Aaron Bernstein

Popular Books on Natural Science

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Содержание

Aaron David Bernstein
Popular Books on Natural Science / For Practical Use in Every Household, for Readers of All Classes

POPULAR TREATISE ON NATURAL SCIENCE

"In primis, hominis est propria VERI inquisitio atque investigatio. Itaque cum sumus negotiis necessariis, curisque vacui, tum avemus aliquid videre, audire, ac dicere, cognitionemque rerum, aut occultarum aut admirabilium, ad benè beatéque vivendum necessariam ducimus; – ex quo intelligitur, quod VERUM, simplex, sincerumqe sit, id esse naturæ hominis aptissimum. Huic veri videndi cupiditati adjuncta est appetitio quædam principatûs, ut nemini parere animus benè a naturâ, informatus velit, nisi præcipienti, aut docenti, aut utilitatis causâ justè et legitimè imperanti: ex quo animi magnitudo existit, et humanarum rerum contemtio."

Cicero, de Officiis, Lib. 1. § 13.

Before all other things, man is distinguished by his pursuit and investigation of TRUTH. And hence, when free from needful business and cares, we delight to see, to hear, and to communicate, and consider a knowledge of many admirable and abstruse things necessary to the good conduct and happiness of our lives: whence it is clear that whatsoever is TRUE, simple, and direct, the same is most congenial to our nature as men. Closely allied with this earnest longing to see and know the truth, is a kind of dignified and princely sentiment which forbids a mind, naturally well constituted, to submit its faculties to any but those who announce it in precept or in doctrine, or to yield obedience to any orders but such as are at once just, lawful, and founded on utility. From this source spring greatness of mind and contempt of worldly advantages and troubles.

PART I.
THE WEIGHT OF THE EARTH

CHAPTER I.
HOW MANY POUNDS THE WHOLE EARTH WEIGHS

Natural philosophers have considered and investigated subjects that often appear to the unscientific man beyond the reach of human intelligence. Among these subjects may be reckoned the question, "How many pounds does the whole earth weigh?"

One would, indeed, believe that this is easy to answer. A person might assign almost any weight, and be perfectly certain that nobody would run after a scale, in order to examine, whether or not an ounce were wanting. Yet this question is by no means a joke, and the answer to it is by no means a guess; on the contrary, both are real scientific results. The question in itself is as important a one, as the answer, which we are able to give, is a correct one.

Knowing the size of our globe, one would think that there was no difficulty in determining its weight. To do this, it would be necessary only to make a little ball of earth that can be accurately weighed; then we could easily calculate how many times the earth is larger than this little ball; and by so doing, we might tell, at one's finger-ends, that – if we suppose the little earth-ball to weigh a hundred-weight – the whole globe, being so many times larger, must weigh so many hundred-weights.

Such a proceeding, however, would be very likely to mislead us. For all depends on the substance the little ball is made of. If made of loose earth, it will weigh little; if stones are taken with it, it will weigh more; while, if metals were put in, it would, according to the kind of metal you take, weigh still more.

If, then, we wish to determine the weight of our globe by the weight of that little ball, it is first necessary to know of what our globe consists; whether it contains stones, metals, or things entirely unknown; whether empty cavities, or whether, indeed, the whole earth is nothing but a hollow sphere, on the surface of which we live, and in whose inside there is possibly another world that might be reached by boring through the thick shell.

With the exercise of a little thought, it will readily be seen that the question, "How much does our earth weigh?" in reality directs us to the investigation of the character of the earth's contents; this, however, is a question of a scientific nature.

The problem was solved not very long ago. The result obtained was, that the earth weighs 6,069,094,272 billions of tons; that, as a general thing, it consists of a mass a little less heavy than iron; that towards the surface it contains lighter materials; that towards the centre they increase in density; and that, finally, the earth, though containing many cavities near the surface, is itself not a hollow globe.

The way and manner in which they were able to investigate this scientifically, we will attempt now to set forth as plainly and briefly as it can possibly be done.

CHAPTER II.
THE ATTEMPT TO WEIGH THE EARTH

It is our task to explain, by what means men have succeeded in weighing the earth, and thus become acquainted with the weight of its ingredients.

The means is simpler than might be thought at the moment. The execution, however, is more difficult than one would at first suppose.

Ever since the great discovery of the immortal Newton, it has been known that all celestial bodies attract one another, and that this attraction is the greater, the greater the attracting body is. Not only such celestial bodies as the sun, the earth, the moon, the planets, and the fixed stars, but *all* bodies have this power of attraction; and it increases in direct proportion to the increase of the mass of the body. In order to make this clear, let us illustrate it by an example. A pound of iron attracts a small body near by; two pounds of iron attract it precisely twice as much; in other words, the greater the weight of an object, the greater the power of attraction it exercises on the objects near by. Hence, if we know the attractive power of a body, we also know its weight. Nay, we would be able to do without scales of any kind in the world, if we were only able to measure accurately the attractive power of every object. This, however, is not possible; for the earth is so large a mass, and has consequently so great an attractive power, that it draws down to itself all objects which we may wish other bodies to attract. If, therefore, we wish to place a small ball in the neighborhood of ever so large an iron-ball, for the purpose of having the little one attracted by the large one, this little ball will, as soon as we let it go, fall to the earth, because the attractive power of the earth is many, very many times greater than that of the largest iron-ball; so much greater is it, that the attraction of the iron-ball is not even perceptible.

Physical science, however, has taught us to measure the earth's attractive power very accurately, and this by a very simple instrument, viz., a pendulum, such as is used in a clock standing against the wall. If a pendulum in a state of rest – in which it is nearest to the earth – is disturbed, it hastens back to this resting-point with a certain velocity. But because it is started and cannot stop without the application of force, it recedes from the earth on the other side. The earth's attraction in the meanwhile draws it back, making it go the same way over again. Thus it moves to and fro with a velocity which would increase, if the earth's mass were to increase; and decrease, if the earth's mass were to decrease. Since the velocity of a pendulum may be measured very accurately by counting the number of vibrations it makes in a day, we are able also to calculate accurately the attractive power of the earth.

A few moments' consideration will make it clear to everybody, that the precise weight of the earth can be known so soon as an apparatus is contrived, by means of which a pendulum may be attracted by a certain known mass, and thus be made to move to and fro. Let us suppose this mass to be a ball of a hundred pounds, and placed near a pendulum. Then as many times as this ball weighs less than the earth, so many times more slowly will a pendulum be moved by the ball.

It was in this way that the experiment was made and the desired result obtained. But it was not a very easy undertaking, and we wish, therefore, to give our thinking readers in the next chapter a more minute description of this interesting experiment, with which we shall for the present conclude the subject.

CHAPTER III. DESCRIPTION OF THE EXPERIMENT TO WEIGH THE EARTH

Cavendish, an English physicist, made the first successful attempt to determine the attractive power of large bodies. His first care was, to render the attraction of the earth an inefficient element in his experiment. He did it in the following way:

On the point of an upright needle he laid horizontally a fine steel bar, which could turn to the right and left like the magnetic needle in a compass-box. Then he fastened a small metallic ball on each end of the steel bar. The balls were of the same weight, for this reason the steel bar was attracted by the earth with the same force at both ends; it therefore remained horizontal like the beam of a balance, when the same weight is lying in each of the scales. By this the attractive force of the earth was not suspended, it is true; but it was balanced by the equality of the weights. Thus the earth's attractive power was rendered ineffective for the disturbance of his apparatus.

Next he placed two large and very heavy metallic balls at the ends of the steel bar, not, however, touching them. The attractive force of the large balls began now to tell; it so attracted the small ones that they were drawn quite near to the large balls. When, then, the observer, by a gentle push, removed the small balls from their resting-place, the large ones were seen to draw them back again. But as the latter could not stop if once started, they crossed their resting-point, and began to vibrate near the large balls in the same manner as a pendulum does, when acted upon by the attractive force of the earth. Of course this force was exceedingly small, compared with that of the earth; and for that reason the vibrations of this pendulum were by far slower than those of a common one. This could not be otherwise; and from the slowness of a vibration, or from the small number of vibrations in a day, Cavendish computed the real weight of the earth.

Such an experiment, however, is always connected with extraordinary difficulties. The least expansion of the bar, or the unequal expansion or contraction of the balls, caused by a change of temperature, would vitiate the result; besides, the experiment must be made in a room surrounded on all sides by masses equal in weight. Moreover, the observer must not be stationed in the immediate neighborhood, lest this might exercise attractive force, and by that a disturbance. Finally, the air around must not be set in motion, lest it might derange the pendulum; and lastly, it is necessary not only to determine the size and weight of the balls, but also to obtain a form spherical to the utmost perfection; and also to take care that the centre of gravity of the balls be at the same time the centre of magnitude.

In order to remove all these difficulties, unusual precautions and extraordinary expenses were necessary. Reich, a naturalist in Freiberg, took infinite pains for the removal of these obstacles. To his observations and computations we owe the result he transmitted to us, viz.: that the mass total of the earth is nearly five and a half times heavier than a ball of water of the same size; or, in scientific language: The mean density of the earth is nearly five and a half times that of water. Thence results the real weight of the earth as being nearly fourteen quintillions of pounds. From this, again, it follows that the matter of the earth grows denser the nearer the centre; consequently it cannot be a hollow sphere.

If we consider, that from the earth's surface to its centre there is a distance of 3,956 miles, and that, with all our excavations, no one has yet penetrated even five miles, we have reason to be proud of investigations which, at least in part, disclose to man the unexplorable depths of the earth.

PART II.
VELOCITY

CHAPTER I.
VELOCITIES OF THE FORCES OF NATURE

In former times, when a man would speak of the rapidity with which light traverses space, most of his hearers thought it to be a scientific exaggeration or a myth. At present, however, when daily opportunity is afforded to admire, for example, the velocity of the electric current in the electro-magnetic telegraph, every one is well convinced of the fact, that there are forces in nature which traverse space with almost inconceivable velocity.

A wire a mile in length, if electrified at one end, becomes in the very instant electrified also at the other end. This and similar things every one may observe for himself; then, even the greatest sceptic among you will clearly see, that the change – or "electric force" – which an electrified wire undergoes at one end, is conveyed the length of a mile in a twinkle, verily as if a mile were but an inch.

But we learn more yet from this observation. The velocity with which the electric force travels is so great, that if a telegraph-wire, extending from New York to St. Louis and back again, is electrified at one end, the electric current will manifest itself at the other end in the same moment. From this it follows, that the electric force travels with such speed as to make a thousand miles in a space of time scarcely perceptible. Or, in other words, it travels a thousand miles in the same imperceptible fraction of a moment that it does a single mile.

And experience has taught us even more yet. However great the distance connected by a telegraphic wire may be, the result has always been, that the time which electricity needs to run that distance, is imperceptibly small; so that it may well be said, its passage occupies an indivisible moment of time.

One might even be led to believe that this is really no "running through" – in other words, that this transmission of effect from one end of the wire to the other end does not require any time at all, but that it happens, as if by enchantment, in one and the same instant. This, however, is not the case.

Ingenious experiments have been tried, to measure the velocity of the elective force. It is now undoubtedly proved, that it actually does require time for it to be transmitted from one place to another; that this certain amount of time is imperceptible to us for this reason, viz., that all distances which have ever been connected by telegraph, are yet too small, to make the time it takes for the current to go from one end to the other, perceptible to us.

Indeed, if our earth were surrounded by a wire, it would still be too short for common observation, because the electric force would run even through this space – twenty-five thousand miles very nearly – in the tenth part of a second.

Ingenious experiments have shown that the electric current moves two hundred and fifty thousand miles in a second. But how could this have been ascertained? And are we certain that the result is trustworthy?

The measurements have been made with great exactitude. To those who are not afraid of a little thinking, we will try to represent the way in which this measurement was taken; although a perfect representation of it is very difficult to give in a few words.

CHAPTER II. HOW CAN THE VELOCITY OF THE ELECTRIC CURRENT BE ASCERTAINED

In order to illustrate, how the velocity of the electric current can actually be measured, we must first introduce the following:

Whenever a wire is to be magnetized by an electric machine, at the moment it touches the machine, a bright spark is seen at the end of the wire. The same spark is seen also at the other end of the wire, if touching another apparatus. Let us call the first spark the "entrance-spark," the other the "exit-spark." If a wire, many miles in extent, is put up, and led back to where the beginning of the wire is, both sparks may be seen by the same observer.

Now it is evident, that the exit-spark appears after the entrance-spark just as much later, as the time it took the electric current to run from one end of the wire to the other end. But in spite of all efforts made, to see whether the exit-spark actually appears later, the human eye has not been able to detect the difference. The cause of this is partly owing to the long duration of the impression upon the retina, which leads us to the belief, that we see objects much longer than we really do; partly, the immense rapidity with which the exit-spark follows the entrance-spark. From these two causes, we are tempted to believe both sparks to appear at the same moment.

By an ingenious and excellent means, however, this defect in our eye has been greatly diminished. It is well worth the trouble to read a description of the experiment attentively. The truly remarkable way in which it was tried, will please all who read it.

In order to measure the velocity of the electric current, the ends of a very long wire are placed one above the other. If, now, one makes the observation with the naked eye, both sparks will be found to stand in a vertical line, one above the other, as the points of a colon, thus (:).

But he who wishes to measure the velocity of the electrical current does not look upon the sparks with the naked eye, but into a small mirror, which, by a clock-work, is made to revolve upon an upright axis with exceedingly great rapidity. Thus he can see both sparks in the mirror. If the apparatus be a good one, it will be observed that the sparks, as seen by the aid of the mirror, do not stand in a vertical line above one another, but obliquely, thus (.·).

Whence does this come?

The reason of it is, that after the appearance of the entrance-spark it takes a short time, before the exit-spark appears. During this short time the mirror moves, though but little, and in it the exit-spark is seen as if it had moved aside from the entrance-spark.

Hence, it is through the movement of the mirror that the time, which is necessary for electricity to go through the circuit of the wire, is ascertained. A little reflection will readily convince the reader, that the time may be precisely calculated, provided three things be known, viz.: the length of the wire, the velocity of rotation of the mirror, and the angular distance of the two sparks as seen in the mirror. Thus: Suppose the wire to be 1,000 miles long; and suppose the mirror is made to revolve 100,000 times in a second. Now, if the electrical current traversed these 1,000 miles of wire during *one* revolution of the mirror, then it follows, that the current must move 1,000 miles in the 1/100 part of a second; or, 100,000 miles in a second.[1]

It is found, however, that the mirror does not revolve an entire circle, or 360 degrees, while the current is passing over 1,000 miles of wire, but we find that the mirror turns through 144 degrees very nearly; therefore the electric current must travel more than 100,000 miles a second. How much

[1] Images of the original pages are available through Internet Archive/American Libraries. See http://www.archive.org/details/popularbooksonna00bernrich

more? Just as many times 100,000 miles, as 144 degrees are contained in 360 degrees (the entire circle), viz., two and a half times. Hence, the current travels 250,000 miles in a second.

PART III.
NUTRITION

CHAPTER I.
NOTHING BUT MILK

Conceive a man, gifted with the keenest intellect, but not knowing from experience, that sucklings grow and become men, and imagine what he would say, if you were to tell him this:

"Know, that the little being you see here, is a suckling, that is, a developing human being, who by and by will become thicker and taller. The bones of his body will become firmer and longer. The muscles that animate these bones will likewise increase in size. The same will happen with regard to his eyes, ears, nose, mouth; to his head, body, and feet; every component part of his small body will be developed further and further, until the child will become a perfect man."

There is no doubt, that he who does not know all this from experience, will shake his head at it.

But if you were to tell him: "This development and growth have their source in the baby's sucking at the mother's breast a white juice called milk, and out of this milk all the constituent parts of the child are manufactured within himself," – certainly your hearer would laugh in your face, and perhaps call you a credulous fool.

"What!" he would exclaim, "do you mean to say that milk contains flesh? Or can you make bones out of milk, or hair? Can you make nails and teeth out of milk? Do you wish to persuade me, that milk may be changed into eyes? that from milk may be manufactured feet, hands, cheeks, eyelids, and the various other parts of the human body?"

And if, in answer to this, you were to reply: "Yes, it is so. Within this little creature is a factory, that not only makes all you have mentioned, but much more. In this establishment, bones, hair, teeth, nails, flesh, blood, veins, nerves, skin, juices, and water are manufactured; all this is made from milk, and during the first months of the child's life from nothing but milk," – then your hearer, though he may have the understanding of the most judicious of men, would be dumbfounded, and would beseech you to tell him more about this factory.

You may be certain, he would like to know, how many boilers, cylinders, valves, wires, ladles, oars, pumps, hooks, pins, spokes, and knobs there may be in this factory; more especially would he wish to know, whether the engine of this wonderful establishment be made of steel, wood, cast-iron, silver or gold, or of diamonds.

Now, if you were to tell him, "It contains nothing of the kind. Of all the factories you have seen in your life, there is none that bears any resemblance to this one. And I will tell you furthermore, that it is not even a complete factory, but it is continually developing; it becomes larger and heavier like the child's body itself; moreover, the factory does not consist of iron or steel, nor of gold or diamonds, but it reproduces itself at every moment; it does so merely from the milk that the child drinks," – then, to be sure, your hearer would begin to doubt his own senses; he would exclaim: "What is the intellect of the intelligent, the judgment of the judicious, what is the wisdom of the wise, when compared to a little of the mother's milk?"

And yet, you are well aware, my friendly reader, that mother's milk is, after all, nothing but milk; and that milk, again, is nothing but a means of nutrition; and nutrition, in its turn, is nothing but a part of the action of the human body.

May I hope that you will favor me with your attention, while, in a few articles, I speak to you about the nutrition of the human body?

CHAPTER II.
MAN THE TRANSFORMED FOOD

Before speaking of the process of nutrition in the human body, we must first obtain a correct idea of what is meant by nutrition.

Why are we obliged to eat?

Of course we know that hunger forces us to do so. But every one is aware also, that above all we must ask, whence hunger arises; that we must first get better acquainted with hunger itself, in order to understand nutrition.

To explain this, however, it is necessary to turn our attention to another thing, no less a miracle than nutrition itself, viz., what in scientific language is called "Exchange of Matter." To all of you it is a well-known fact, that nothing in the human body remains even for a moment in the same state; but that in every part of the body a continued exchange takes place. Air is breathed in and exhaled again; but the air exhaled is different from the air inhaled. By this process an exchange of matter has taken place; new matter has entered the body and waste matter has been thrown out.

This exchange of matter – we shall speak more about it at another opportunity – is a principal necessity for the body and its functions; it consists in the main of an incessant change, by which our body is forced to cast out matter that formed parts of it, and is therefore obliged, in order to compensate for the loss, to take in new matter. Hence there is no exaggeration in the expression, "Man is continually renewing himself;" we indeed lose and receive particles of our body at every moment. People have gone so far as to calculate that it takes seven years for the renewal of the whole body of man, and that after this space, there is not even an atom left of the man as he was seven years before.

The regular exchange of matter, as we have seen, supposes the body to be a barter-place, where people take in at the same ratio they pay out. Since, however, man often pays out involuntarily and suffers so many losses – by the mere process of breathing he ejects matter which he must replace afterwards – this exchange of matter is the cause of the body's possessing the feeling of want. The body has paid out and receives nothing in return; this feeling of want is what we call "Hunger." It forces us to absorb as much as we have paid out.

Nutrition, consequently, is the continual replacing of continual losses. It is the wonderful transformation of food into the materials composing the human body.

When looking at our fellow-men, however, we must not think, that they are merely beings that have eaten food; but rather that they themselves, viz., their skin, hair, bones, brain, flesh, blood, nails, and teeth, are nothing but their own food, consumed and transformed.

CHAPTER III. WHAT STRANGE FOOD WE EAT

Man, according to what has preceded, is nothing but transformed food.

This idea may frighten us; it may be terrible to our hearts; but let us frankly confess, it is a true one! Man consists only of such substances as he has consumed; he is, in fact, nothing but the food he has eaten; he is food in the shape of a living being.

A child is said to live on his mother's milk; but what else does this mean than: "It is mother's milk, that has become alive by having been changed into head, body, hands, feet, etc., etc."

Indeed, it may sound strange, yet it is quite correct: This mother's milk in the shape of a human being consumes again new mother's milk, and, by respiration, by evaporation and secretion of matter, casts out the used-up milk.

This being so, it will now appear evident to every one, that by a profound chemical knowledge of our daily food, we may readily learn to know the chemical components of man, and *vice versâ*; knowing the substances of which man is made, it is easy for us to determine, what kind of food he must take, in order to continually renew his body.

Since the mother's milk is the simplest and most natural food for the child, let us consider it according to its importance. We shall then have a stepping-stone towards the knowledge of the food of adults and its effects. The mother's milk contains all the elements, with which the human body can renew itself; should there be but one of those elements wanting in it, the child would inevitably perish.

If, for example, milk did not contain calcareous earth, the consequence would be, that the bones of the child would, soon after its birth, neither grow nor increase in number, but they would fast diminish, and the child would die in consequence of this. The attempt was once made to feed animals on articles without calcareous parts, when, strange to behold, they all grew fat, but very weak in their bones, and finally broke down.

If milk contained no phosphorus, not only would the bones and teeth suffer from the want of it, but even the completion of the child's brain could not properly take place, and the child could not replace the quantity of brain which it emits and loses every moment by breathing.

If there were no iron in the mother's milk, the child would die from the green-sickness, a malady which, by the way, is dangerous also for grown people, and which is cured by medicines containing plenty of iron.

If there were no sulphur in it, the child's bile could not develop; the bile, as every one knows, has an important function in the human body.

These are but accessory elements of the mother's milk, elements which usually are not looked upon as articles of food; for who is aware that he must eat, and actually does eat daily, phosphorus, iron, calcareous earth, and sulphur? And not only these; there are a great many other articles, such as magnesia, chlorine, and fluor, that we eat without being aware of it; moreover, our proper food consists also of three gases: nitrogen, oxygen, and hydrogen; and of a solid substance called "carbon," which is no less and no more than pure coal.

All these, my friendly readers, are contained in milk – all these are the elements which in truth constitute the human body. Perhaps some persons believe that there is nothing easier than to procure proper food. It would only be necessary to take a certain quantity of carbon, hydrogen, oxygen, and nitrogen; a little bit of potassium, natron, calcium, and magnesia; to mix a small piece of iron, sulphur, phosphorus, chlorine, and fluor, and take this mixture by the spoon at regular intervals, in order to give the body the necessary aliments. This, however, would be a mistake, for which the perpetrator would pay with his life.

Although it is true that these substances form the proper and most important constituents of our daily food; yet, in order to enjoy the desired result, we must not partake of them in their primary forms; they can actually feed our body only when they are combined together in a peculiar, wondrous manner.

In the next chapter it may be seen how nature first must combine these substances before they are presented to us as proper food; and it will also be seen, that we receive them sometimes in altogether different forms and combinations; for example, in the mother's milk, when we eat the above-named elements in the forms of caseine (cheese), butyrine (butter), sugar of milk, salt, and water.

These latter names have a more savory sound, have they not?

CHAPTER IV.
HOW NATURE PREPARES OUR FOOD

In the preceding article it was stated, that the food of the child which lives on mother's milk, consists in its primary elements of peculiar substances. These are principally oxygen, hydrogen, and nitrogen; three gases to which may be added a large quantity of carbon, or, what is the same, coal. Besides this wondrous mixture of air and coal, the mother's milk contains still other elements, but in a smaller proportion. In every-day life many of them are unfamiliar; for example, natron, calcium, magnesia, chlorine, and fluor; the others, however, are known to every one; viz., iron, sulphur, and phosphorus. All these strange ingredients nature has carefully transformed into milk. For in their primary state, and even in various chemical combinations that may be produced artificially, they would be little adapted for the purpose. It is therefore essentially necessary that nature herself should make them ready for us. This she does by letting them pass first into the vegetable state, and changing them afterwards into new forms.

The plant feeds on primary chemical elements; or, to state it more correctly, the plant is nothing but transformed primary elements! Not before the transformation of these elements into plants are the elements adapted for food for animals and men.

Moreover, all that man eats must first have been in the vegetable state. Now, it is true that man also eats the flesh, fat, and eggs of animals; but whence have the animals meat and eggs? Only from the plants they consume.

There is a remarkable succession of transformations in nature. The primary elements nourish the plant; the plant nourishes the animal; and both, plant and animal, form the nourishment of man.

Even the mother's milk, the simplest and most natural food of the child, owes its existence only to the fact that the mother has eaten vegetable and animal matter. This food, prepared for the mother by nature, has been changed into the body of the same; and partly, also, it has become the milk destined to nourish the child.

Hence it is evident that mother's milk consists of oxygen, nitrogen, hydrogen, carbon, and a small portion of other chemical primary elements. But these substances when appearing in the shape of milk, are combined in such a manner as to form ready-made food; as such they constitute, as stated above, caseine, butyrine, sugar of milk, salt, and water.

The next questions are: "What do these elements of food perform when in the child's body? What becomes of these substances after they have been eaten by the child? How are they changed during the time of their stay in the body? And in what condition do they leave the child's body, and how do they force him to desire food again?"

These questions properly belong to the chapter on "Nutrition," where they will be answered in their turn. Afterwards, we must be permitted to turn our attention to a further question, viz., "What articles of food are the most advantageous to man from the time he is weaned or the time, he takes from among vegetable and animal matter the same substances for food, that are contained in the mother's milk?"

In order to arrive at the answers to all these questions, we were obliged to first prepare the ground a little. This was a gain on our part, for now we shall attain the end in a shorter time than would have been possible otherwise. We trust that we may give our reader a correct idea of the subject, if he will but come to our aid with his most earnest attention and reflection; these are needed here the more, as we have to treat a difficult subject in a very short space.

CHAPTER V. WHAT BECOMES OF THE MOTHER'S MILK AFTER IT HAS ENTERED THE BODY OF THE CHILD?

When the child has freed itself from the body of its mother, it consists of blood, flesh, and bones, which heretofore were formed and nourished by the blood of the mother.

As soon, however, as the child is born, it ceases to be nourished in this manner. It ceases, also, to secrete through its mother, substances which are useless to it. The child now begins to breathe for itself, and by its breath secretes carbon in the form of carbonic acid. Its skin begins to perspire, and secretes chiefly hydrogen and oxygen in the shape of water or vapor; by the urine, finally, it secretes nitrogen. These substances – carbon, hydrogen, oxygen, nitrogen – before their secretion, constituted vital parts of the child's body; now, however, they are wasted, and for this reason must be thrown off.

It is evident that the child wants compensation for this loss. This is given by the mother's milk; for it contains chiefly these same substances.

But how is this effected?

The milk passes from the child's mouth through the gullet into the stomach. While yet in the mouth, the milk is mixed with a certain liquid called saliva. This saliva possesses the quality of preparing the milk for the necessary change which will take place, when it reaches the child's stomach. The principal work, however, is carried on in the stomach itself. Its sides secrete a liquid called "gastric juice," whose business it is, to transform into a pulp milk, and also solid food, provided the latter be well masticated and moistened.

Science has taught us to prepare gastric juice artificially. The process of digestion, that is, the transformation of solid food – the crust of bread, meat, etc. – into a pulp, may nowadays be observed in a glass filled with warm, artificial, gastric juice.

After the digestion is completed, the lower opening of the stomach, which leads into the duodenum, and which, during the process of digestion, was closed by a muscle, opens itself. The pulp, now called "chyme," flows into the continuation of the stomach – the "alimentary canal" or "duodenum." This is but a long bag with many folds and windings.

The chyme is here mixed again with a liquid called "intestinal juice;" it has the quality of continuing digestion until the chyme separates into two parts; one of them, a milky fluid called "chyle," contains the substance which feeds the body. The other is the solid parts not adapted to nutrition; they are thrown out by the lower opening of the "rectum."

But how is this nutritive part, the chyle, conveyed into the various parts of the body?

The intestinal canal is filled with extremely small vessels called "lacteal absorbents." These vessels absorb the chyle. This absorption, on account of the great length of the intestinal canal – in adults it is nearly thirty feet long – is, in a healthy body, accomplished very thoroughly. The real nutriment for the body is now contained in the lacteal absorbents, an infinite number of small tubes.

All these small vessels, however, converge towards the lower part of the spinal column, and uniting, form a vessel which ascends into the chest; here it empties into a large blood-vessel, the blood of which is on its way to the heart. Thrown out of the heart in another direction, the blood is pushed through the whole body.

Thus the food, after having been transformed into a juice very similar to the blood, joins the blood after a circuitous journey, and is finally mixed with, or, more properly, changed into, blood.

CHAPTER VI.
HOW THE BLOOD BECOMES THE VITAL PART OF THE BODY

One would be well justified in calling the blood "man's body in a liquid state." For the blood is destined to become the living solid body of man.

People were astonished, when Liebig, the great naturalist, called blood the "liquid flesh;" we are correct even in going further and calling the blood "man's body in a liquid state." From blood are prepared not only muscles and flesh, but also bones, brain, fat, teeth, eyes, veins, cartilages, nerves, tendons, and even hair.

It is utterly wrong for anybody to suppose, that the constituents of all these parts are dissolved in the blood, say as sugar is dissolved in water. By no means. Water is something quite different from the sugar dissolved in it; while the blood is itself the material from which all the solid parts of the body are formed.

The blood is received into the heart, and the heart, like a pump, forces it into the lungs. There it absorbs in a remarkable manner the oxygen of the air which comes into the lungs by breathing. This blood, saturated now with oxygen, is then recalled to another part of the heart by an expansive movement of that organ.

This part of the heart contracts again and impels the oxygenated blood into the whole body by means of arteries, which branch out more and more, and become smaller and smaller, until at last they are no longer visible to the naked eye. In this manner the blood penetrates all parts of the body, and returns to the heart by means of similar thread-like veins, which gradually join and form larger veins. Having reached the heart, it is again forced into the lungs, and absorbs there more oxygen, returns to the heart, and is again circulated through the whole system.

During this double circulation of the blood from the heart to the lungs and back, and then from the heart to all parts of the body and back again – during all this, the change of particles, so remarkable in itself, is constantly going on: the exchange by which the useless and wasted matter are secreted and new substances distributed. This fact is wonderful, and its cause not yet fully explained by science; but so much is certain, that the blood when being conveyed to all parts of the human body, deposits whatever at the time may be needed there for the renewal of that part.

Thus the blood that has been formed in the child from the mother's milk, contains phosphorus, oxygen, and calcium. These substances, during the circulation of the blood, are deposited in the bones, and form "phosphate of lime," the principal element in the bone. In the same manner fluor and calcium are given to the teeth. The muscles, or flesh, also receive their ingredients from the blood; so do the nerves, veins, membranes, brain, and nails; also the inner organs, such as the heart, lungs, liver, kidneys, intestines, and stomach.

They all, however, in return give to the blood their waste particles, which it carries to that part of the human body where they may be secreted.

If any member of the body is so bound, that the blood cannot circulate, it must decay; for the life of the body consists in its constant change and transformation, in the continual exchange of fresh substances for waste ones. But this vital exchange is only kept up by the constant circulation of the blood, which, while it decreases by being transformed into vital parts of the body, is always formed anew by our daily food.

Food is therefore very justly called "Means of Existence," and the blood may rightly be called the "Juice of Life."

CHAPTER VII.
CIRCULATION OF MATTER

Thus we have seen that the human body is vital blood, transformed and solidified. Now, blood is food transformed; food consists of primary elements prepared and changed by nature; hence, man himself is primary matter transformed and vivified.

But the human race being thousands and thousands of years old, and there being upon the earth besides man the whole of the animal kingdom, developing, preserving, and nourishing itself bodily like man; the question arises: Whence do they all come, these primary elements that are obliged forever to undergo transformation before they can become animated vital matter? Do these primary elements not incessantly decrease during the long process of their being changed into plants and consumed by man and animal, in order to form human and animal bodies afterwards?

The answer to this interesting question has been given already. The human body is not framed or created anew at every moment by food; but it is at every moment, that small particles of the human body die. These particles are returned to mother earth from which they sprang, thus going back to the primary elements.

It is not only those who are dead, that render to the earth what belongs to her, that return to nature what she gave them; but in a far greater degree it is the living, that pay their debt to nature.

Man's body is not his own; nature has lent it to him but for a short term of service; then nature wrests her loan back from him. Thus must man, spite all his pride, accept her never-ceasing offer; daily he must borrow and daily he must repay in part, until the moment comes when he borrows for the last time, the moment he expires; and dying he leaves it to those around his bedside, to pay his last debt to earth.

Is it not wonderful? His own blood is the messenger that daily carries new loans to him, and, in the shape of transformed food, of transformed elements of nature, equips his body. But his own blood is at the same time also his cashier, who, having rendered him service, takes the loan away, by secreting from the body elements that are thus returned to nature.

With every revolution of the blood the body is supplied with transformed food, which is immediately changed into vital parts of the body; with every return of the blood waste matter is carried off and deposited, where it may be thrown out.

The blood carries waste matter to the kidneys that they may send out of the body, in the shape of urine, waste nitrogen, mixed with a part of the phosphate of lime, that served to form bones and teeth, but is now useless. The blood, besides, secretes perspiration through the skin. This is a liquid containing water, hence oxygen and hydrogen; but is moreover mixed with various other waste substances of the body, as for example, carbonic acid, nitrogen and fat. Chiefly, however, the blood is employed in carrying waste carbon to the lungs, so that they may, by the process of respiration, exhale carbonic acid, a gas which would prove of deadly effect if remaining in the lungs too long, or if inhaled.

The quantity of man's secretion per day is by no means small. It amounts to the fourteenth part of his own weight: nay, more – the weight of his perspiration alone, secreted partly by evaporation in the shape of gas, partly as a liquid in drops, amounts during twenty-four hours to nearly two pounds.

Secreted substances have lost all the qualities of transformed and vital matter. They return to the primary elements and serve as food principally to plants, which before had offered those very same substances as food to man.

It is in this manner that the great circulation of matter in nature takes place. From the lifeless primary elements to the plant; from the plant, in the shape of food, to animal and man; from these, as waste substances, back again to the primary elements, there to begin anew a circulation, by means of which inanimate elements are reanimated, and vital elements made lifeless again; that is, life changed again into death.

And it is in this circulation that our "Nutrition," or, more precisely, the "Change of Matter in Man," consists, an important link in the life-preserving chain of nature.

CHAPTER VIII.
FOOD

From what has been said, it must appear evident that only such dishes make good food as contain the same constituents as the blood.

To have these constituents, food must contain salt, fat, and sugar; all these ingredients must, of course, be in a certain proportion.

That water is essential for the support and renewal of the body is clear to every one. The flesh we eat, contains nearly eighty per cent. of water, and yet a man must die, if he were to eat nothing but meat and to have no water, for the reason that the eighty per cent. of water he takes in would by no means be sufficient to form all the liquids necessary for the human body.

The albumen that we eat, forms in the blood chiefly the substances composing the muscular part of the flesh. But it is an error to suppose, that therefore it is absolutely necessary to eat eggs – the white of an egg is nearly pure albumen – because the caseine (cheese) contains precisely the same ingredients as the albumen; for we have seen before, and our readers are doubtless aware of it, that the mother's milk contains caseine, while it is entirely free of albumen. Hence, he who eats plenty of caseine, as do shepherds in Switzerland, for example, scarcely needs any meat. But besides caseine there is another element, viz., the vegetable albumen called gluten, which contains albuminous matter; so do all glutinous plants. Peas, beans, and lentils in particular form food productive of flesh.

The salts that must be given to the blood, do not only consist in the common kitchen-salt. By the expression "Salts" are meant various combinations of substances which are usually not considered articles of food, for example, the combinations of phosphorus, iron, etc., but are not visible to the eye. They help to form bones, teeth, nails, cartilages, and hair.

The fat which we take, appears to many people to be a very important part of our food, and they believe that by eating much fat, one may become fat. But this is not correct. Ferocious animals that live only on meat and fat, do not get fat; while herbivorous animals fatten excessively, if provided with good mast, consisting of course but of plants. Yet fat is, for all this, by no means superfluous to our body. Man needs it, because it is the fat which chiefly supports his respiration. But the fat that is needed for the body, is formed by man himself; so that but little of it need be eaten, and that little only for the purpose of helping to form new fat from sugar.

It is therefore best to consider fat and sugar as food belonging together; for the fat is formed in the body from sugar, and the small quantity of fat which we take daily is only to promote the transformation of sugar into fat.

But let no one believe that one must needs actually eat sugar; no, every food that contains starch supplies the place of sugar very well, as starch is changed, when in the body, first to sugar and then to fat. The potato contains starch and serves its purpose well; it is necessary, however, to put butter with it in order that the starch and sugar formed from the potato in the stomach, may be easily converted into fat.

An excellent article of food is bread, for it contains nearly all the elements of nutrition. It contains vegetable albumen, and therefore is converted into flesh. It has nearly all the salts that are essential to the body; moreover, it contains starch from which fat is produced. Therefore, by the mere addition of a little butter in order to make the formation of fat easier, and by drinking water besides, the human body is able to exist. On the other hand, the potato, if taken alone, is an insufficient means of nutrition. Neither would meat or albumen, if taken alone, be able to preserve life.

Various experiments have been tried with animals, and a great deal of information about the best means of feeding the body has been collected. In order to investigate the effect of the nutritive qualities of food, inquiries have been made especially at military establishments, such as barracks, etc.

CHAPTER IX.
ABOUT NOURISHMENT

In obedience to the demands of modern science, numerous experiments about nutrition have been made, in regard to digestion as well as to the effects of hunger and of various elements of food.

As to digestion, the most excellent observations were made on men afflicted with a fistula in the abdomen, that is, a wound penetrating to the stomach. By means of this wound, it was ascertained very minutely how long it took to digest food, and what kind of transformation it underwent. From this and other experiments it appeared, that the time for digestion, though varying greatly with the various articles of food, lasts from one and one-half to five and one-half hours. Those most quickly digested are: soft sweet apples, beaten eggs, and cooked brain. To digest boiled milk, raw eggs, soft sour apples, roasted beef, liver, two hours were required. Cooked spinal marrow, raw cabbage, fresh milk, roasted beef, oysters, soft-boiled eggs, and raw ham, took nearly three hours. Wheat bread, old cheese, potatoes were digested in nearly three and one-half hours; pork, boiled cabbage, lamb's fat, not before five hours.

The experiments about the effects produced by hunger were tried only on animals. The results were that during the state of starvation three-fourths of the blood disappeared; the fat was almost entirely consumed; the flesh disappeared one-half; even the skin diminished one-third, and the bones lost about one-sixth of their weight. The least decrease was found to be in the nerves, a striking proof that nerves possess a great power of self-preservation, provided there be but a minimum of matter to feed them. From numerous experiments the conclusion was drawn, that an adult weighing about one hundred and thirty pounds must die if he were to lose, say fifty pounds, by starvation.

With regard to the effects of the various articles of food, experiments applied to dogs have shown that they can live on bones for a long time; but that they die if fed on sugar only, and when examined after death, no trace of any fat is to be found.

Animals fed on substances that contained no phosphorus and lime became fat; but they died for want of the proper nourishment for their bones. Animals died also when nourished only with pure albumen or pure caseine. The most remarkable fact in this connection is, that they perished in the same length of time in which they would have died, *if they had taken no food whatever*.

Experiments tried on man have shown that it is injurious to eat *uniform* food. A constant change in our food is extremely nourishing and healthy. This is an experience made in prisons and barracks; changes of food are made there every day during the week, so that each day they have a different dinner. Once, a physician in England wished to try the effects of uniform food on himself. He took nothing but bread and water for forty-five days; in consequence of this he decreased eight pounds. Then he ate for four weeks but bread and sugar, then bread and oil three weeks; but finally he succumbed under his experiments, and died, after having experimented thus for eight months.

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