments, constitute the machinery of motion, which is operated by the vital force through the motor nerves. A general law, governing all the vital machinery, provides that, within certain limits, an organ shall correspond with the work it is required to do. Under this law, the muscles increase, both in size and force, by their judicious use, and the supply of vital energy is correspondingly augmented.

When the muscles are brought into use, there is an increased flow of blood to them, which demands a corresponding increase in the action of the whole circulatory apparatus; but this augmented circulation throws more blood to the lungs to be purified and aerated, and this requires fuller and deeper breathing. A larger flow of oxidized blood being transmitted through the capillaries, the chemical changes, both in the tissues themselves and in the combustible elements of the food, are directly increased.

340. Influence of Exercise.—Now this complicated chain of causes and effects, springing from muscular contraction, terminates in two important results: first, the cell structure of the muscles themselves is more frequently renewed, by which means the contraction of the muscle is rendered more efficient; and if the demand is kept up by habitual activity, the number of cells will be increased, thus giving greater volume and density to the muscles that are in frequent use.

In the second place, the chemical change connected with the renewing of the tissues—the removal of the old matter and depositing of the new, as well as the rapid oxidation of the carbon and hydrogen of the food—is directly connected with the evolution of vital force. This not only serves to increase the power of muscular contraction, but it re-inforces all the vital functions and imparts activity to the mind.

341. Muscular Activity and Good Health.—This activity of the muscular apparatus, terminating in an increased waste of material, with a correspondingly augmented force distributed to all the organs, calls for a supply of new material to be furnished by the digestive apparatus. This is the only legitimate and natural means of creating an appetite; for it not only demands the food, but at the same time supplies the force for its speedy and perfect digestion. But while it furnishes vital force for the digestion of the additional food demanded, this is only the measure of the augmented vital force of all the organs. Muscular activity is, therefore, to be regarded as the first link in the chain of phenomena leading to, and securing that very desirable result, *good health.* More or less directly connected with a vigorous exercise of the muscles, stands the healthy performance, correct habit, and persistent endurance of all the functions of life.

342. Exercise as a corrective.—If a person has contracted a vicious habit of imperfect and shallow breathing, vigorous exercise will soon compel a free and full use of the lungs, and directly establish a more correct habit of breathing. If sedentary employments endanger a curvature of the spine, a brisk walk of half an hour, once or twice a day, will be found the most effectual remedy. The almost instant fatigue of walking in a bent posture will compel the erect attitude as a means of relief.

But muscular exercise has its healthful restrictions. It should never be violent, nor should it be continued to fatigue. Whatever form of exercise may be selected, the action should commence moderately and be gradually increased to the proper intensity. Active forms of exercise should not be suddenly suspended; and if the exercise has produced perspiration, additional clothing should be put on.

343. Pure Air for Exercise.—Exercise should be conducted in the open air, if we would derive from it the greatest benefit. If the air we breathe be vitiated by a mixture of unwholesome gases, or if its proper proportion of oxygen be reduced by having been previously breathed, the good effect of exercise on the vital force is lost, and even a positive injury may be the result.

Muscular activity can be continued longer in the open air, without producing a sense of fatigue, than in a close room. An invalid will sit up longer when riding in a carriage, than in an easy chair in the sick-room. If, however, the condition of the weather forbids out-door exercise, or circumstances render it inconvenient, the windows may be thrown open and the room freely ventilated, so that a good substitute for the free air of out-doors may be had, which will be much better than omitting the exercise.

344. Sunlight.—Light exerts a curious influence on the ability to endure exercise without suffering fatigue. Repeated experiments have demonstrated that persons can endure labor with less fatigue in the sunshine than in the shade, the temperature being the same. We shall, perhaps, never know how the sun's rays impart force to both vegetable and animal life, but the fact may be ascertained every day.

Kitchens and workshops should be well lighted, as well as ventilated, and living-rooms should be on the sunny side of the house, and the light should be freely admitted. Miners, and others who work by artificial light, are, as a general rule, short-lived, and have a feebler vitality than those who enjoy sunshine. Invalids, and persons confined by chronic forms of disease, should have light, cheerful rooms.

345. Amount of Exercise.—Exercise, whether in the form of manual labor, or taken expressly for its sanitary effect, should be reduced to a habit, and should have its regular periods of activity and rest. The amount of exercise necessary to secure its best effect is modified by so many circumstances, that no special rule can be given. The general law governing exercise, as we have elsewhere said, is that it is beneficial up to the point of fatigue; but as soon as this feeling is distinctly perceived, exercise should be suspended at once.

Persons who are beginning a course of active exercise will soon reach this point, but each succeeding day they will find themselves able to continue the exercise longer, and even add to its force and activity, until eight or ten hours of the day may be devoted to active labor, without materially impairing the vital energy. Fatigue is more readily induced by the violence of the exercise than by its long continuance. A person who will walk a mile in thirty minutes and feel no fatigue, will be entirely exhausted after running that distance in ten minutes.

346. Mental Functions and Exercise.—The mental condition during exercise is of the first importance in regard to its sanitary value. If exercise be imposed as a daily task—if it be taken as a medicine to secure health, it will soon become irksome, and even repulsive, and no good will be derived from it. Whatever may be the form of exercise, the mental action should be directed to some other point than that of the mere muscular motion.

If walking is selected, the mind should be pleasantly employed on some subject entirely disconnected from the exercise itself. The muscular movements of walking should be performed entirely by the reflex action of the spinal cord.

Recapitulation.

Judicious exercise increases both the volume and force of muscles. It hastens the renewal of the tissues, and thus conduces to good health. Exercise should be in the open air when possible, for in a vitiated air it soon produces fatigue. Sunlight has an invigorating influence on all the vital functions. Exercise should be habitual, and the attention should be directed to some other object.

LESSON XLIII.

EXERCISE AND REST.

347. Rules of Exercise.—Summing up what has been said on the subject of exercise, we present the following rules, namely:

1st. It should call into play the largest number of muscles, and include such a variety of attitudes and motions as to distribute the exercise over the whole body.

2d. The movements should be energetic and active, but never violent.

3d. The exercise should carry with it some mental stimulant, or it should leave the mind free to employ itself on other subjects without interfering with the muscular movements.

4th. It should be regular and habitual.

5th. It should have the full advantage of free air and light.

6th. It should begin gradually, and be increased to full energy.

7th. All kinds of exercise should be avoided which require the muscles to be held long in a state of rigid contraction.

348. Gymnastics.—In selecting a form of exercise to fill these indications, we have a wide field in which to make our choice; and yet but few of the special modes which have been invented and prescribed as sanitary measures, are free from formidable if not fatal objections. The various forms of gymnastics and calisthenics, while they fill most of the requirements, fail to furnish any mental stimulus other than the muscular movements themselves; and yet these demand so much of the attention, that the mind can not leave the movements to seek other fields of employment.

The various games of ball, etc., while they call into activity a wide range of muscles, and have the advantages of open air and ample light, and, withal, furnish a vigorous mental stimulant in the chances of the game, yet there is a constant tendency for that activity to be converted into violence, that may end in actual injury, and more than defeat the object of the exercise.

349. Manual Labor.—Walking, when properly performed, is one of the most healthful forms of exercise, and one which is nearly always available. We said, *when properly performed*, for every body has not learned to walk correctly. A promenade should always be performed in the open air, with the body and head erect, and the shoulders thrown back so as to give free expansion to the lungs. The clothing should be adapted to the condition of the weather, and should be so adjusted as to permit the free use of every muscle of the body, without compression or restraint.

But the demand for active exercise finds its legitimate and complete fulfillment in the various forms of useful labor. This is demonstrated every day in the fact that the most perfect symmetry of form and vigor of constitution is found among those who spend most of their waking hours in manual labor. Labor only requires to be regulated by a proper knowledge and correct application of physiological laws, to meet all the demands of healthful exercise.

350. Kinds of Labor not Healthy.—But all forms of labor are not alike promotive of health. That form of it is best which furnishes the greatest variety and widest range of activities. These conditions are found in the highest perfection in agricultural and horticultural pursuits. The division of labor which, in our modern civilization, has been carried to so great an extent, and which has resulted in such a wonderful economy of labor, has a direct tendency to reduce its value as a means of maintaining good health.

The tendency of this system is to confine the work to the repetition of a few motions—the activity of a part, and often but a small part of the body; and while these organs are generally overworked, the remainder of the body becomes feeble from disuse. Some occupations employ the hands alone, while the other muscles of the body are unused and the brain unemployed. Such occupations are pernicious to health, and should be avoided.

351. Bad effects of Overexercise.—But exercise, like every other good thing, is liable to be abused, and thus become a positive injury and a fruitful source of disease. It is only when labor is perverted that it degenerates into drudgery and becomes a curse, destroying the symmetry of the body, entailing on its victim disease and suffering, and greatly reducing the period of human life.

The tendency of modern society is to inflict positive injury on a large class, by idleness and want of any healthful exercise, and to break down the constitution and ruin the health of another class by overwork. Eight hours of labor—active, but not violent—with an interval of one or two hours' rest, will, in most constitutions, be endured, without loss of energy or injury to health, for six days in succession, and, with a day of rest intervening, may be repeated from week to week indefinitely. A few may endure more than this, but these are the exceptions and not the rule.

352. Exercise for Young Persons.—Young persons in active employments need more frequent intervals of rest than those of mature age; and the same is true in regard to exercise, if confinement is the rule. Pupils required to remain quiet in the school-room, should have at least fifteen minutes of active exercise at the end of each hour. Such a course would not only secure better health to the scholars, but a more satisfactory progress in their studies.

Persons laboring in shops will greatly improve their health by devoting an hour each day to amusement in the open air and sunlight. This is especially true of those occupations which employ only the hands, or, possibly, only a single hand. Such persons require as much exercise of the whole body as their health would demand if they were actually unemployed. Boys generally manage to get exercise enough; and if girls from fourteen to twenty years of age were compelled to exercise every day in the open air, we should soon have a different race of women.

353. Rest—its necessity.—But vital machinery is not made for constant activity. A regular alternation of action and rest is the law of life every-where, and the intervals of repose are as essential to health as are the periods of activity. Rest is rendered necessary from two considerations: In the first place, the cells composing the muscular fibers are broken down and removed more rapidly during the active contraction of the muscle, than the nutritive process is able to replace them; but while we rest, the preponderance is on the other side—the wastes are replenished and the muscular tissue restored to its original integrity.

In the second place, active exercise expends force more rapidly than it can be supplied by the brain and nerves: hence, as fatigue comes on, the muscles contract more slowly and with less energy, until finally the entire exhaustion of strength, above what is necessary to keep in motion the involuntary organs, takes place, and motion ceases from prostration of the voluntary powers.

354. Two kinds of Rest.—Corresponding to this division, rest must be of two kinds, looking to the accomplishment of these two objects. A mere suspension of muscular contraction is all that is necessary to restore the wasted tissues, for nutrition will go on with an activity stimulated by the demand for new matter, while the waste from action will be suspended. Under these influences, but a short period of repose will be required to restore the equilibrium.

That rest is most perfect, however, which most completely suspends muscular action; and from this it follows, that a reclining position is better adapted to rest than either sitting or standing. But to restore exhausted contractile force, requires more than muscular repose: it demands brain rest, which can only be had in sleep.

Recapitulation.

General rules for exercise. Gymnastics do not furnish any mental stimulus other than the muscular movements themselves. Walking is a healthy and available form of exercise. Manual labor properly regulated is most conducive to health. Kinds of labor which are to be avoided. Rest must follow activity. Muscular rest, distinguished from brain rest.

LESSON XLIV.

BRAIN REST.

355. The Nervous System.—The systems of nutrition and voluntary motion, which we have been considering, are entirely dependent on the nervous system for the supply of force necessary for their several functions. All the diseases of these systems which do not depend on structural derangements of the organs, are therefore to be traced to disturbances in the nervous system.

But this dependence is reciprocal. The brain depends on the digestive apparatus for a constant supply of healthy blood, rich in the elements of brain nutrition. It is also dependent on the uninterrupted action of the respiratory organs, for a supply of oxygen necessary to carry forward the chemical changes so intimately connected with the evolution of that vital force. Without the chemical changes dependent on digestion and respiration, the supply of vital force is cut off; and without a healthy action of the brain and nerves, its distribution is impossible.

356. Brain needs Exercise. — The brain and its appendages are subject to the general physiological law of alternate activity and rest, which is so intimately connected with the normal condition and healthy action of all the other organs of the body. As the brain is the most delicately organized part of the body, and receives proportionally the largest supply of blood, its tissues are transformed with a corresponding rapidity.

If the exercise of brain be regular, and not too violent nor too long protracted, and the nutrition be sufficient to supply the material wasted by the activity, the result of the exercise will be the same here as elsewhere. The efficiency of brain action will be in proportion to the frequent and perfect renewal of its cell structure. The functions of sensation and motion do not exhaust the cerebrum as rapidly as the function of thought.

357. Brain fatigue. — During our waking hours, there is hardly such a thing possible as absolute brain rest. The attention is constantly called to the various objects of sense around us, and the perceptive faculty is as constantly required to note the various sensations, so that the representative faculty can recall them at pleasure.

It is true that, under ordinary circumstances, this action is so nearly spontaneous that it can hardly be called brain labor. But let a person spend a day in sight-seeing, in some new and interesting locality, or listen closely for an hour or two to an intricate argument, or an elaborate discourse on any subject that secures his attention, and a sense of brain weariness will be felt. The undivided attention can no longer be fixed and held to the subjects of observation, and the mind will fail to grasp the scope of the argument, or perceive the nice distinctions which the speaker, from familiarity with his subject, may present even with great clearness.

358. Brain weariness.—This point of mental fatigue, or brain weariness, is induced more readily in young persons than in those of mature age, and in that class who are not accustomed to brain work, than in those whose business has been study. This fact is especially commended to the notice of parents and teachers.

Pupils, at the immature age of ten or twelve years, are required to confine their attention, often for a period of eight hours a day, to studies which are frequently abstruse, uninteresting, and, to them, difficult; and this, generally, with but very brief intervals of rest. After an hour or less of close application to study, if the pupil be required to divert the brain action in the direction of brisk muscular exercise, involving chiefly the functions of the spinal cord, the brain will return to its task refreshed, and in this manner it may labor safely and profitably five or six hours a day.

359. Mental effort long continued.—After a period of close mental application, if the pupil finds himself unable to confine his attention to the subject of his investigation, or discovers an inability to exercise his ordinary powers of mental perception, he should be admonished at once and intermit his labors. All exertion beyond this point is more than a waste of time and effort; it is inflicting a positive and, to some extent, a permanent injury on the brain. If exertion be persisted in after this stage, a condition of exhaustion will follow, from which recovery can be found only in sleep. But sound, refreshing sleep is not always attainable under these circumstances.

The system of cramming, which is becoming so common in our schools, and which prescribes for pupils of tender age an amount of mental labor that would be more than enough for well matured and disciplined minds, has a tendency to arrest mental development by overwork.

360. Time of Study.—No general rule can be laid down prescribing a definite number of hours of mental labor to each pupil in a school. So many modifying circumstances may interpose, such as age, sex, general health, temperament, previous habits of study, etc., that the whole matter must be left to parents or teachers, to be governed by their judgments under very broad instructions. Before the age of ten years, study should be amusement rather than business; between ten and fifteen years, the confinement should not exceed an hour of close application without intermission.

As a general rule, boys endure confinement to study better than girls, and persons of bilious better than those of a nervous temperament; but those who are least able to sustain a protracted effort, can generally accomplish more, by close application, in a given time, than those who suffer less from long continued mental labor.

361. Special Training.—In cultivating and developing the mental powers, the same law governs the process as that which controls the education and training of muscular movements. If the entire attention be directed to the training necessary to the performance of a single motion or group of motions, great perfection may be attained in that direction; but all the other movements being neglected, the aggregate of muscular power is reduced, and the educated faculties soon fail for want of the force which can be evolved only in the symmetrical development of all the faculties.

Conforming to this law, it follows that, if the mental faculties be educated in a single direction, a much higher perfection is attainable, in that particular line, than would be possible if the culture and training were distributed equally among all the faculties. But the few favored faculties, depending on the general brain force for the power of their expression, and this failing through neglect of general culture, soon reduce the overtrained powers to the imbecility of the neglected faculties.

362. Relation of Mind to Matter. — Many well-disposed persons object to referring the mental manifestations, in any case, to the proper development and healthy action of the brain, because of a supposed tendency to materialism. But the relation of mind to matter is a question of fact, and is independent of all theory.

Nothing is clearer than that all our knowledge of an outer world, as well as our knowledge of the thoughts and actions of other minds, reach us through sensation; and, on the other hand, that we can transfer our thoughts to other minds only by muscular motion. But sensation and motion are primary brain functions. There is no necessity, however, for confounding the agent which operates, with the instrument by means of which the operation is performed.

Recapitulation.

There is a mutual dependence between the brain and the other organs of the body. All vital action is dependent on a healthy condition of the brain. The brain requires exercise in order to maintain its powers of action. Of the three brain functions, thought is the most exhausting. Brain labor demands frequent intervals of rest. Protracted study most injurious to young persons. Special training operates unfavorably on the general development of mind.

LESSON XLV.

BRAIN POISONS.

363. Alcohol, Tobacco, and Opium.—It may be regarded as an axiom in hygiene, that *the proper development and healthy action of the brain and nerves, in the absence of structural derangements in the other organs, is the prime condition of good health.* This being true, it follows that our first care in the preservation of health is to guard well the brain, supply it with pure, well aerated blood, give it the proper alternations of exercise and rest in each of its threefold functions, and preserve it from the influence of poisons which impair its powers, disturb its functions, or derange its delicate structure.

Of this class of poisons the most dangerous are alcohol, opium, and tobacco. Two of these, at least, are in common use in this country, and the third (opium) is rapidly gaining favor with certain classes in American society. If we had the means of tracing to its legitimate source every disease that afflicts civilized man, we have no doubt but that a large majority would be found to originate, either directly or indirectly, in the habitual use of these narcotics.

364. Alcohol—its chemical relation.—Alcohol is the most active, and on this account, as well as on others that will appear hereafter, it is the most dangerous of this class of poisons. Alcohol is the product of fermentation; the result of, or, rather, one of the bodies resulting from, the decomposition of sugar. If it is produced from grain, potatoes, etc., the starch is first converted into sugar, and this into alcohol and carbonic acid: the one a poison when taken into the stomach, the other a most deadly poison when inhaled.

In all the various forms of intoxicating liquors, the active agent is alcohol; and the effect of a given quantity of it is the same, whether in the concentrated form of distilled liquors, such as brandy, rum, gin, or whisky, or in the milder dilutions of fermented mixtures, such as wine, beer, cider, etc. In all these mixtures the fluids with which it is mixed serve only as solvents of the alcohol, and do not decompose it nor change its character.

365. Alcohol and Organic Substances. — Though alcohol produces its chief and most observable effect directly on the great nervous centers, yet there is an indirect action through the nutritive functions, which is too important to be overlooked. The chemical action of alcohol is to arrest or impede change in organic substances wherever it comes in contact with them.

Animal tissues may be preserved in alcohol for an indefinite period, so as to be entirely proof against the putrefactive process. Vegetable substances, also, may be preserved from decay indefinitely by immersion in alcohol. But the life processes, from the first stage of digestion to the completed work of transforming the tissues, is incessant change; and whatever interferes with this regular succession of chemical transformations, in the same proportion disturbs the vital functions and impairs health.

366. Alcohol is Indigestible. — The first effect of alcohol, when taken into the stomach, is to impair the capability of change in the food in the process of digestion, for digestion consists of a series of chemical changes. Beefsteak that has been macerated in alcohol for forty-eight hours is perfectly indigestible. Although the brandy taken at dinner impairs digestion while it is present in the stomach, yet a wise provision is made by which the stomach is soon relieved of its presence.

Alcohol is entirely indigestible, and does not pass with the chyme into the intestinal tube, but is instantly taken up by the absorbents and carried into the veins, and by way of the right side of the heart and pulmonary artery, it reaches the lungs and begins to escape with the breath exhaled. That which gives odor to the breath of one who drinks is, substantially, pure alcohol. A very small part of it has lost one-third of its hydrogen, and is converted into a compound which chemists have named *aldehyde.*

367. Alcohol impairs Chemical Change. — Though the odor of alcohol can be detected on the breath in a few minutes after it has been taken into the stomach, yet it is not all disposed of so soon, for the odor frequently remains on the breath for twenty-four hours. All this time the poison has been mixed with the blood, and passing the capillary circulation, it has produced its specific effect on the changes, so intimately connected with life itself, going on in this region of waste and repair. These changes consist in the oxidation of the carbon and hydrogen of the digested food, and the consequent evolution of animal heat and vital force.

That it really impairs all these actions and diminishes change in the capillaries, and consequently reduces the normal amount of vital force by which the nervous system is enabled to maintain the various voluntary and involuntary motions necessary to life, is no longer a matter of conjecture. It has been demonstrated that, under the influence of alcohol, the amount of carbonic acid exhaled from the lungs is diminished from thirty to fifty per cent.

368. Alcohol lessens Muscular Force.—This reduction of the chemical changes going on in the capillary circulation indicates a corresponding change in the brain force, as transmitted by way of the motor nerves to the muscles by which the various movements of the body are performed. This deduction of science has been fully demonstrated by repeated experiments, made by actual measurement of muscular power in the same individual under the influence of alcohol and without it. These experiments prove that the reduction of strength is very accurately measured by the diminution of carbonic acid from the lungs in breathing. This reduced supply of nervous force is soon apparent in the impaired powers of endurance, observed in those who use alcoholic drinks.

369. Alcohol causes a sense of heat.—The effect of alcohol on the animal heat is among the most curious of the physiological phenomena that attend its action on the living body. The diminished production of carbonic acid, when under the influence of alcohol, would suggest a reduced combustion in the body, and a corresponding reduction of temperature; but the testimony of the person under its influence is conclusive in the opposite direction; he avers that he feels warmer, and the flush of the blood in the superficial vessels appears to corroborate his testimony.

Liebig, the justly celebrated German chemist and physiologist, attempted to solve the mystery by supposing that the oxygen inhaled entered into combination with the alcohol, and thus produced heat without evolving vital force; but this solution will require an increased amount of carbonic acid in the breath, when, in fact, the quantity is diminished.

370. The Thermometer shows a reduction of Temperature.—But the mystery disappears at once when we appeal to the thermometer. A delicate thermometer placed under the tongue will show an unsteadiness in the temperature for the first fifteen or twenty minutes after taking four ounces of brandy. In some instances the temperature falls from the first, but in most cases there is an increase of heat, ranging from one-half to three-fourths of a degree, and continuing from ten to fifteen minutes; after which there is a reduction in temperature of two or three degrees, lasting for several hours, even while the face is flushed and the person affirms that he is warmer.

But common observation shows that he will freeze much quicker with than without the brandy. The flush of his face is the result of diminished action, suffering the blood to accumulate in the capillaries; and his sense of heat depends on perverted sensibility.

Recapitulation.

Narcotics operate as brain poisons. To this class belong alcohol, tobacco, opium, etc. Of these, alcohol is the most active. It is the active principle of all spirituous and fermented liquors.

When a given amount is taken, its effect is the same, whether concentrated or diluted.

The chemical action of alcohol on organic substances arrests change. This impairs digestion, and diminishes vital force. The sense of heat following the use of alcohol is the result of deranged sensibility.

LESSON XLVI.

BRAIN POISONS—CONTINUED.

371. Narcotic Poisons.—The direct action of alcohol, and other narcotic poisons, on the nervous system consists chiefly in diminished sensibility and its consequences. If the mouth be filled with a strong alcoholic liquor, such as brandy or whisky, and the same retained but a few minutes, it will be found that the sense of taste is nearly, if not entirely, destroyed for the time being.

The mucous membrane of the stomach is continuous with that of the mouth: it will, therefore, be similarly affected by like agents. Alcohol will produce a double effect on digestion: it will render the food less subject to change, and, therefore, more difficult of digestion; and it will so reduce sensibility in the nerves of the stomach that the imperfectly digested food will be suffered to pass the pyloric orifice into the intestinal canal, and a great portion of the food be lost, if nothing worse occurs from the presence of undigested food in the intestines.

372. Alcohol and the Digestive Function.—But this abuse of the stomach can not be long indulged in without permanently impairing the sensibility of that organ, and establishing the habit of imperfect digestion, if not inducing confirmed dyspepsia. The first effect of this impaired digestion is a demand for more food than would be required if digestion was perfect; for it is not the amount of food we eat that repairs the daily wastes of the body, but that which is digested and assimilated.

This increased demand for food after taking the "bitters" is often mistaken for a healthy appetite, and regarded as an indication of increasing tone and vigor in the digestive apparatus. If the alcohol be left off, the returning sensibility of the stomach will admonish the brain of the true condition of that organ, and its inability to digest food, and consequently it will refuse it, a loss of appetite being the result.

373. Alcohol impairs sensibility.—The diminished sensibility in the nerves of the stomach is not a local affection, but extends to the whole sentient apparatus. It is to this fact that alcohol owes most of its reputation as a medicine. It renders the patient insensible to pain, and he mistakes this insensibility for the cure of the disease, of which the pain was but the warning of a faithful sentinel. The insensibility to injury, of those who are intoxicated is very commonly noticed, and illustrates the effect of this poison on the very important function of sensation.

The general sense of feeling can not be impaired without the local senses suffering more or less. Of these the sense of vision early feels the effect of the poison, rather in a perversion of vision than in a loss of sight. To intoxicated persons, things often appear double, and frequently things at rest appear to be in motion. The sense of hearing is less affected by alcohol than the other senses, and yet the long continued use of the poison often seriously impairs that faculty.

374. Exhilaration.—The feeling of exhilaration, which is generally mistaken for exalted sensibility, is, in fact, the result of a partial paralysis of the sentient extremities of the nerves. The vital force, by the movement of which sensation is carried on, being withdrawn from the nervous expansions, is concentrated on the great nervous centers, thus manifesting the disturbed equilibrium of nervous force rather than an increase of it.

The phenomenon of exhilaration can be studied better in the inhalation of chloroform, or nitrous oxide, than in the slower process of administering narcotics by the stomach. The exhilaration is the same, and in either case the power to feel impressions made on the sentient nerves is diminished from the beginning; and, if carried far enough, terminates in total insensibility, unconsciousness, and, finally, in death.

375. Fascinating influence of Alcohol.—This exhilaration, always tending toward insensibility and unconsciousness, is that which renders alcohol so fascinating and so dangerous a poison. Its first effect is to render the victim unfit to judge of his own condition, of the nature and situation of things around him, or of his relations to these surroundings. Through the medium of the general nervous sensibility, we determine our condition of body and mind: through this medium we are conscious of our own powers, and determine, with a good degree of accuracy, the physical, mental, and moral possibilities and duties of our situation. But the moment we place ourselves under the exhilarating influence of alcohol, and in the exact ratio in which that influence affects us, we lose this power. Our judgment of ourselves, of our powers, and of our duties, is distorted and false, and this false judgment may lead us to ruin our health, corrupt our morals, and alienate our friends.

376. The Action of Alcohol.—There are several fallacies connected with the too common indulgence in alcoholic exhilaration, which demand exposure for the good of the young and the unguarded. There is an idea, widely entertained, that the effect of alcohol as seen in the furious, or the insensible state of drunkenness, differs *in kind* from the exhilaration produced by a single glass of wine. This is not true. The action of alcohol on the nervous system is a *unit:* it is diminished sensibility, manifesting itself in exhilaration, and this is drunkenness *in kind*, whatever the degree may be; and the exhilaration itself disqualifies the victim of it from judging of the degree. Hence, it follows that a man who has taken alcohol, and is under its influence, is drunk to that extent, but how *much* he is drunk he is not competent to know.

377. The Danger of the Poison.—This last fact is a significant one, and solves the most profound social mystery of the past ages as well as of the present. It is this: Young men see the ruin of health, morals, fortune, character, and domestic happiness in the hundreds of their acquaintances, who go down to early and dishonored graves, victims of the drinking habits of society, and yet they venture to travel the same dangerous road, when one of positive safety is open to their choice.

They do not understand that the danger lies in taking the poison, but suppose that it is in taking *too much*—an evil which they resolve always to avoid. But not understanding the nature of alcohol, nor knowing that to indulge in its exhilaration is, to that extent, to surrender the means of self-knowledge, and consequently of self-control, they move steadily on to ruin. A knowledge of the physiological effect of narcotics, and correct habits of life established on that basis, are the only safeguards against their fascinations.

378. The Moderate Use of Alcohol.—The habitual use of alcoholic drinks, even though the quantity indulged in does not produce such drunkenness as will disqualify the subject for the ordinary business of life, will yet leave the unmistakable traces of its effects in a diseased condition of the brain and nervous system. Sensibility in all the organs of the body will be more or less blunted; the power to resist disease, and the ability to restore to healthy action the morbid condition of any organ or function, will be greatly impaired, the whole nutritive system will be found the subject of more or less derangement, and the force and endurance in the muscular system will feel the effect of the poison in a great diminution of its energy. Taken in this manner, it is a slow but very sure poison.

Recapitulation.

Narcotics render the food less subject to change, and, therefore, more difficult of digestion. Alcohol impairs sensibility in all the organs. The exhilaration produced by alcohol is the result of diminished sensibility in the nervous system. This disqualifies the person to judge of his condition. Drunkenness differs in degree, but not in kind. The moderate use of alcohol is a dangerous delusion.

LESSON XLVII.

BRAIN POISONS — CONTINUED.

379. Effects of Alcohol on the Mind.—The effects of alcoholic drinks on the mental powers are among the most ruinous, as they are the most prominent of its morbid influences. Exhilaration is disturbed equilibrium of nervous force, with a constantly progressing diminution of the aggregate of that force, ending in insensibility and delirium, and, finally, in unconsciousness.

While the powers of imagination are momentarily exalted, and the command of language is greater, the judgment is impaired, the power of perception is blunted, and the reasoning faculties are rendered unreliable. With these derangements of the purely intellectual faculties, the passions are excited to morbid activity; and especially those of the grosser kind, being released from the restraint of the intellectual faculties and moral sensibilities, lead their victim into every species of debauchery and crime.

380. Alcohol destroys Mental Harmony.—In the human constitution, the intellectual powers, the animal appetites, the passions, and the moral affections are so adjusted that when a healthy balance of power is maintained among them, and a proper subordination observed, the result is the harmony of the whole group, bringing the highest happiness to the individual and the greatest good to society.

The universal testimony of all ages, and every form of civilization, is, that the use of alcohol has everywhere disturbed this nicely adjusted balance, and destroyed the equilibrium among these powers, bringing ruin on society, destruction on nations, and misery to its immediate victims, and to the domestic circle in which they moved. These disastrous results attract attention most where the poison is used in large quantities, but the effect is the same in kind, and is always in proportion to the quantity taken, other things being equal.

381. Effects of Brain-poisoning.—The immediate effects of alcohol are temporary, and if the quantity taken be not very large, the disturbances pass off as soon as the alcohol can be discharged from the circulation by the lungs and other organs, and the nerves recover from its paralyzing influence. Fortunately, the poison is volatile, and its vapor passes through the membranes and other tissues of the body with scarcely any obstruction. From this cause, death seldom results immediately from alcoholic poisoning; but the secondary effects of the poison remain in a train of deranged physical functions and impaired or disturbed mental powers.

The effect of alcohol on albumen is to coagulate it. Now, the brain consists largely of albumen, and alcohol acts on it as it does on the white of an egg, which is nearly pure albumen: it hardens it, and thus destroys its delicate texture, and proportionally impairs all its functions. This effect has long been observed in the brains of habitual drunkards.

382. Alcohol invites Disease.—The membrane which forms the walls of the air-cells in the lungs, as well as that which makes the fine capillary tubes of the pulmonary circulation, is highly albuminous in its character. The effect of alcohol is to thicken these membranes, and thus interrupt the easy transmission of oxygen to the blood and of carbonic acid from it. This effect on the respiratory organs will usually relieve itself in a few days, but in the meantime the vital force is diminished with the reduced supply of oxygen, and the power to resist disease is greatly impaired.

From this cause, those who use alcoholic drinks are more liable to be attacked with epidemic diseases than those who abstain. If the use of the poison becomes habitual, this effect, both on the brain and respiratory organs, will be rendered permanent, and the impaired health and obtuse intellect will be entailed on the victim.

383. Moral Effects of Brain-poisoning.—The impressions left on the mental and moral powers by long and frequent indulgence in the use of alcohol may be resolved into two classes: first, those arising from an enfeebled will-power; and, second, those springing from obtuse moral perceptions. Among the first results of even moderate drinking habits, we notice the loss of self-control. If the friends of the victim expostulate with him, and bring to his blunted and obtuse sensibilities a perception of his danger, he betrays a vacillating will—an inability to take a firm stand and guide his future course in the path of absolute sobriety.

This inability of self-control gives rise to irregular and fitful moods of life, and betrays a want of confidence on the part of the victim, in his ability to carry out any good resolve which he may make. This weakening of the will-power betrays itself in the persistent drinking habits of those who are fully convinced of the ruin on which they are surely drifting, as well as in the numerous failures resulting from attempts at reformation.

384. Diminished Will-power.—The force of this drinking habit, of which so much has been said, resolves itself chiefly into this feeble will-power. If we diminish the ability to resist a force, we do, practically, the same thing as if we had increased that force. There is little doubt but this is merely a symptom indicating the diseased condition of the brain, present in the victim of the poison.

While the unfortunate man of drinking habits may not be able to carry into action any good resolve, or guide his life to any virtuous end on account of an actually diseased condition of the brain, yet he is morally responsible: his very disease is a crime—the crime of his youth. All either know or should know that alcohol is a poison, producing these effects, and to use it is to incur the consequences.

385. Blunted Moral Sensibility.—Perhaps the effect of alcohol which is most to be deplored, is that which is exerted on the moral sensibilities. More than half the crimes that are committed in this country, are either perpetrated under the immediate influence of alcoholic delirium, or may be traced directly to the blunting and paralyzing influence of the criminal's drinking habits.

The nice perceptions of right and wrong, and the conscientious regard for the obligations of duty, are so impaired that the person who habitually takes the poison can stoop to low and dishonorable acts, or even to the commission of crimes, at which his moral sensibilities would have revolted when free from the degrading influence of the poison. The social vices, such as gambling, licentiousness, etc., if not the direct outgrowth of the drinking habits of society, are, at least, fostered by, and associated with these habits.

386. How far these Derangements may be Cured.— After these injuries are inflicted on the brain and its appendages, the prospect of a permanent cure is very remote. If the patient be placed beyond the reach of the poison, as in an inebriate asylum, or be sustained by the encouraging council and sympathy of friends, and especially if he be kept constantly employed, he may, to some extent, restore a healthy action to the brain and reclaim its lost powers, but he is never safe. His impaired will-power is never restored to its original integrity. His only safety is in keeping beyond the reach of the poison.

All experience proves that it is not safe for him to taste alcohol, even as a medicine. Here, as in other diseased conditions, the true policy is to prevent rather than cure, and, fortunately in this case, certain prevention is within easy reach of every one. It is simply not to drink alcohol in any form.

Recapitulation.

Alcohol deranges the whole mental machinery, and destroys harmony of action between the mental and moral powers. Its immediate effects are temporary; but, if the habitual use of alcohol be established, the derangement will become permanent. The loss of self-control is among the first effects of drinking habits. Moral sensibilities are impaired by the use of alcohol. How far this diseased condition is curable.

LESSON XLVIII.

TOBACCO.

387. Tobacco—its mode of Poisoning.—Tobacco is among the most powerful of the narcotic poisons which the vegetable kingdom affords. It differs from alcohol, however, in many particulars, which modify its effects on those who use it. As alcohol is the active poison in all the various forms of intoxicating drinks, so *nicotine* is the exhilarating agent in tobacco, whether it be chewed, smoked, or taken as snuff. This nicotine is an alkaline principle, volatile at a high heat; but, at ordinary temperatures, it is not converted into vapor in any sensible quantities, and, therefore, does not penetrate the membranes and pervade the tissues of the whole body as alcohol does; and on this account its narcotic effects are slowly developed.

In addition to its exhilarating effect, nicotine is directly emetic, even when the poison is not taken into the stomach, but absorbed by the skin. While the paralyzing effects of alcohol begin with the nerves of sensation, the action of tobacco is primarily on the nerves of motion, diminishing the contractile force of the muscles.

388. Effect of Tobacco on Digestion.—From these characteristics, we will be prepared to learn that tobacco produces its disturbances among the nervous and vital functions slowly, and often without the cause of these disturbances being suspected.

We have already alluded (§ 269) to the effect of the use of tobacco on the saliva, and its influence on the perfect digestion of food, and we have only to add in this place, that, in common with all narcotics, tobacco has a tendency to prevent change in the composition of organic substances, although this tendency is feeble compared with that of alcohol.

The proportion of the food digested in the stomach of those who use tobacco, compared with the digestive action of those who do not use it, nor any other narcotic, is greatly in favor of the latter class, other things being equal.

389. Tobacco diminishes the Desire for Food.—The specific effect of tobacco on the stomach, tending more or less toward nausea, has the effect to diminish the desire for food; and though the rate at which the tissues are transformed is perceptibly diminished, yet leanness, and sometimes emaciation, result from the use of tobacco. Perhaps it was this peculiar effect of tobacco which first prompted its use among savages (who were subject to great irregularity in the supply of food), that they might endure starvation without suffering the pain of hunger.

The ultimate effect of tobacco, however, is to slowly reduce the aggregate of the vital force, impairing first the motor functions of the nervous system, affecting the involuntary motions more directly than the voluntary. The senses most seriously affected by the use of this poison are taste and smell, but this is probably owing to the local action in the method of using it.

390. Strength of the Tobacco Habit.—The feeling of exhilaration from the use of tobacco is hardly perceptible until its action is withdrawn, when a sense of irritability and indescribable wretchedness takes possession of the victim of the poison, and will not yield to any terms till the exhilaration is restored. Where the habit is of long standing, and the quantity used is large, the feeling of irritability on being deprived of it sometimes amounts to actual insanity for the time being.

The habit, from this cause, is even more inveterate than that of using alcoholic drinks, and the power of voluntary control over the habit appears to be as completely paralyzed by tobacco as by the more powerful narcotics. No one is sensible of the effects of tobacco on the nervous system till he has abandoned the use of it, and so far recovered from its effects as to have lost the desire for its peculiar exhilaration.

391. Effect of Tobacco on the Mental Functions.—Tobacco exerts its characteristic influence on the intellectual functions. Its action is slow, and its exhilaration at any time almost imperceptible; but in a series of years it works most disastrous consequences, impairing first the power of decision—the will-power; after that, the memory feels its effects, the finer moral feelings are blunted, and the mental perceptions—the powers of abstract thought—are impaired, and the whole mental fabric, slowly undermined, falls into ruin.

So stealthy is its approach, so insidious its march, that neither the victim nor his friends suspect the cause of his feeble health and failing mind; and even when the faithful physician has the sagacity to detect the cause, and professional honor enough to tell the whole truth without concealment, the chances are greatly against the patient's being able to exercise self-control enough to apply the proper remedy—the entire disuse of the poison in every form.

392. Duration of human Life affected by Tobacco.—Though tobacco is so active, and so virulent a poison, yet it is rarely the immediate and direct cause of death; and it has even been affirmed by good physiologists that its use has not diminished the average duration of human life. This does not follow, however, from the fact by which it is sought to be established.

If the duration of human life now is as great as it was two hundred years ago, or before tobacco came into general use, it must be remembered that the average comfort and protection of man has greatly increased, and his knowledge of the laws of health and his means of controlling diseases, have been greatly advanced in that period; and if human life has not been correspondingly prolonged, there must be some counteracting cause. May not that cause be found in the use of alcohol and tobacco?

393. Early Decay, one of the Effects of Tobacco.—Whatever may be the influence of tobacco on the health and vital force of those who lead lives of muscular activity in the open air, there can be no question of its pernicious effects on persons of sedentary habits, and especially on those devoted to mental pursuits.

The victim of the tobacco poison makes an apology for the use of his cigar by declaring that it gives force and clearness to his mental operation, and yet he does not perceive that even that apology is an admission of the fearful effects of the poison on brain action. If a man has so reduced his brain-power that it is necessary to cut off the vital force from the nervous extremities, in order to supply the force for efficient brain action, he is certainly on the road to mental imbecility and physical decrepitude. There is no doubt but that thousands destroy years of their ripest usefulness, and induce imbecility and second childhood, by the habit of using tobacco.

394. Opium — its peculiarities as a Poison.—Opium has long been used in China and Japan as alcohol and tobacco are used in Europe and America. Within the last half century, the use of opium as an exhilarant has been increasing with alarming rapidity in this country.

It is a narcotic, less diffusible than alcohol, but more active than tobacco, in the ordinary modes of its use. It is equally as fascinating in its influence as either of those poisons; and the fact that it may be used for years and yet its use kept a secret, gives it a power that neither of those can exert. Tobacco and alcohol betray their victims, but opium keeps the secret for them till it binds them so securely in its fetters that escape is almost impossible. Safety is found only in firmly discarding the use of all narcotics, except when absolutely demanded in acute disease.

Recapitulation.

Tobacco is a less volatile poison than alcohol. Its effect on the saliva impairs digestion, and the tendency to induce nausea diminishes the desire for food. The exhilaration from tobacco is feebler than that from alcohol; but, when the habit is formed, the desire for it is equally strong. Tobacco slowly, but very certainly, impairs all the mental functions of the brain, and produces early decay and premature old age. Opium, as an exhilarant, stands intermediate between alcohol and tobacco. Its use is more easily concealed than is the use of alcohol or tobacco.

LESSON XLIX.

BRAIN EXERCISE AND REST.

395. Early failure of Mental Faculties.—The brain, as the instrument of thought, acquires power and tact by exercise and judicious use. This aptitude is much more readily acquired when the brain action is regular and habitual. Persons who have accustomed themselves to exercise the mind in thought under certain circumstances, or in connection with certain movements of the body, will find it very difficult to bring all their mental powers to bear under different circumstances.

The duration of mental activity, or the period of life when mental force begins to fail, is a subject which is attracting much attention, both on account of its intrinsic importance, and because that in different persons this decrepitude of old age appears at periods so widely different. Much of this may depend on hereditary constitutional peculiarities, but more will be found to be connected with the modes of mental training.

Minds not trained to think soon fall into decay; and those in which the training has been confined to a few faculties, and in which all the others have been neglected, fail early in life. A broad and general training of all the faculties, and the uniform exercise of them, will secure the greatest exemption from the mental infirmities of age, other things being equal.

396. Brain rest — its necessity in brain labor. — But brain activity demands rest, as activity everywhere in the vital machinery calls for its period of repose. The powers of thought may be relieved somewhat by changing the mode of thought, and transferring the mental activity to other channels; but actual brain rest is obtained only in sound sleep.

The notion which was so popular a few years ago, that students and brain-workers in general require but little sleep, is not only false but most pernicious in its consequences on the student who reduces it to practice. The romance of the "midnight lamp" has been a very expensive luxury, dimming many of the brightest stars of human genius.

397. Sleep should be in proportion to brain activity. — Sleep should be periodical and habitual, if we would derive the greatest benefit from it as a restorer of wasted brain force. As activity naturally associates itself with light, so the repose of sleep is associated with darkness; and as the day of twenty-four hours is nearly equally divided (taking the whole year together) between light and darkness, there is a very suggestive hint as to the proper proportion of time to be devoted to rest. This will depend very much, however, on the intensity of brain action.

If the mind could be trained to endure twelve consecutive hours of labor, the succeeding twelve hours should be devoted to sleep, in order to repair the waste of such a protracted effort. But such prolonged activity is possible in but few persons; and even where it is possible, it is bad economy. With the best trained and disciplined thinkers, about two hours of close application is the extent of time which can be economically employed without an interval of relaxation.

398. Wakefulness—its effect and its remedy.—The student whose life is properly divided between activity and rest, will find that from eight to ten hours of quiet, sound sleep will be sufficient to maintain the highest mental vigor. Persons of irritable, nervous systems and of studious habits often fail to sleep soundly. This wakefulness may be generally overcome by establishing and rigidly maintaining the habit of retiring and rising at certain hours.

A firm mattress, a well ventilated bedroom, a light and early supper, and a cold sponge bath before lying down, will seldom fail to procure sound sleep. The habit of sleeping at intervals during the day, and especially the regular after-dinner siesta, greatly interferes with the sound and refreshing quality of the night's repose. Sleep can never be refreshing while the stomach is engaged in the business of digestion, and for this reason we should never eat within two hours of our time of retiring.

399. Light—its effect on brain activity.—Carefully conducted experiments have established the principle that sleep is more invigorating when the sleeper is in the dark than in sunlight; and, conversely, that activity is best sustained in sunlight, either direct or diffused. These are truths too intimately connected with health to be neglected with impunity. Sunshine exerts a strange force on brain activity, augmenting the power with which the whole vital machinery operates.

Persons who work in mines by means of artificial light, and those who live in badly lighted apartments, soon show the effects of this want of sunshine in the reduced color of the blood, the general relaxation of the muscular system, and the diminished mental activity.

400. Best Time for Sleep.—In securing the number of hours of sleep which we propose, the time of retiring should be fixed so that sleep will not trespass on the sunlight of the morning. One hour in the morning is worth more for mental labor than two hours after ten o'clock in the evening. To retire early and rise at daylight is the order of nature, and they who violate it will, sooner or later, pay the penalty. Late and irregular hours, inducing dreamy slumber rather than sound sleep, will dissipate brain force, and destroy both mental vigor and physical health.

401. Reduction of Vital Force in Sleep. — Sound, refreshing sleep is a state of absolute inaction of all the voluntary functions, and of entire unconsciousness with regard to ourselves or our surroundings. The involuntary functions sympathize with this state of rest, and the force expended in their performance is materially reduced. The circulation becomes slower, the pulse softer and less forcible, and the breathing is neither so full nor so frequent.

This reduction of vital action during sleep brings several important suggestions. In sleep we are more susceptible to the action of external agencies which tend to produce disease than when awake, and therefore we should be careful to guard against them.

Sleeping apartments should be well supplied with fresh air, but its introduction should be so arranged that the sleeper will not be in the direct current, or draft. The production of animal heat is reduced during repose, and on this account the sleeper should be protected by sufficient covering to secure comfort.

402. Procuring Sleep by Medicine. — Among the many errors with regard to sleep, none is more mischievous than the habit of resorting to medicine to relieve sleeplessness. Anodynes and narcotics never produce natural, refreshing rest; and the disturbance in the nervous system, left as the result of the remedy, is generally more injurious than the wakefulness it was intended to relieve.

The most dangerous effect to be dreaded in such use of medicine, is the necessity of repeating and even increasing the dose till the habit becomes too strong to be broken. But it is especially in behalf of infants that we enter our solemn protest against the whole family of anodynes, cordials, soothing syrups, etc. No human power of computation can measure the mischief done to helpless humanity in this way while yet in the cradle.

Recapitulation.

The duration of the period of mental activity is dependent on a variety of causes. Uncultivated minds fail at an earlier period than those properly trained. Sleep necessary to maintain mental vigor. It should be periodical, and reduced to a habit. Wakefulness—its remedy. Sleep should be in the night, and should be a state of absolute unconsciousness. Rest should not be procured by anodyne medicines.

LESSON L.

ACCIDENTS AND DISEASES.

403. Injuries from Accident. — It has been the object of these lessons to communicate such a knowledge of the laws of life as will put the student in possession of the means of preserving health and vigor under all ordinary circumstances. But with our present surroundings we are liable to injuries from accidents and casualties, which no prudence or foresight can avoid; and even diseases may attack us, that no inherent vigor of health or vital force will be sufficient to throw off.

If, as has been said, "good health is not only a blessing, but a duty," it must be admitted to be, sometimes, a duty very difficult of performance. It is important, therefore, that every body should understand something of the management of the minor accidents to which mankind is subject, and how to treat the slighter disturbances of health so as to prevent them from passing into the more formidable types of disease.

404. Bleeding from Wounds. — In a majority of cases of minor accidents or of threatened disease, it is not so difficult to know what should be done as what should not be done. One of the great difficulties in these cases is to manage the ignorant officiousness of kind and benevolent persons, who often do immeasurable mischief when prompted by the very best of motives.

In all cuts or wounds made by sharp instruments, the first thing that demands attention is the bleeding. If the blood flows rapidly and in jets, we will understand that an artery is injured, and our business is to make pressure on the bleeding vessel near the wound, on the side toward the heart, by the best means that we can devise. Having thus temporarily arrested the bleeding, a surgeon should be obtained immediately, and the artery secured by a ligature. If the injured vessel be on the scalp, it may be permanently closed by continued pressure.

405. Treatment of Cuts by sharp instruments.—If, however, the bleeding be in a regular, constant stream, we may be assured that the blood is flowing from a vein or veins. In this case nothing more is necessary than to apply cold water freely until the bleeding has abated, when the edges of the wound should be carefully drawn together and secured, in actual contact with each other, by strips of adhesive plaster; and where the parts admit of it, the dressings should be supported by a light bandage, applied with only a moderate degree of tightness. This dressing should not be removed for five or six days, but may be frequently wet with cold water. All that is necessary is that the divided edges be maintained in contact, with nothing between them, and that the air be carefully excluded from the injured part.

That is a mischievous error which supposes that salves, ointments, and stimulating applications have healing virtues. Injuries of this kind can be repaired only by the vital force producing new cells, and with these uniting the divided tissues and thus repairing the injury.

406. Bruises and Burns—how treated.—In bruises and lacerated wounds, the exclusion of the air and the application of cold water, to keep down excessive inflammation, together with absolute freedom from motion in the parts, comprise all that is necessary to be done. After suppuration has commenced, the wound should be frequently washed with tepid water, and the parts supported by an appropriate bandage.

In burns and scalds where the cuticle has been removed, and a large surface of the true skin exposed, the important matter is to secure protection from the air. This may be done by saturating cotton batting or some other soft substance with glycerine, or oil of any kind that is not rancid or stimulating. The object is to substitute for the cuticle something that will protect the sentient extremities of the nerves from exposure, which is the cause of the excruciating pain of burns.

407. The approach of Acute Diseases.—Fevers, and most acute diseases, are preceded by a sense of languor, an indisposition to activity, and a loss of appetite. Admonished by these symptoms, the body should be sponged with tepid water so as to thoroughly relieve any mechanical obstruction of the perspiratory pores. This should be followed by brisk friction with a flesh-brush or rough crash towel till a glow of heat is felt over the surface of the skin.

Follow this with absolute quiet, both of body and mind, and limit the food to gruel, beef tea, or thin porridge, taking even these only as the appetite calls for them. If twenty-four hours of this treatment brings no relief, your physician should be consulted. Avoid all excitants, stimulants, or exhilarants, and resist all persuasions to take solid food when the appetite admonishes you of the inability of the stomach to digest it.

408. Diarrhea and Habitual Costiveness.—In warm weather, it frequently occurs that the perspiration is suddenly checked, and the fluids thrown to the internal surface produce a troublesome diarrhea. All that is necessary in this condition, in ordinary cases, is to use the tepid bath and flesh-brush, drink copiously of slippery-elm water, or flaxseed tea, and abstain from solid food and from all nostrums which promise to cure bowel complaints.

Some persons are much troubled with habitual constipation of the bowels. Diet and exercise are the remedies for this troublesome condition. Bread made of unbolted flour, with a free use of succulent vegetables and ripe fruits, will seldom fail to relieve the most stubborn case of costiveness, if the patient takes sufficient exercise in the open air.

409. Selection of a Physician.—But few duties devolve on the heads of families more important, and, to most persons, more difficult, than the selection of a family physician. This difficulty is greatly increased by the fact that people in general, though well educated, and intelligent on other subjects, know but little of the physiological laws underlying the whole subject of health.

A physician should, first of all, be possessed of a large endowment of common sense and moral honesty. To these indispensable qualities should be added a thorough knowledge of medical science in all its departments, and a well-trained faculty of close observation and patient investigation of the phenomena of health and disease, as they will be presented to him in his daily routine of business.

Firmness and decision are traits of character which will be largely in demand in his daily intercourse with the sick. The impudence of quackery, the ignorant officiousness of well-meaning friends, and the vacillating indecision of the sick, demand that, for the safety of the patient and the maintenance of his own good name and clear conscience, the physician should exercise an unfaltering firmness.

410. Medicines—their use and abuse.—Among the most pernicious ideas which have possessed the public mind, is the notion that health may be disregarded, since we have medicines to cure all the diseases our recklessness may induce. Let the public learn that medicine is always an evil—a great evil, though it may be necessary in order to obviate a greater evil.

One of the most unaccountable traits in the character of modern society is the propensity to swallow drugs, and to be deluded by the boastful pretensions of ignorant venders of nostrums, warranted to cure all diseases, restore shattered constitutions, and be a perfect substitute for a careful observance of the laws of health. The faithful physician has no higher duty to perform, than to properly inform the public mind on this subject and correct these fearful abuses. But this demands a large share of moral honesty and self-denial, for the ill health of the country, which gives him his business, is largely the result of this ignorant and indiscriminate use of medicines.

411. Preservation of Health a Moral Duty.—There is a moral obligation resting on every one to preserve and maintain the highest health that is attainable, both of body and mind. God has created us for the discharge of important duties in life, and the fulfillment of this Divine purpose depends on the health that will give us ability equal to the task. Within certain limits, the means of health are placed in our own hands, and we can not, ignorantly or recklessly, disregard its conditions without incurring guilt.

We have no more right to render our life a failure than we have to commit suicide. Moreover, the laws of life and health are Divine laws, emanating from the wisdom and benevolence of the Creator, and to violate them is rebellion against his authority. Our own happiness, the greatest good of society, and our regard for the Divine authority, all conspire to demand of us a thorough knowledge and faithful observance of the Laws of Health.

Recapitulation.

Accidental injuries are unavoidable, therefore every person should have some knowledge of their treatment. Bleeding from an artery can be arrested only by a ligature. Cuts from sharp instruments require simple dressings. In burns and scalds the surface must be protected. The selection of a physician is a difficult and responsible task. Medicines, though sometimes necessary, are always to be regarded as evils.

INDEX.

INDEX.

Frank Jewett

Frank S

Frank Jewett