LESSONS ON OBJECTS,

GRADUATED SERIES;

DESIGNED FOR

Children between the ages of Six and Fourteen Years:

CONTAINING, ALSO,

INFORMATION ON COMMON OBJECTS.

Elizabeth Mayo

ARRANGED

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PREFACE.

THE fourteenth edition of "Lessons on Objects" was published in London in 1855, under the auspices of the Home and Colonial Training Institution, and underwent at that time a thorough revision.

In this American edition many changes have been made in the arrangement of the Lessons. Some of the terms have been modified, others left out altogether. A number of the lessons have been omitted and others substituted in their place, and much information on common objects has been added. In the original work there were but few Model Lessons; in this, a large additional number have been inserted. These have been taken from "Manual of Elementary Instruction," "Model Lessons," and "Notes and Sketches of Lessons," all London publications. The arrangement of the Steps correspond to the arrangement in the "Manual of Elementary Instruction." The first three steps are designed for the first three years of the child's school life, or for the Primary Schools. The fourth and fifth steps are adapted to the junior or intermediate grade, or for pupils from ten to fourteen years of age.

The Models given are designed to aid the teacher in the preparation of her lessons, as suggestions in regard to the proper method of arranging and presenting them, and not as forms to be implicitly or blindly followed.

In cases where lists of the names of the qualities of objects are given, it is not essential that the children should be led to the discovery of all the qualities named.

As the object of these Lessons is to cultivate the senses, to awaken and quicken observation, and lead the children to observe carefully everything in nature about them that comes within the range of the senses, it is important as far as possible to give the children a good deal of latitude, and let the discoveries be their own, except as they may be guided in part by the teacher. So that if they should leave out in their investigations some qualities named, and put in others not named, it is not a matter of importance, provided they are correct as far as they go, and *accuracy of observation* is cultivated. It should be added, that as the *ideas* are clearly developed, the giving of *terms* to express these ideas is designed as a preparation for "Language Lessons," and to give the children a vocabulary by which they are enabled to express the observations they are continually making on the objects of the external world. Thus *observation* and *language* are both cultivated.

We cannot do better here than insert the *Preface to the Fourteenth London Edition.*

PREFACE

TO THE FOURTEENTH LONDON EDITION.

When this work was first presented to the public, nearly thirty years since, the idea of systematically using the material world as one of the means of educating the minds of children, was so novel and untried a thing in England, that the title "Lessons on Objects" excited many a smile, and the success of the little volume was deemed to be, at best, very dubious. The plain sound sense of the plan, however, soon recommended it to our teachers, and they discovered that reading, writing, and arithmetic, do not form the sole basis of elementary education, but that the objects and actions of every-day life should have a very prominent place in their programme.

In spite of the ominous forebodings which attended the first introduction of this little volume, the public has given a decided sanction to the system of teaching it, and the degree in which it has in consequence modified books for the young and the practice of elementary instruction, can scarcely be calculated.

Successive editions of the Lessons have issued rapidly from the press, hitherto without any alteration; but it is now thought desirable to profit by the experience gained by the introduction of such a course of instruction, and to make a few changes and additions. As the work is much used in institutions for the training of Teachers, the following account of the plan of the whole course is given as a guide in the use of the lessons, and a help in carrying out the idea. Those who fall into a mechanical way of giving such instruction, and do not perceive the principle involved, completely defeat its intention, and they had far better keep to old plans and old books.

The work contains progressive series of lessons, the prevailing aim being to exercise the faculties of children according to their natural order of development, aiming also at their harmonious cultivation.* The first series chiefly exercises the perceptive faculties, arresting attention on qualities discoverable by the senses; and then furnishing a vocabulary to clothe the ideas, and so fixing them in the mind, where they will be ready for reproduction when the faculty of conception begins to act. The second and third series, in addition to this, exercise the conceptive powers in recalling the impressions made upon the senses by external objects, when they are removed from observation—also in leading from what has become known to what is unknown. In the fourth series, the children are exercised in tracing resemblances and differences, in drawing comparisons and recognizing analogies, thereby cultivating the power of arranging and classifying.

In the fifth series, the reason and judgment are brought into activity; in tracing the connection between cause and effect, between use and adaptation; language or the power of expression is cultivated; the ideas developed in the lessons of the previous series are expressed either in simple words or short sentences; but throughout this series the pupils are required to put down all the knowledge they acquire, in the form of consecutive narrative. This plan promotes fixedness of attention during the giving of the lesson, a clear apprehension of facts and truths, and facility in arranging and expressing what has been acquired.

* See "Home Education," p. 198.

An objection has been made to these Lessons, that they put fine words into children's mouths, and give them an air of pedantry—but the evil in reality is the effect of the ignorance that has hitherto prevailed as to the properties of the most common things by which we are surrounded, and the consequent poverty of the poor man's language. When the love of knowledge is excited, and the habit of intelligent observation cultivated, words and phrases are required to define accurately what so often otherwise remains vague impressions on the mind; consequently a more extended vocabulary is requisite, and when no simple and common words can be found to express (for instance, such very important and common qualities as opacity and transparency), the only terms our language affords must be used, and the reproach of pedantry be risked.

Teachers making use of these Lessons are earnestly advised to read carefully the introduction to a series before they commence the lessons which it contains, and to endeavor to understand, and then to act up to the principles and aim set forth. They should guard against mere mechanical work, or allowing this in their pupils; the latter, after having heard a few names, will often, without thought or observation, apply them indiscriminately. Neither should the lessons be slavishly followed in all that is set down; they should rather be used as affording suggestive hints; and variety should be sought for—the children often themselves indicate what their minds require.

ELIZABETH MAYO.

Hampstead, July, 1855.

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LESSONS ON OBJECTS.

HINTS ON SKETCH WRITING.*

THERE is, perhaps, no practice better adapted to insure effective oral teaching, than diligent preparation of the lessons which the teacher intends to give her pupils. The recent impulse imparted to popular education, while it has directed attention to this important subject, has shown, also, how much it has been neglected. This fact, with the difficulties attending first attempts at the practice, renders it desirable to furnish a few hints to teachers and students, which may help them in this branch of their work, and lead to its better appreciation.

Experience daily proves that an unprepared lesson, or what may be termed EXTEMPORE teaching, is sure to be vague, diffuse, and shallow; and on the other hand, that a well-prepared lesson is generally clear, to the point, and given with spirit and effect.

If, with all the advantages of well-disciplined minds, those who instruct adults find careful preparation indispensable, far more so must it be to those who have to

* Taken from "*Notes and Sketches of Lessons.*"

teach children, and who in many cases are very deficient in mental culture.

An accurate knowledge of her subject gives self-possession and composure to the teacher; enables her to attend to the effect of the lesson on the minds of the children; prevents tedious repetition, and important omissions; and gives her such a power over the children as to produce a consciousness that the teacher is guiding them, not they her. Success is then sure to follow, in winning their attention, and eliciting their inquiries and remarks. Moreover, the teacher who has diligently acquired, thoroughly digested, and suitably arranged her matter, will not easily be seduced from her subject by incidental association or irrelevant questioning; she readily detects the one, and discourages the other.

Drawing up sketches also affords much salutary mental discipline to the teacher herself. She is practised in analyzing subjects of instruction; and then, in reconstructing them on the principles of good teaching. She learns to view the lesson as a whole, to see the prominent bearings of the subject, and to grasp and retain them firmly while working them out.

Again: if a teacher can overcome her natural love of ease, and once make up her mind to the practice of preparing sketches of lessons, it will not only tend to cultivate and discipline her mind, but greatly contribute to the *pleasure* of her daily occupation, economizing at once time and labor. She will enjoy the interesting work of determining the end to be aimed at, of seeking the means of its attainment, and then of watching its success. Further:

if, after having prepared the sketch, the teacher takes care, at the close of the day, to enter that sketch in a book, and to notice the omissions made, and other incidents connected with the lesson as given, she will at the end of a single twelvemonth find her task greatly lightened, and her work with every new class of children comparatively easy. Her pupils withal, by the help of a systematic and regular course of well premeditated and prepared instruction, will have their minds properly exercised, and make solid progress: the same lesson will not, as is now often the case, be repeated within too short a space of time; and when it is again given, it will have the full benefit of the teacher's experience and correction.

It may seem very trite to say that, in order to prepare a good sketch of a lesson, a teacher should thoroughly acquaint herself with the subject, both in itself and in its different bearings on relative subjects; yet much vagueness on the part of the teacher, and much inattention on the part of the children, are owing to the neglect of a truth so obvious. Whatever may be the skill of the teacher, without proper and ample materials, no valuable result will be produced.

In a Scripture lesson, the meaning of the passage selected should be carefully studied; the parallel passages and texts consulted; every reference to places, manners, customs, &c., clearly understood; that the teacher may come forward with a mind enriched with knowledge, and a heart imbued with religious feeling.

In secular instruction, the best information should be obtained from books and actual observation. The points to which to lead the pupils should be determined, whether relating to historical facts, to utility, or to the connecting dependence of one part of the subject on another. Truth, thus acquired by search, will be valued and remembered, the harmony and dependence between various truths perceived, and its existence become a reality to them.

It is of great importance that teachers should be well supplied with concordances, commentaries, and other books of reference. The scanty library of many of our teachers, while the mechanic is so well supplied with choice tools of every kind, is enough to make those deeply mourn who wish well to the cause of education.

The expenditure on this account would be richly repaid in the enhanced usefulness of the teacher.

Assuming that good and sufficient matter has been collected, the next point is to determine what the *special subject*, or *leading idea*, of the lesson shall be. In order to do this, in a Scripture lesson, for example, the teacher should ascertain the current of thought that runs through the passage, the particular truth it teaches, and the practical application of which it is susceptible. The advantages of attention to this rule in religious instruction, are strikingly expressed by Inglis, in the "Sabbath School." He says, "A person, when he has settled the subject of his lesson in this way, has before his eyes a definite purpose to serve. Instead of occupying himself with unconnected explanations, pious, but pointless reflections, and hap-hazard questions, he tries, we shall say, on that day and by that one lesson, to convince the children—of the value of their souls; or, of the evils of hypocrisy; or, of the holiness of God; or, of the

happiness of heaven; something at least tangible and important. Instead of wandering at random wherever the impulse of association or the answers of the children may lead him, his subject is a helm to his thoughts, and guides them steadily to the point. He tries to lodge one or two great truths in the minds of his scholars; and this distinctness of purpose gives method and clearness to every part of the lesson. Both teacher and scholars know where they are, and what they are about."

In preparing the sketch of a lesson on a secular subject, the teacher should in like manner, so far as is practicable, confine herself to a single point,—or at most, a few points, toward which the whole instruction should tend, as rays to a centre. Her attention should not be directed to what she can or might say on the subject, but to supply what is most suited to the children's minds and acquirements, to their present and future wants; and what they can well receive and digest.

The *plan, or method of the lesson*, is another very important consideration. The information which the teacher has collected is placed in her own mind in the order in which she has acquired it, and not in that in which it should be imparted to the children. She has, therefore, to endeavor to throw herself into the minds of her pupils; to realize to herself their actual state, and to consider what is known, that she may obtain a firm footing from whence to proceed to that which is unknown and new. She has also to analyze her subject, that she may commence with what is simple and elementary, and so to arrange her points that she may proceed, by a series of well-graduated steps, to that which is more difficult, or is complex in its character. The ideas presented or gathered from the subject will then be received in their right order, their suitable connection felt, and the whole will be adjusted satisfactorily in the mind. She has, moreover, to determine how she should present her subject so as to seize that point of view which is most suitable, and likely to excite the greatest degree of interest and healthy exercise in her class,—varying this, in different sketches, that she may not continue in a hackneyed course, or put the children's minds in trammels. Teachers are very apt to adopt some model in their teaching, and to wear it threadbare. They, in consequence, lose freedom of mind themselves, and their pupils become weary of travelling always by the same road. It is better to make a few mistakes (by which, indeed, they gain experience), than lose their energy and independence of thought.

In drawing out the heads, it is of great importance that a proportionate degree of attention be paid to each, that too much be not given to the subordinate, while the principal are left indefinite and incomplete. Care should also be taken that the heads are not too numerous: minute divisions impoverish the subject, and diminish its effect. They should also be marked by clear, distinct, and broad lines. Teachers who endeavor to take a comprehensive view of their subject, will succeed far better than those who bring to it a critical, fanciful spirit.

It is hardly necessary to point out that there is a great difference between a sketch designed simply for the teacher's use, and one written for the inspection of others; the object of the one is simply to suggest, that of the other to

inform. In general, the former contains only the memoranda of what the teacher intends to bring before the children, in the order it is to be given; while the latter should contain more or less of the teacher's method of giving the lesson, and greater fulness of information.

To a teacher of long experience, who has in her own mind a well-acquired method, memoranda may be sufficient; still, method must be attended to in preparation, though it may not be essential to exhibit it in notes for her own use. She should not only know that a lesson requires reasoning, description, illustration, and application, but her own mind should be made up as to how a point is to be reasoned out, described, illustrated, or applied. The character of the matter is important, and the arrangement of it necessary; but the method of presenting it to the children is as important as either; for, as the late Dr. Mayo has well said, "it is as important *how* children learn, as *what* they learn." But for students in a training school, who prepare sketches for their own improvement and the inspection of others (and it is to this class that these hints may be considered more immediately applicable), it is requisite to state in the sketch the method as well as the matter of the lesson. Information may be nicely put together, but more is needed to insure a good lesson—the manner in which children's minds are to be exercised upon it; this should, therefore, be stated in the sketch. It is easy enough to collect information from books, but not so easy to show how such information is to be used as a means of developing the minds of the pupils; and this is what ought to be done by a good teacher.

Method and order should by no means be confounded;—order has to do with the arrangement of the information, the raw material, as it were, of the lesson; method, with the moulding and fashioning which it undergoes in the hands of the teacher, constituting the manner in which it should be presented to the children, so as to exercise their mental powers at the right time, and in due proportion. Order deals, as we have seen, with the information—the subject matter of the lesson; method, with the mind, the development and furnishing of which is the object of the instruction. Thus, order is more concerned with the instrument used; method, with the end to be attained. And while order is method to a certain extent, method includes more than mere order.

In addition, therefore, to information and order, a student's sketch should show how it is proposed to introduce what is general and abstract; to help to the conception of what is absent; to illustrate what is not understood; to resolve the complex into its simple elements; and to fix in the memory that which is received by the understanding. In fine, the sketch should contain the skeleton, or outline, of the lesson, showing the principal points on which it is intended to exercise the children's attention, and the manner in which the subject should be treated, so as to secure their interest, and fix the ideas clearly and thoroughly in their minds.

A teacher, in the selection of her subject, may have a *general* aim; thus, in a Bible lesson, to produce a religious impression; in a lesson on an object, to call out observation; in a lesson on number, to cultivate accuracy and draw forth power; in a lesson on an animal, to exhibit the wisdom and goodness displayed in its structure, and thus to draw forth admiration and love toward the Divine Creator. But, in the treatment of the particular lesson, there should, we repeat, be one, or at most two or three prominent points put down in the sketch, which should be natural, simple, and striking; it should be the special aim of the teacher to work them out. The sketch should declare the plan by which the children are to be conducted to these points: thus, in a lesson on an object, it should show how any particular idea is to be developed, or how the children are to be led to discover the fitness of the object for its use; in a lesson in natural history, how an animal's organization is adapted to its habits; on number, by what steps the children are to be induced to draw conclusions for themselves; in a Bible lesson, how it is purposed to produce an impression, and to bring a truth or precept within the sphere of the children's perception and self-application.

With respect to the details of information, a sketch, whether drawn up by a teacher for her own use in the school, or by a student in training,* should contain what may be called *suggestive hints* of the subject of the lesson. It should equally avoid detailed information, on the one hand; and on the other, mere general notices, such as constitute a table of contents, or heading of a chapter. In the former case the document would present the appearance of a depository of information, rather than a sketch; and the

* For examples of these two kinds of sketches, or rather of memoranda and sketch, see the memoranda and the sketch for lessons on the Mole, p. , Fourth Step.

to the discovery of any truth. Precise, unvarying rules may be laid down for mechanical operations; but mind alone can act upon mind, and bring it into vigorous exercise; and all instruction must be dry and uninteresting, which has not undergone some modification from the person by whom it is communicated.

There are several faults into which teachers are likely to fall; one is that of telling too much, for though the information may be received with pleasure, and appear to profit, yet under such a mode of instruction, the pupils' minds remain almost passive, and they acquire a habit of receiving impressions from others, at a time when they ought to be gaining mental power by the exertion of their own faculties. Another mistake is that of giving a term before the pupil has felt his want of it.* When the idea of any quality has been formed in his mind, without his being able to express it, the name given under such circumstances fixes it on the memory: thus, when a child observes that whalebone, after having been bent, returns to its original position, he may be told that this property which he has discovered is called *elastic.*

In the First Step the children are led to discern and name the several parts of an object, as also to the distinct perception of some of the more obvious qualities, without

* The writer desires particularly to enforce this remark, having in one or two instances seen the lessons altogether misused. Thus the qualities were told, and the explanation of the terms given, instead of the object being presented to the children that they might make their own observations upon it, and learn from the teacher how to express qualities clearly discerned by them, although unknown by name.

the communication of a term by which to express such perception, except in those cases where the term is familiar.

LESSON I.

A BASKET, FOR ITS PARTS.

Require the children to name the object, and to tell its use—as to hold potatoes, peas, bread, tea, sugar, books, work, paper, &c.; and then to point out its parts, as the lid, the handles, the sides, the bottom, the inside, the outside, and the edges; to describe the use of the lid—to cover the things contained in the basket, and to prevent them being seen; and to tell also the use of the sides and of the bottom. What would happen if the basket had no lid? The things it contained would be seen, and the dust would get in. What would happen if it had no handle? It could not be conveniently held. Show me how you would be obliged to hold it if it had no handle. Would you like to have to hold it in that way? What would happen if there were no sides to the basket? The things it contained would fall out sidewise. What would happen if there were no bottom to the basket? They would fall downward, nor would the basket stand safely. Then make the children repeat together the names of the various parts of a basket. "The basket has a lid, a handle," &c.

LESSON II.

A NEEDLE, FOR ITS PARTS.

The children to give the name, and tell how the needle is used: What persons use needles? What *men* use ence. What they have seen pigs doing? Their color, shape, &c. Where pigs live? If they have ever seen a sty? What they eat out of? &c., &c. Thus leading them to talk familiarly and to say all they can about pigs.

II. Speak of the use of the pig to man. What it's flesh is called? If they have ever tasted it?

III. Who made the pig? How we should feel toward God, who has given us this useful animal. How it should be treated; giving some examples which have come under their notice of cruelty to the pig; appealing to the children if this conduct is right, or pleasing to God. How God would regard such children. How all animals which God has made should be treated, and if they would like to be treated cruelly themselves. By these and similar questions exciting humane feelings toward animals.

LESSON VII.

A PENCIL, TO DEVELOP THE IDEA OF ITS PARTS AND THEIR USES.

The children repeat together: This is a pencil. Who can tell the use of a pencil? It is used for writing. What do you mean by writing? Look at me. The teacher makes some unmeaning marks on paper, and asks: Is this writing? No. The teacher next forms some letters or words, on the board, and asks: Is this writing? Yes, it is. Now you can tell me when we *write* with a pencil. When we use it to make words. Do any of you know any other use of a pencil? Some child will perhaps say: It is used

to draw with. Repeat together: "*A pencil is used to write with and to draw with.*" If you wished to write or draw, could you do so if you had a pencil alone, and nothing more? No. Right; you must have paper, or something to write or draw upon. Now look well at the pencil, and tell me if it is everywhere alike, as this piece of chalk is? What can any of you see? The wood of the pencil. What more? The lead of it. The wood is not then the *whole* of the pencil? what is it? It is a part of it. And what is the lead? The lead is also a part of the pencil. What can you say the pencil has? The pencil has parts. Try and find some other parts. Call a child to touch some part of the pencil; he will most likely touch the ends; the children may not know how to call them; they may be told they are the ends of the pencil, and then repeat together: The pencil has ends. How many ends has a pencil? Two. Before any one can use the pencil for writing, what must be done to one of the ends? It must be cut. What do we form when we cut it? We form a point. What more do you see on the pencil? Some words. That is the maker's name. Now repeat together the parts a pencil has. A pencil *has* wood, &c. What is the use of the lead? What would be the consequence if there were no lead in the pencil? What is the use of the wood? What do you think would be the consequence if the pencil were all lead? Yes; one disadvantage would be that it would blacken our fingers. Now tell me where the lead is. Repeat together: "*The lead runs along the middle of the pencil.*" Where is the wood? Repeat together: "*The wood is round the lead.*" Where is the point? Repeat together: "*The point is at one end of the pencil.*"

LESSON VIII.

MILK.

What is this in the glass? Milk. Where do we get milk? It comes from the cow. How can you tell that this is milk and not water? By its being white. Is there any other reason for your saying that it is not water? We cannot see through it. Repeat together: "*Milk is white, and we cannot see through it.*" Taste it. It is very nice. What kind of taste has it? It has a sweet taste. Repeat: "*Milk has a nice sweet taste.*" You have told me in what it is unlike water, now find out something in which it is like water; now look at me (the teacher pours out a little of the milk in drops); it will wet anything; it forms itself in drops. We call those things which make others wet, and form themselves into drops, *liquids.* What then is milk? Milk is a liquid. Tell me some other liquids. Water, beer, &c. What use do we make of milk? We drink it. Why are little children fed upon milk? To make them grow. Yes; and because it makes them grow it is said to be *nourishing.* Tell me some other things that are nourishing.

Do you know any other animal besides the cow that gives milk? Yes, the ass and the goat. I think you can all tell me why God gave animals milk. Yes, He gives it

to them to be food for their young. Why is milk so suitable for the food of young animals? Because it is so nourishing. How kind it is in God to give animals such nice nourishing food for their young, to keep the little things alive till they have teeth to bite the grass! What is the young of the cow called? A calf. Now repeat all you know about milk. "*Milk comes from the cow. God gives it to the cow to feed the young calf when it has not teeth to bite the grass. Milk is white, and we cannot see through it; it tastes nice and sweet; it is a liquid, and makes very nourishing food.*"

LESSON IX.

A FEATHER.

What is this? A feather. Whence does it come? It comes from off a bird. How do you think a bird would feel without its feathers? Very cold. Of what use then are feathers to birds? They keep them warm. What do we wear to keep us warm? Coats, frocks, aprons, &c. Do you know one word by which to speak of all these together? Yes; *clothing.* Yes, and feathers are the clothing of *birds.* Now look at this feather (the teacher throws it up in the air); what do you see? It flies about. If I throw this cent in the air, will it do the same? No, teacher, it will fall to the ground at once. Why does the feather float in the air, and the cent fall to the ground? Because the feather is *light*, and the cent is *heavy.* I wish some of the older children to tell me why a covering so light as feathers is best suited to birds?

Because they have to fly in the air. Yes; and if they had very heavy clothing they would *fall down.* We see then that the great God who is in heaven cares even for the little birds. He tells us in His Holy Word, that not even a sparrow falls to the ground without His knowing it; and if He observes all that the little birds do, and takes such care of them, do you think He will ever forget you or me? Oh no, dear children! He knows everything you do, and everything that happens to you; and, in the same chapter of the Bible in which He speaks of His care of the sparrows, He says, much more will he take care of His children; you shall learn this verse, and I hope, when you see the little birds flying about so happily, you will remember that God, who takes such care of them, will never forget you.

But now examine the feather, and tell me what colors you see in it. Part of it is *white*, and part of it is *brown.* Here is another feather; what color is it? It is *green.* What then do you perceive as to the color of feathers. They differ. You may say, then, *feathers are of different colors.* Pass the feather round, and try to find out more about it. It is *soft.* Is every part of the feather soft? No, not the part in the middle. And what of that? It is *hard.* That hard part of the feather is called the shaft. What can you say of the shaft? It is hard. All repeat: *the shaft of the feather is hard.* What other difference is there between the shaft of the feather and the downy part of it? * The shaft shines, and the downy part does not. What do you call things that shine? *Bright.* And things that do not

* As feathers vary very much, the qualities will, of course, depend upon the particular specimen chosen for the lesson.

shine? *Dull.* Then the shaft of the feather is *bright*, and the down is *dull.* What other difference do you perceive? Feel the feather. We cannot easily bend the shaft. Do any of you know what we call things that cannot be easily bent? I think you must have heard; but attend, and try and remember what I say to you: things that cannot easily be bent are said to be stiff. Tell me some things that are stiff? Wood, slate. And what can you say of the shaft of the feather? It is stiff. Yes, the shaft is *stiff*, you cannot easily *bend* it; but the down you can *easily bend.* Hold up the feather to the light; we can see through it. Can you see through the feather itself? No, but between the parts of it. But if I put all the parts of the feather close together, what do you find then? We cannot see through it.

And now you shall tell me what are the uses of feathers? They are used for beds. Why do they make nice beds? Because they are soft. Why are they a suitable clothing for birds? Because they are light. Feathers then are useful to us because they are *soft;* they are useful to birds because they are *light*, and keep them *warm.* Did you ever see a slender piece of wood, pointed at one end, with three feathers fastened on the other end? Yes, teacher. What is it called? An arrow. Why were the feathers put on the wood? To make the arrow fly in a straight line.

Well; you shall now repeat all that you have said about feathers: "*Feathers are the clothing of birds; God has given birds a very light clothing, that they may the more easily fly in the air; God takes care of the birds, much* *more will He take care of us; feathers are of various colors; the shaft of the feather is hard, bright, and stiff; the downy part is soft and dull, and we can easily bend it; we cannot see through the feather; feathers are used for stuffing beds, because they are soft, and for arrows, to make them fly in a straight line."*

LESSON X.

LOAF SUGAR.

You can all tell me what this is. Yes. It is sugar. What kind of sugar is it? White sugar. Those who can tell me what sugar is, hold up their hands. You remember where the lead comes from? Out of the earth. And the feather? From off the bird. Now I will tell you about sugar; it is made from the juice that is pressed out of the stem of a plant. Here is the picture of the plant. The plant is called the sugarcane, and a very nice juice, which contains the sugar, is pressed out from the stem. Lo[illegible] the people in this picture. Are they like me? No, t[illegible] er, they are very dark. Some day we will talk about th[illegible] countries in which the sugar-cane grows, and where the dark-colored people live. Now, you must tell me all you can yourselves find out about the sugar. It is *sweet*. You all know that. Repeat: "*Sugar is sweet.*" Look, I put a piece of the sugar into some water; what do you perceive? It *dissolves*. Look again: I hold it to the flame of the candle. It *melts*. What then can you say of sugar? It dissolves in water and it melts in fire. Repeat: "*Sugar dissolves in water and melts in fire.*"* Now in what do lead and sugar differ? They both melt in fire, but the sugar alone dissolves in water. Now look at the sugar, and feel of it, and tell me anything you find out. It is hard. What more? It is white. Is all sugar white? No, some sugar is brown. Look at this piece of sugar again. It is bright. Is it bright in the same way that lead is bright? No, little bits of the sugar are bright. Yes, it appears like a number of little bright sparks; it is said to be *sparkling*. What can you say of sugar? It is sparkling. Repeat together: "*White sugar is sparkling.*" Well, try again. It is in a *lump*. Is all sugar the same? No, brown sugar is not in a lump as this is. Did you ever see an uncut piece of white sugar in a grocer's shop? What was its shape? *Round.* Was it all the way up the same size? No, it became smaller and smaller, till it ended in a rounded point. What is the use of sugar? To sweeten tea. What more? To sweeten puddings; to sweeten our food. Now repeat the heads of the lesson; "Sugar is made from the juice of *sugar-cane*; it is *very sweet*; it *melts in fire* and *dissolves in water*. Loaf sugar is *white*, *hard*, and *sparkling*; sugar is used to *sweeten our food*."

* The teacher should have a clear perception of the difference between the melting or fusion of a solid substance and the dissolving of substances.

LESSON XI.

FLINT.

What is this? A flint. What is a flint? A sort of stone. Where do we find stones? In the earth. Look at it; what can you say of it? It is *black.* The teacher holds up the flint. What do you all say of the color of the flint? It is black. Repeat together: "*The flint is black.*" What more do you see? It shines. All of you repeat: "*The flint shines.*" Do you think a piece of flint would make a good window? No. Why not? We could not see through it. All repeat: "*We cannot see through flint.*" Tell me some other things through which you cannot see. The walls, the slates, &c. Now pass the flint round and feel of it. What now can you say of it? It is hard; it is cold. Repeat together: "*The flint is hard and cold.*" What more do you observe? It is smooth. Repeat: "*The flint is smooth.*" Feel the edges. They are sharp. Repeat: "*The edges of the flint are sharp.*" The teacher strikes a piece of flint and a piece of steel together. What am I doing? Striking the flint and steel together. What do you see? Sparks of fire. What produced the sparks? The striking the flint and steel together. Repeat together: "*Flint strikes fire with steel.*"

Now repeat all that has been said about flint: "*Flint is a stone; it comes out of the earth; it is black; we cannot see through it; when we touch it we feel that it is cold, hard, smooth, and sharp at the edges; and it is used to strike fire.*"

LESSON XII.

WOOL.

What is this? Wool. Where does wool come from? It comes from off the sheep's back. What is a sheep? An animal. What is wool then? Part of an animal. Of what use is the wool to the sheep? It keeps it warm. Can the sheep make its own wool? No. Who gave the little sheep this warm clothing? God. Yes, God gave the sheep this warm clothing, because it could not make clothing for itself.

Now pass this wool round the class: look at it, and feel it, and tell me what you can find out about it. It is soft. Repeat: "*Wool is soft.*" It is all hairs. Yes. Repeat then: "*Wool is formed of hairs.*" Feel it again. It is *dry.* Repeat: "*Wool is dry.*" What more? It is warm. Does it feel warm, as fire does? No. What do you mean then? That anything made of wool keeps us warm. Repeat: "*Wool keeps us warm.*" Yes, it keeps us warm, because it prevents the warmth of our bodies from passing away from us.

Who can tell me what wool is used for? To make stockings and flannel. What do you call that very thick flannel which you have on your beds? Blanket. Do you know any kind of clothes which are made of wool. Yes, our fathers' coats. And what have some persons on their floors to keep their feet warm? Carpets. Carpets are made of wool.

Now repeat all you have said of wool: "*Wool comes* *from off the sheep's back; it is the clothing which God gives the sheep to keep it warm; wool is soft, dry, and made up of hairs; it keeps us warm; it is made into stockings, flannel, blankets, and carpets.*"

LESSON XIII.

A PIECE OF BARK.

What is this? A piece of bark. All look at it. Where do we find bark? On trees. On what part of trees? On the stem. On which part of the stem? Look and see. (The teacher brings in a piece of the stem of a tree on which the bark still remains.) On the outside. Repeat together: "*Bark is the outer part of the stems of trees.*"

Look at the bark; what do you perceive? It is *brown.* Repeat: "*Bark is brown.*" Look again; is it like glass? No, we cannot see through it. What can you say of it then? We cannot see through bark. Compare it with glass. It does not shine. When anything does not shine at all, it is said to be *dull;* what is the bark? It is dull. Repeat: "*The bark is dull.*" Show me some things in the room that are dull. Now feel of the bark. It is *rough.* And what more? It is *dry.* Now look (the teacher separates the fibres), it has strings or hairs. These strings or hairs are called *fibres*, and we say the bark is *fibrous.* Repeat: "*The bark is fibrous.*" Some plants have very fibrous stems, and are very useful to us on this account; here are some of the fibres of hemp; and here are some of flax, which supplies much of our clothing. I think you

can find out something more if you feel the bark again. Yes; it is hard.

Now repeat all you have said: "*Bark is the outside covering of the stems of trees; it is brown; we cannot see through it; it is rough, dull, dry, hard, and fibrous.*"

LESSON XIV.

A BOOK.

In the following lessons, terms expressing qualities that may be developed are given. The lessons may be carried out on the same general plan as the preceding. In no case should a term be given before the *idea* is developed, and the necessity for it is felt. Where the quality is not apparent to the senses, it must be brought out by experiment.

Parts.

The outside.	The leaves.
inside.	pages.
edges.	margin.
corners.	beginning.
binding.	type.
paper.	letters.
back.	numbers.
sides.	stops.
top.	words.
bottom.	sentences.
title page.	syllables.
preface.	lettering.
introduction.	stitching.
contents.	lines.
end.	paragraphs.

The children should determine the position of the different parts, their form and uses.

LESSON XV.

A PIN.

Parts.
The head.
shank.
point.

Qualities.
It is hard.
white.
bright.
solid.
smooth.
The head is round.
The point is sharp.
The shank is straight.
tapering.

Use.—To keep together for a time parts of dress, &c.

LESSON XVI.

A CUBE OF WOOD.

The cube will convey to the children a good idea of a *surface;* but as some confusion is likely to arise in their minds, when they are informed that what bounds every part of an object, and can be felt or seen, is the *surface*, and then, when they find that the surface is divided into parts, to be told that these divisions are called surfaces, it is therefore necessary to give them a name for the divisions of the surface—that of *faces* has been adopted. A sphere may be shown as an example of an undivided surface, and by comparing it with the cube, a clear idea of what is meant by *surface* and *faces* may be elicited.

Parts.
The surface.
faces.
edges.
corners.

Qualities.
It is hard.
light.
solid.
brown.
smooth.
dull.
burns with a flame.
The faces are flat.
square.
The edges are straight.
The corners are sharp.

LESSON XVII.

A THIMBLE.

Parts.
The inside.
outside.
top.
bottom.
rim.
border.

Qualities.
It is hollow.
silver.
full of little holes.
white.
bright.
hard.
curved.
The inside is smooth.
The outside is rough.

Use.—To preserve the middle finger from being pricked in working.

LESSON XVIII.

A KEY.

Parts.
The ring.
barrel.

Qualities.
It is hard.
steel.

Parts.	*Qualities.*
The wards.	The bright.
grooves.	smooth.
edges.	stiff.
surface.	liable to rust.
corners.	Part of the barrel is hollow.
	The barrel is in the form of a cylinder.
	The ring is curved.

Places locked up by a key.—Doors, gates, boxes, desks, portmanteaus, trunks, portfolios, tea chests, closets, drawers, cabinets, &c.

LESSON XIX.

A CUP.

Parts.	*Qualities.*
The bowl.	It is hollow.
handle.	hard.
upper rim.	curved.
lower rim.	glossy.
bottom.	smooth.
inside.	glazed.
outside.*	thin.
edges.	The rim is circular.
surface.	

* From the examination of such an object as a cup, glass, any vessel, or a box, children may be led to discriminate clearly the difference between outside and surface, and to see that the former is the opposite to the inside, while the latter is the boundary of every part of an object.

LESSON XX.

A PAIR OF SCISSORS.

Parts.	*Qualities.*
The limbs.	It is steel.
bows.	bright.
blades.	hard.
shanks.	cold.
rivets.	solid.
pivot.	The blades are pointed.
points.	One face is flat.
surface.	The other curved.
faces.	The front edge sharp.
	The back blunt.
	The bows are curved.

The children should name the kind of materials which scissors will cut, and point out the different manner in which knives and scissors cut.

LESSON XXI.

A BIRD.

Parts.		
The head.	Principal [illegible]s.	The qualities would depend on the kind of bird chosen for the lesson.
body.		
wings.		
legs.		
bea[illegible]		
eye[illegible]		
nostrils.		
neck.		

Parts.

The feathers.
bones.
claws.

Parts.

The skin.
feet.
joints.

LESSON XXII.

AN ORANGE.

Parts.

The peel.
rind of the peel.
white of the peel.
juice.
pulp.
seeds.
eye.
divisions.
membrane.
inside.
outside.
surface.

Qualities.

It is reddish yellow, or orange color.
in the form of a ball.
rough on the outside.
The pulp is juicy.
soft.
cooling.
sweet when ripe.
vegetable.
solid.
It has a sweet smell.

SECOND STEP.

In this Step the children continue to be exercised on the more obvious qualities, and the specific term by which to express the quality is given.

LESSON I.

A PIECE OF INDIA RUBBER, TO DEVELOP THE IDEA OF ONE KIND OF ELASTICITY.

Present the India rubber, and ask its name; then call a child to try and see what he can do to it. He can bend it and stretch it. Then call the children's attention to the shape and size of the India rubber, and to the child when stretching it, asking them what he is doing to it, and what change they notice in it when he is stretching it? It becomes longer. Then tell the child to let go the end he has pulled out, calling on the c[illegible]en to observe what happens to the India rubber. It [illegible]s to its shape. What was done to the India ru[illegible]ow did it appear while it was being stretched? [illegible]appened to it when let go? Now what have you particularly observed in India rubber? India rubber will stretch when pulled out, and returns to its place when let go. Children, repeat this together. Do you know how to describe this property of India rubber? It is said to be *elastic.* Repeat this word together. When are things said to be elactic? Tell me something that is elastic. Why do you say that India rubber is elastic?

Call upon a child to name that property of India rubber which has been illustrated in the lesson, and then all repeat the name of the property together.

LESSON II.

A PIECE OF SPONGE, TO DEVELOP THE IDEA OF ONE KIND OF ELASTICITY.

The name of the object first to be determined; then a child is to be asked to try what can be done to it, when it will be found that it can be pressed close together. Ask how the sponge appears when it is pressed tightly. It appears much smaller than before. Then tell the child to let it go, bidding all observe; the sponge returns to its former shape and size. One child is now to describe that which they have all observed to occur, both when the sponge was pressed, and when the pressure was removed; then all repeat together: "*Sponge can be pressed into a small space, but returns to its own shape and size when no longer pressed.*" Do you recollect something else, that after you have stretched it out, comes back to its shape when you let it go? What did you say that the India rubber was? In what are the India rubber and the sponge alike? They both return to their size and shape when you leave them

to themselves. Was the same done to both? What was the difference? The India rubber was stretched, the sponge was pressed. In what were they alike? They both returned to their shape when left to themselves. What did we say the India rubber was? The sponge is also elastic. Now what things are elastic? Why is the India rubber said to be elastic? Why is sponge said to be elastic? The children to be questioned as to the different ways in which things return to their shape or size, till they gain the clear idea "*that those things are said to be elastic, which, when their shape or size has been changed by force, return to it if left to themselves.*" They should repeat this together several times. The children then to say what is one of the most striking qualities of a sponge.

LESSON III.

WHALEBONE, TO DEVELOP THE IDEA OF ONE KIND OF ELASTICITY.

See that the children know what the object is; and then call one of them to try and see what he can do to it; he will find that he can bend it; tel[illegible] to let go one end of it, and bid the others obse[illegible] happens; after this, question them concerning [illegible]ng to its former shape. What kind of a line was i[illegible]t was bent? What when you bent it? What was it when you let one end of it go? Then give a child a piece of cloth; tell him to bend it; then tell him to let go of one end of it, and see whether it will do as the whalebone did, telling him also to state what he sees. The cloth remains bent, but what did you observe in the whalebone? After bending it, it returned to its own shape. What then can you say of whalebone? It can be bent, and on being let go, returns to its own shape. Anything which has this property which you have observed is said to be elastic. Repeat this word together. What is whalebone? Why is whalebone said to be elastic?

Let the children be required to say what other things they have learned about, which are elastic, and describe in what respect their elasticity differs from that of whalebone. One of these, *when stretched*, returns to its former shape; another, *when compressed*, returns to its former shape; and whalebone, *when bent*, returns to its former shape. In what were they all alike? They all take their own shape when left to themselves. What can you say of all? They are all elastic. Let the children next give the reason for their calling India rubber elastic, and then be told to repeat together: "*India rubber* is said to be elastic, because, after being stretched out, it goes back to its own shape when left to itself." Let another of them say why sponge is said to be elastic, and then let all repeat together: "*Sponge* is said to be elastic, because, after having been compressed, it takes its own shape and size when left to itself." Another should say in what manner whalebone is elastic, and then all repeat together: "*Whalebone* is elastic, because, when it has been bent, it goes back to its own shape when left to itself."

LESSON IV.

A PIECE OF GLASS, TO DEVELOP THE IDEA OF TRANSPARENCY.

The teacher is to show the children a piece of glass, and to lead them to observe its transparency; preparing them for this by holding a pebble, or any similar object, behind the black board or the slate, and asking them what she has in her hand; this they will not be able to tell; the object should then be withdrawn from behind the board, and held behind the glass, and the same question asked, which they will now be able to answer. She may then ask them why they could not tell her what she had in her hand when she held it behind the slate, and why they could tell her what it was when she held it behind the glass. Then they should be asked what they can say of the glass, and repeat together: "We can see through the glass."

The teacher asks the children what they have observed in glass, and says: Now I will tell you what we call that quality which you have observed. [illegible] we can see through a thing we say it is *transp*[illegible]peat this word together. What is glass? Wh[illegible] say it is transparent? What can you say of [illegible] When are things called transparent? Desire the children also to mention some other things that they can see through, and what they can say of them; the word *transparent* is then written on the board, and they learn to spell it.

LESSON V.

A PIECE OF SLATE, TO DEVELOP THE IDEA OF OPACITY.

What is this? A piece of slate. Repeat together: "*This is slate.*" Which of you can tell me in what part of a house slate is sometimes used? (Show of hands.) Yes; in the roof. It does well for covering the roof; but what would you say to making the windows of slate? Why would it not do as well as glass? We could not see through it. Let us try whether we can see anything through slate. The teacher holds it up, and puts several things behind it, which of course cannot be seen. What then can you say of slate? Why would it not do for windows? We should not be able to see through it. But more than that. Suppose the windows of this room to be of slate instead of glass, what would the room be? It would be dark. What is it that comes into the room through the glass? Light. What then is it that does not come through slate? Not even light can be seen through slate. What can you say of slate? We cannot see through slate. Now that you have observed this quality in slate I will tell you what such things are said to be. Tell me again what this quality is which you have observed in slate. That we cannot see through it; we cannot even see light through it. Such things are said to be *opaque.* Repeat this word together. Now repeat together: "*Slate is opaque.*" Tell me something else that is opaque. Why are wood, stone, and such like things, said to be opaque? What do you say wood is? Repeat together: "*Wood is*

opaque," &c. When is anything said to be opaque? The word must now be written on the board, and the children should learn to spell it. Now repeat together that quality of slate which you have now noticed. "*Slate is opaque.*"

LESSON VI.

LEATHER.

What is this? It is leather. What is leather? It is the skin of animals. Name some animals, the skins of which are used for leather. The cow, the horse, the calf, the sheep, and the dog. Does the skin of these animals look like this leather? No. What is the difference? Their skins are covered with hair. What has been done to them in making the leather? The hair has been scraped off. Yes; and the skin has been cleaned and smoothed. How do we get paper? It is made of rags. Is leather made by man, as paper is? No. But has he nothing to do to the skin of the animal in order to make it into leather? Yes; it is *prepared* by him for use.

This is a piece of the skin of a horse. What has been done to it? It has been prepared. Now look at it and tell me what you see in it. It is black. Yes; this side of it is black; but this [illegible]*wn.* And what side would you call that which is [illegible] The upper side. And what that which is brown [illegible]nder side. Then how should you describe this [illegible] leather? The upper side of it is black, and the under side brown. Look at it again. We cannot see through it. You have learned the term for this, have you not? Yes; it is opaque. (The teacher writes the word on the board, and the children spell it.) Tell me some things which are opaque. Stone, wood, slate. What are all these? Look at the leather again. It is dull. Observe both sides of it. The upper side is rather bright; the under side is dull. Now you have said that this leather is *black* and *bright* on the upper side, and *brown* and *dull* on the under side, and that it is *opaque*. How did you find out these qualities? Yes, by your sight.

Now, take the leather in your hand, and tell me what you observe. It is thin. But if you compare it with the paper, what would you say? It is not so thin as the paper. What more do you notice when you feel of it? It is smooth. Compare the two sides. The upper side is the smoother. Try again what you can do with it. We can easily bend it. What could you do with the paper? Fold it up. Can you do the same with the leather? No; we can bend it; on this account it is said to be *flexible*. When do we call a thing flexible? When we can easily bend it. What can you do with the paper besides bending and folding it? We can tear it. Try to tear the leather. We cannot do so. Why? Because it is *tough*. Take it in your hand again, and try if you can say anything more of it. It is light. Now, you have told me that this leather is *thin, smooth, flexible, tough*, and *light;* how did you discover these qualities? By our hands. Yes, by feeling or touch.

Now shut your eyes, and I will hold the leather near you, but without letting you see it or touch it; what can you tell me about it now? It has a smell. Whatever has

a smell is said to be *odorous*. What then is leather? It is odorous. How did you find out that it was odorous? By the nose. In what manner? By smelling it. You found out some qualities in this leather by the *eye*. Yes. In what way? By looking at it. And some qualities you found out by the *hand*. Yes. How did you do this? We touched it. And you found out that it was odorous by the *nose*. In what manner? We smelled of it.

Are you now wearing anything made of leather? Yes, shoes. Why is leather fit for shoes? It is strong. Yes, it is strong or *durable*. Why does your mother, in wet weather, wish you to have a good pair of leather shoes in which there are no holes? That our feet may be kept dry. Then the water does not come through leather. It is *waterproof*. Why then is leather fit for shoes? Because it is durable and waterproof. You have before mentioned some other qualities which make leather fit for shoes; you would not like, I should think, to wear iron shoes? Why not? Because they would be so heavy. Leather then is fit for shoes because it is *light*. Why would wooden shoes be unpleasant to wear? They would hurt the feet. Why does leather not hurt the fe[illegible] It bends to the shape of the foot. Yes; it is *flexibl*[illegible]

Now, I will show yo[illegible]ing more in the leather; see, I put it in the fire[illegible]*les* up. What did you notice in the paper when put into the fire? It was soon burned up. And what do you observe in the leather? It has a very unpleasant smell when burning. This is what happens to animal substances when you burn them; they frizzle up, and give out a disagreeable *odor*.

Now, repeat together all that has been said about leather: "Leather is the *skin of an animal.*" What is done to it? It is prepared. "Leather, then, is the *prepared skin of an animal.* By the eye, or by the sense of sight, we find out that it is *black* and *bright* on the *upper side*, *brown* and *dull* on the *under surface*, and that it is *opaque;* by our hands, or by the sense of feeling, we find that it is *thin*, *tough*, *flexible*, and *smooth;* by the nose, or by the sense of smell, we find that it is *odorous.* When we put it into the fire it *frizzles up*, and gives off a *disagreeable odor:* it is fit for *shoes*, because it is *lasting*, *thin*, *light*, *flexible*, and *waterproof.*"

LESSON VII.

LOAF SUGAR.

Ideas to be developed by this lesson—*soluble*, *fusible*, *brittle.*

Qualities of Loaf Sugar.

It is soluble.	It is white.
fusible.*	sparkling.
brittle.	solid.
hard.	opaque.
sweet.	

Use.—To sweeten our food.

* The difference between fusibility and solubility may be rendered obvious to the children, by dissolving one piece of sugar in water, and holding another over the candle. It is better that such simple experiments should be performed in their presence, than that a mere description of the operation should be given.

LESSON VIII.

A PIECE OF GUM ARABIC.

Ideas to be developed by this lesson—*semi-transparent*, *adhesive.*

Qualities of Gum Arabic.

It is hard.	It is soluble in water.
bright.	adhesive when melted.
yellow.	solid.
semi-transparent.	

Use.—To unite light and thin substances.

LESSON IX.

SPONGE.

Ideas to be developed by this lesson—*porous*, *absorbent.*

Qualities of Sponge.

It is porous.	It is elastic.
absorbent.*	dull.
soft.	flexible.
tough.	light brown.
opaque.	

Use.—For washin[illegible]

* The quality of abs[illegible] be made obvious to the class by showing that the sponge suck[illegible]y liquid. It possesses this quality in consequence of its being full of pores. The use to which an object is applied, often leads to the observation of the quality upon which the use is dependent.

LESSON X.

WOOL.

Qualities of Wool.

It is soft.	It is tough.
absorbent.	durable.
white.	opaque.
flexible.	dry.
elastic.	light.

Uses.—For making cloth, flannels, blankets, carpets, stockings, &c.

LESSON XI.

WATER.

Ideas to be developed by this lesson—*colorless, reflective, inodorous, cleansing.*

Qualities of Water.

It is liquid.	It is inodorous.
reflective.	transparent.
glassy.	cleansing.
colorless.	

Uses.—To cleanse; to fertilize; to drink; for cooking purposes.

LESSON XII.

A PIECE OF WAX.

This substance is here introduced, because it possesses many of the qualities already noticed.

Qualities of Wax.

It is solid.	It is sticky.
opaque.	yellowish.
dull.	hard.
tough.	odorous.
fusible.	smooth.

Use.—To make candles and tapers.

LESSON XIII.

CAMPHOR.

Ideas to be developed by this lesson—*aromatic, stimulating, inflammable, soluble in spirits.*

Qualities of Camphor.

It is aromatic.	It is soluble in spirits.
stimulating.	hard.
white.	solid.
semi-transparent.	very inflammable.
bright.	light.

Uses.—For medicine; to prevent the taking of disease; to preserve cabinet[illegible]m small insects.

LESSON XIV.

BREAD.

Ideas to be developed by this lesson—*edible, wholesome, nutritious, moist.*

Qualities of Bread.

It is porous.	It is opaque.
absorbent.	solid.

Qualities of Bread.

It is wholesome.
nutritious.
edible.
The crumb is yellowish white.
soft, when new.

The crumb is moist.
The crust is hard.
brittle.
brown.

Use.—To nourish.

LESSON XV.

SEALING WAX.

Idea to be developed by this lesson—*impressible.*

Qualities of Sealing Wax.

It is hard.
bright.
brittle.
fusible.
opaque.
soluble in spirits.
light.
solid.

It is smooth.
colored.*
inflammable.
odorous.
When fused it is soft.
impressible.
adhesive.

Use.—To seal letters.

LESSON XVI.

WHALEBONE.

Idea to be developed by this lesson—*fibrous.*

Qualities of Whalebone.

It is elastic.
durable.
hard.

It is fibrous.
opaque.
stiff.

Uses.—As a stiffener; for whips, &c.

* The color will be determined by the specimen presented.

LESSON XVII.

GINGER.

Ideas to be developed by this lesson—*pungent, medicinal, jagged.*

Qualities of Ginger.

It is pungent.
dull.
hard.
dry.
fibrous.
aromatic.

It is tough.
opaque.
wholesome.
medicinal.
jagged.
light brown.

Uses.—To flavor food; for medicine.

LESSON XVIII.

BLOTTING PAPER.

Ideas to be developed by this lesson—*pinkish, pliable, artificial.*

Qualities of Blotting Paper.

It is absorbent.
porous.
soft.
thin.
pinkish.

It is pliable.
dull.
inflammable.
easily torn.
artificial.

Use.—To suck up superfluous ink.

LESSON XIX.

A PIECE OF WILLOW.

Qualities of Willow.

It is hard.
inflammable.

It is fibrous.
dull.

Qualities of Willow.

It is opaque.
solid.
elastic.

It is flexible.
white.
odorous.

LESSON XX.

MILK.

Idea to be developed—*greasy.*

Qualities of Milk.

It is white.
liquid.
opaque.
wholesome.

is greasy.
nutritious.
sweet.

Uses.—To make cheese, butter, puddings; to drink; food for young animals.

LESSON XXI.

RICE.

Qualities of Rice.

It is white.
hard.
opaque.
smooth.
stiff.
bright.

It is solid.
porous.
absorbent.
wholesome.
nutritious.

Use.—To nourish.

LESSON XXII.

SALT.

Ideas to be developed by this lesson—*granulous, sapid, saline, preservative.*

Qualities of Salt.

It is white.
sparkling.
granulous.
sapid, or has a taste.
salt, or saline.

It is hard.
opaque.
soluble.
fusible.
preservative.

Uses.—To flavor food; to preserve from putrefaction; to manure land.

LESSON XXIII.

A HORN.

Qualities of a Horn.

It is hard.
dull.
uneven.
hollow.
odorous when burnt.

It is tapering.
opaque.
stiff.
yellowish brown.
fibrous.

Uses.—To make combs, glue, lanterns; handles to knives and forks.

LESSON XXIV.

IVORY.

Qualities of Ivory.

It is hard.
white.
smooth.
bright.

It is opaque.
solid.
durable.

LESSON XXV.

A PIECE OF THE BARK OF THE OAK TREE.

Idea to be developed by this lesson—*astringent.*

Qualities of Bark.

It is brown.	It is stiff.
rough on the outside.	solid.
smooth on the inside.	durable.
opaque.	fibrous.
dry.	dull.
inflammable.	astringent.*

Uses.—To guard the tree from injury; for tanning

LESSON XXVI.

AN UNCUT LEAD PENCIL.

From this object the children may become acquainted with the *cylinder;* for they will not fail to observe that the ends are flat, and that the other face is curved.

Idea to be developed by this lesson—*cylindrical.*

Parts.	*Qualities.*
The surface.	It is hard.
faces.	odorous.
ends.	long.

* The children may be made to understand the quality of astringency, by drawing their attention to the contracting effect produced in the mouth by eating a choke cherry or piece of alum.

Parts.	*Qualities.*
The lead.	It is solid.
wood.	opaque.
	inflammable.
	dry.
	brown.
	One face is curved.
	The ends are flat.
	circular.
	The form is cylindrical.
	The lead is gray.
	brittle.
	friable.
	bright.

Uses.—For writing, drawing, &c. Let the children point out on what occasion a pencil is preferable to a pen, and *vice versa.*

In this lesson, and others, the conceptive faculty may be exercised, by requiring the children to recall to their minds some object in which they had observed before the quality of inflammability, [illegible]o that of friability.

[illegible]SON XXVII.

A WAX CANDLE.

This object recalls the idea of the *cylinder*, obtained in a previous lesson, and presents the peculiar *parts* of the candle itself.

Parts.	*Qualities.*
The wick.	It is cylinder.
wax.	hard.

Parts.	*Qualities.*
The surface.	It is opaque.
faces.	yellowish white.
ends.	The wax is sticky.
edges.	fusible.
top.	The wick is inflammable.
bottom.	tough.
middle.	white.
	fibrous.
	flexible.

Use.—To give light.

The children should be asked, What must be done before the candle gives light? What becomes of the wick? What of the wax?

LESSON XXVIII.

A PEN.

A pen presents many different *parts;* the *qualities* of some of these are opposite to the *qualities* of others.

Ideas to be developed by this lesson—*angular, grooved, spongy.*

Parts.	*Qualities.*
The quill.	The quill is transparent.
shaft.	cylindrical.
feather.	hollow.
laminæ.	bright.
pith.	hard.
nib.	elastic.
split.	yellowish.
shoulders.	horny.

Parts.	*Qualities.*
The surface.	The shaft is opaque.
faces.	angular.
skin.	solid.
groove.	white.
inside.	stiff.
outside.	hard.
	grooved.
	The pith is white.
	spongy.
	porous.
	elastic.
	soft.

THIRD STEP.

INTRODUCTORY REMARKS FOR THE DIRECTION OF THE TEACHER.

In this series the children may be led to the observation of *qualities* which cannot be discerned merely by the senses. Thus by showing them at the same time wool and woollen cloth, and questioning them as to the difference of the two, they will readily conceive the ideas of *natural* and *artificial.* In this manner they may be led to remark the distinction between *foreign* and *native; exotic* and *indigenous; animal, vegetable, mineral, &c.*

At this Step the conceptive powers should be more decidedly called into exercise; the way for this is prepared by the clearness and vividness of the ideas obtained through the careful cultivation of perception.

LESSON I.

CHALK.

What is this? A piece of chalk. Where do we get chalk? Out of the earth. What are those places called out of which chalk is taken? Chalk pits. God has placed

a great deal of chalk in the earth in some countries, so that it rises up and forms low, rounded hills. Where have you ever seen a hill? Chalk, you say, comes *out of the earth,* dug from *chalk pits.* Paper, you remember, is *made* by man—leather is *prepared* by man, but chalk is neither made nor prepared by man; and it is therefore said to be a *natural* substance. Why is chalk said to be natural? Because it is neither made nor prepared by man.

Why do you think that this is chalk? It is white. Yes, chalk is *white,* but milk is white also; how then do you know chalk from milk? Milk is liquid. Yes, the chalk does not flow or form itself into drops; it is in a solid lump. Chalk is *solid.* Why do we call it solid? Because it does not form drops, but is found in a lump.

Now look at this lump of sugar; this, like the chalk, is white and solid; how do we know it from the chalk? It is sparkling. Yes, and the chalk is *dull.* Now you have seen that the chalk is *white, solid,* and *dull.* Look at it again. We cannot see[illegible]ugh it. What then can you say of it? It is op[illegible]us by the sense of sight you discover that ch[illegible], *solid, dull,* and *opaque.*

Now feel [illegible]alk. It feels very dry. Rub it. It crumbles. Into what condition does it crumble? That of a powder. Chalk is *dry* and *crumbling.* What happens when I draw the chalk across the slate? Some of the chalk remains on the slate, and leaves a mark. That is because the chalk is *crumbling.* What quality of chalk makes it useful to us? That of its being crumbling. Who gave it this most useful quality? God. Yes; God, who made the chalk, made it of a crumbling nature.

And now tell me another sense by which we find out a quality, in addition to those of sight and touch? The sense of smell. Well, smell of the chalk. It has no smell; it is inodorous. How do you find out that sugar is sweet? By tasting it. But as chalk is not meant to be eaten, you need not taste it, though you may put it to your tongue, and tell me what you observe. It sticks to the tongue. Yes; repeat together: "*Chalk sticks to the tongue.*" Where have you seen chalk used? To write on the black board.

Now all of you repeat everything you have learned about chalk.

"Chalk is dug out of *chalk pits.* There is so much *chalk* in the *earth* in some countries, that it forms *hills. Chalk* is a *natural* substance, of great use to man. When we look at chalk we find that it is *white, solid, dull,* and *opaque;* by feeling it we find that it is *dry* and *sticks to the tongue;* it is *crumbling,* and therefore useful for *writing* with; it is *inodorous;* and it is used for writing on the black board."

LESSON II.

COAL.

I hold in my hand a piece of a natural substance, and I wish you to tell me what it is? But first tell me what I mean by a natural substance? That which is not made by man. The natural substance which I hold in my hand was dug out of the earth; it is black, and very useful to man; guess what it is. Yes, it is a piece of coal. Why did you

think it to be coal? Because you said that it was black, and that it came out of the earth, and was useful to man. What quality of coal is it which makes it so useful to man? Its being so *inflammable.* How is it that this quality of coal makes it so useful? Because we can cook our food, and warm our rooms with it. Yes; how sad it would have been last winter, if there had not been coals for fires. Who made coals inflammable? God. How very good is our Heavenly Father in giving to different things differing qualities, that they may be of varied use to man! He has caused some to be liquid, that we may *drink them;* some to be wholesome, that we may be *nourished* by them; some to be crumbling, that we may *write* with them; and some to be inflammable, that we may be *warmed* by them.

Now examine this piece of coal. It is very bright, and it is opaque. Repeat together: "Coal is *very bright,* and it is *opaque.*" Feel it. It is hard, solid, and brittle. Repeat together: "Coal is *hard, solid, brittle.*" Sometimes, teacher, there are li[illegible]ght yellow patches in the coal. Yes, those are [illegible] of iron; and we sometimes find pieces of slat[illegible]al, and then we say it is not good, it will not *burn well.*

What use do we make of coal? We cook our food and warm our rooms with it. What other use is made of coal? Gas is made from it. What is the use of gas? To light the streets. What other use is made of coal? It is used in producing steam. What does steam come from? From boiling water. What makes the water boil so as to become steam? The fire. And what makes the best fire? Coal. If we cannot get coal, what could we use instead of it? Wood. And what must we do to get wood? We must cut down our trees. Now repeat together your lesson upon coal: "Coal is a *natural substance* dug *out of the earth;* it is very useful to *man*, because it is very *inflammable.* It is *black, bright, brittle, hard,* and *opaque.* It is useful for *cooking our food* and *warming our rooms;* for making *gas*, and producing *steam*, and also for many other purposes."

LESSON III.

A MATCH.

Do you know what this is? Yes, teacher, it is a match. Are matches found ready made? No. How do we get them? They are made by some person. Tell me then what the different parts of a match are. The sulphur and the wood. And where is the sulphur put? At the end of the match. How many ends has the match? Two. Do you observe any other parts? The sides. Then the parts of a match are, the *wood*, the *sulphur*, the *ends*, the *sides.*

And now tell me what is sulphur? Where does it come from? It comes out of the earth. Who can tell me what we call things which are dug out of the earth, but which do not *grow* out of it? Stones. No; we do not call everything dug out of the earth stone; I think some of you will recollect a very useful thing, which, though it is dug out of the earth, we do not call a stone; what is it? Yes, coal. But you would not call coal a stone, would you, or sulphur? No; but everything that is dug out of the earth may be called a *mineral.* What then is a mineral? And now tell me what sulphur is. It is a mineral.

Why is sulphur said to be a mineral? Name any other minerals you know.

Now look carefully at the sulphur, and tell me something about it. It is yellow. Yes; all of you repeat together: "Sulphur is *yellow.*" See, I put some of it to a lighted candle. It is on fire. What do you say those things are that readily take fire? They are inflammable. Sulphur is *inflammable.* Did you notice anything more in the sulphur when it took fire? The flame was very blue. Repeat: "Sulphur burns with a *blue flame.*" I think you can find out something more by my having set the sulphur on fire. It gives off a very unpleasant smell. What are those things called that give out a smell? Sulphur is *odorous.* By what did you find out that sulphur was odorous? By the nose. What use did you make of your noses then? We smelled with them. By what did you find out that sulphur was yellow? By the eye. What use did you make of your eyes then? We saw with them. There is something more that the [illegible] does to the sulphur; what is it? The fire melts [illegible]t: "Sulphur *melts* when heated." What is the [illegible]t makes sulphur useful to us? Its being inflamm[illegible].

Of what is the greater part of this match made? Of wood. You have told me that sulphur is a mineral, because it is found in the earth; now what is wood? It is a *vegetable.* Yes; all repeat together: "Wood is *vegetable.*" What is it taken from? A tree. What kind of wood is this? It is pine. Yes; and here is a picture of the pine tree.

Now examine this piece of wood, and tell me something about it. It is hard; it is dry; it is opaque; in color it is yellowish white. Repeat these qualities of wood all together: "Pine wood is hard, dry, opaque, dull; the color is yellowish white." Now I will put a bit of it to the flame of this candle. It has taken fire: it is inflammable. What difference did you observe between the sulphur and wood when put into the flame? The sulphur took fire sooner, and burned with a blue flame. Yes; and it also melted into drops; but what does wood become when it has been burned? It becomes ashes. Now think a little and try to find out why both sulphur and wood are required in order to make a good match? The sulphur is used in a match because it takes fire so quickly. And what of the wood? How long did the sulphur burn? It burned but a very short time. It would not burn long enough to enable any one to light a candle or fire from it; but the wood burns a much longer time; so we have the sulphur because it takes fire quickly, and sets fire to the wood; and the wood, because it burns much longer, and enables us to light a fire or candle without hurry.

Now you shall repeat all you have said about the match. "A match is made of *wood* and *sulphur*. The sulphur is placed at *one end;* it is a *mineral substance*, and comes out of *the earth;* it is *yellow;* it is very *inflammable*, burning with a *blue flame;* it also *melts in fire*, and is very *odorous*. Wood is a *vegetable substance*, and comes from a *tree* called *a pine tree*. The wood is *inflammable*, but it does not burn away so *fast* as the *sulphur;* it burns to *ashes;* its color is *yellowish white;* it is *hard*, *dry*, *dull*, and *opaque*."

LESSON IV.

A ROSE LEAF.

What is this? It is a leaf. Where are leaves found? On plants and trees. What leaves do cows and horses eat? Those of the grass. What leaves do we sometimes eat? Cabbage leaves and spinach, &c. Do you know a word by which you can at once speak of trees, and grass, and cabbages? What is one of the largest vegetables you have ever seen? An elm tree. Tell me the name of a smaller one. Wheat. Tell me of one we often eat. Lettuce. What are all these called? Vegetables. Where do vegetables come from? They grow out of the ground. If I had a piece of land without any vegetables growing upon it, what must I do to raise some? You must sow some seed in it. Where must I put the seed? In the earth. If I were to sow some grass-seed, what would follow? Some grass would spring up. And what would it be at first? Very small. If it were healthy, would it continue so small? No. What would it do? It would grow. If I were to put an acorn in the ground, what would happen? A little root would burst out of it and go down into the ground, and a little green shoot would come up and put out some little leaves. Yes, and at first it would be very *small;* but it would *grow*, so that in many years it would become a great *oak*. But would the same occur if I buried a piece of flint or coal in the earth? No. These do not *grow* out of the earth as vegetables do.

Now you know the difference between a mineral and a vegetable. Look at this leaf, and tell me its different parts. By what part do I hold it? The stalk. What does the stalk bear? The leaf. The stalk that bears a leaf is called the leaf stalk; what is this? A leaf stalk. Find out some of the parts of the leaf. The edge. Here are two leaves, one from a rose tree, the other from the plant on which the lily grows; what difference do you observe in the edges of them? The rose leaf has little points, which the lily leaf has not. Yes; the points are called teeth, because they are like the sharp pointed teeth of some animals; and an edge, that has such points, is said to be *toothed.* What is this edge? It is toothed. Why is it said to be toothed? Because it has points like the teeth of some animals.

Find out some other parts of this leaf. There is a line down the middle of it. Yes; that line is called the *midrib.* See whether the midrib is the same on both sides of the leaf. It sinks in on one side and stands out on the other. Which of you can tell me what they call the hollow line made by the plough in a ploughed field? A furrow. And what do they call the raised part on each side of it? A ridge. What is the midrib like on this side of the leaf? A *furrow.* And on this side it is like a *ridge.* Now you see there are two sides or surfaces to the leaf; by what names would you distinguish them? When the leaf is on the tree, which side is uppermost? This, therefore, is called the *upper side;* and what would you call the other? The *under side.* Look carefully at the leaf again. There are other lines upon it. Where do these lines spring from? From the midrib. And where do they end? In the edge. These lines are called the *veins;* in

what are they like the midrib? They sink in like furrows on the upper side of the leaf, and rise up like ridges on the under surface of it. Do you see any other part. The end. The point or end is opposite to the *stalk.*

Now tell me some of the qualities of the leaf; what can you say of it? It is green; it is rather bright. Look again, and see if both sides are bright. No; the under side is dull. Here are several leaves; what difference do you observe in their upper and under surfaces? The upper surface is the brighter. Feel of the rose leaf. It is thin; it is soft. Anything more? It bends easily. What do you say of a thing which bends easily? It is pliable. What can you then say of this leaf? It is pliable. What more do you notice when you feel of it? It is light and smooth. What is its shape? It is round. (The teacher draws a correct circle on the black board.) What, is it like this in shape? No, not quite. I will draw the shape of an egg; which is it more like? It is more like the shape of the egg. We call the shape of an egg *oval;* what would you say is the shape of this leaf? It is oval.

Now you must let me hear you all together repeat the heads of this lesson on the rose leaf. "A rose leaf is a *vegetable substance;* it grows on a *leaf stalk;* it has a *toothed edge;* it has a *midrib,* which is like a *furrow* on the *upper side,* and like a *ridge* on the *under side;* it has also many *veins,* which are like *furrows* on the *upper side,* and like *ridges* on the *under side.* Its color is *green;* its shape is *oval.* To the touch it is *thin, soft, smooth;* it is *pliable;* the upper side is rather *bright,* and the under side is *dull.*"

LESSON V.

HONEY COMB.

What is this? A piece of honey comb. Where does it come from? A bee hive. Who placed it in the hive? The bees made it there. Can you tell me how the bees made it? No, I am sure you cannot. They have no hands, nor tools, yet see how beautifully it is made; not one of you could form such a piece of comb. Where did the bees learn how to make the comb? Yes; God taught them, and enabled them to do it well. He has taught all animals to do whatever is necessary to their comfort. Now look at the honey comb, and tell me what you see. It is full of holes. The holes are called cells. What parts do you see in the cells? What do we call that part of this room in which the windows are, and where the door is? The sides. Well, see what the cells have? They have sides. Count how many sides each cell has. Yes; each cell has *six sides*. Look again at the room, and tell me what you call those parts of it in which the sides meet each other. The corners. And what has each cell? It has corners. How many corners has each cell?—count them. Six. Repeat: "Each cell has *six corners*." When you look into the cell, what part of it do you see? The bottom, or floor of it. And what is the other end called? The top. What is there round the top? An edge.

Now try to find out some qualities of the honey comb; you may take it in your fingers. It is very light and sticky. Now look at it. It is dull. It is yellow. Hold it up

to the light. Is it transparent, or is it quite opaque? What do you observe? We see the light through it. When you see light through a substance it is said to be *translucent*. Why is this honey comb said to be translucent? Because we can see the light through it. Now look at it as I press it in my fingers. I have crushed it; it is *brittle*. Now I put it into the flame of a candle; it melts. When does it melt? When it is heated. It is fusible.

What use does the bee make of the cells? It stores up honey in them. And where does the bee get the honey? From flowers. Yes; in summer the bee collects honey, which it stores up in some of the cells; but it also uses others of the cells for another purpose; the young bees are kept in them, and these are fed and watched by the old bees till they get their wings, and then they fly, and begin to work themselves. And what do we make of the honey comb? We melt it down into wax. And what use do we make of the wax? We make candles of wax. Yes; and we rub furniture with it, to make it bright. I should think that some of you have seen wax used for other purposes beside these. Yes, teacher, my mother uses it. What does she use wax for? She rubs her thread with it to make it firm and strong. Now repeat all you know about the honey comb. "Honey comb is made by *bees*, who put into it the honey they get from *flowers*. It is formed of a number of little *cells*, each of which has *six sides*, and *six corners*, a *bottom*, or floor, and a *top* with an *edge*. Wax is very *light*, *thin*, and *sticky*; its color is *light yellow*; it is *dull*; it is *translucent*; it is *brittle*, and *melts when heated*. We use it to make *candles* and to polish *furniture;* it is used to *strengthen thread.*"

LESSON VI.

A BUTTERFLY.

What is this? It is a butterfly. What is a butterfly? An insect. What is an insect? It is neither a vegetable nor a mineral; it is an *animal.* Now examine the butterfly, and tell me its different parts. It has wings. How many wings has a butterfly? Four. What difference do you observe in these four wings? Two of them are large and two are small. What can it do with its wings? It can fly. Where are the wings placed? Two on each side of the body. In what position are the wings when the insect is flying? Are they in the direction of the walls of the room, or of the ceiling? They are in the direction of the ceiling.* In what other direction does the butterfly sometimes place its wings? It sometimes puts them upright, so that they touch each other; but when it flies they are always spread open. If you had a piece of thin paper, which you wished to float on the air, would you roll it up, or spread it out? I should spread it out. Yes; then the air would support it. What does the butterfly do that is like this? † It opens its wings and spreads them out.

* If the children have learned the difference between the horizontal and vertical position, they may here apply their knowledge.

† The youngest children should be led to the observation of facts. The reasoning upon them, and drawing conclusions from them, is the work of a later period.

What more do you observe in the butterfly's wings? They are beautifully marked. See, I rub the wings with my finger. What do you perceive? The color comes off. There is a kind of down upon the wings which is easily rubbed off. Repeat together: "The butterfly has *four wings,* two of them are *large* and two *small.* They are placed on either *side of the body.* When it flies the wings are *spread out;* when at rest, they are often *upright.* They are covered with beautifully colored *down,* which is *very easily rubbed off.*"

Now what other part do you observe in the butterfly? The legs. How many legs has a butterfly? It has six legs. Where are they placed? Underneath the body. What can the butterfly do with its legs? It can walk. Does it use them much in walking? No. What do you generally see a butterfly doing? Flying about. And when it is not flying, what is it doing? It is standing. What does it stand upon? Its legs. When we ourselves walk or move along we bend our legs; what do we call that part where the leg bends? We call it a joint. And what can the butterfly do with its legs? It can bend them. What then must it have upon its legs? Joints. Repeat together what you know of the butterfly's legs: "The butterfly has *six legs* placed *under its body;* the legs have *joints;* it uses its legs chiefly to *stand upon.*"

Now find out another part of the butterfly. Its body. What sort of a body has it? It is long and small. You may call it *slender.* Where is the body placed? Between the wings. What more do you observe in it? It is covered with hairs. Repeat together: "The body of the butterfly is *slender* and covered with *hairs;* it is placed between its *wings*."

What other part do you see? The head. And what has the butterfly upon its head? It has horns. How many? Two. What sort of horns are they? They are long. And what more? Fine. What do you observe as to the ends of these? They are thick. The horns of the butterfly always end in thick knobs. What more do you see on the head? Eyes. How many? Two. What is the use of the eyes? They are to see with. Look again at the head; there are some things that stick out. These are called feelers; most insects have four feelers. Look, here is something which I draw out from between the feelers. What is it like? It is like a rolled up hair. This is the butterfly's mouth, and it is called a trunk. Which of you can tell me what butterflies feed upon? Honey. And where do they find honey? In flowers. Yes; generally at the bottom of the flowers. Could they get at it if they had mouths like yours and mine? No. What then is the particular use of such a mouth as this to a butterfly? To get at the honey at the bottom of the flowers. Yes, the butterfly darts its trunk into the flowers, and as it is hollow, it can suck up the sweet honey through it. What pleasure you will now have in observing a butterfly, and in thinking that God has given it just such a mouth as an insect which feeds on honey needs, while ours is the best for us! Now repeat together the names of the parts of the butterfly's head: "The butterfly has *two eyes* on its *head*, and *two horns*, which are *long*, each ending in a *knob*. It has *four feelers;* between two of which is

placed its *mouth*, which is a long curled-up *trunk;* it darts this trunk into *flowers* to get at the *honey*."

The children's remarks upon the color and marks of the butterfly must be determined by the particular species of that brought before them. The teacher should lead them to admire its beauty, and to observe the happy life it seems to lead, and then draw attention to the sin of teasing a little creature which God has formed to be happy, and of injuring that which God has made so beautiful. No opportunity should be lost of endeavoring to counteract that propensity to cruelty which is so common in children; this evil disposition springs generally from a love of showing power; they should therefore be encouraged to exercise any power God may have bestowed, in increasing the happiness of all His creatures. They should be early trained to feel that they are accountable for every faculty they possess, even for their power over the most insignificant insect.

In what kind of weather do butterflies come out? In fine sunshiny weather. How do they employ themselves? In flying about and gathering honey. Would it be right in us to imitate the butterfly? No; because God has given us all work to do, and tells us in His Word to be as industrious as the ant. The life of the butterfly is short, it needs but to provide for the present day; but we should labor while we have youth and strength, that we may not be a burden to others when we become old.

Now repeat together all that we have said of the butterfly. "The butterfly is an *insect:* it has *four wings*, two of which are *large* and two are *small;* when it flies these are *spread out;* they are covered with beautiful *down,* which is easily *rubbed off:* between the wings is the *body,* which is *long* and *slender,* and covered with soft *hairs;* under its body are *six legs,* which have *joints;* it does not use its legs much in *walking,* but chiefly in *standing:* upon the head there are two *long horns,* with *knobs at the end;* two *eyes;* four *feelers;* between two of the feelers is placed the *mouth,* which is a *long, hollow* trunk, curled up when not in use; it darts this *trunk into flowers,* to get at the *honey,* upon which it feeds."

LESSON VII.

RECAPITULATION.

Here are the four objects upon which you have had lessons this week. What are they? A match, a leaf, a piece of honey comb, and a butterfly. Which of these is made by man? The match. What things must the person have who would make a match? Sulphur and wood. What kind of a substance is sulphur? It is a mineral substance. And what is wood? It is a vegetable substance. Upon what other vegetable substance have you had a lesson? A leaf. Are the leaf and the wood whole vegetables? No; they are but parts of vegetables. The butterfly is a whole animal. Tell me the name of another animal. A dog. I will write the names of these two animals on the board—butterfly, dog. Now, tell me the names of two whole vegetables, that I may write them down also. A rose tree, wheat. Now of two minerals. Sulphur and flint. We have now two *animals,* two *vegetables,* and two *minerals.*

Now tell me what can the butterfly do? It can fly.* What can the dog do? It can run. Can the dog fly, or the butterfly run? No. But can you not find out something that we can say is done by both of them, when the one flies and the other runs? They both move. In what manner does the butterfly move? It flies from flower to flower. Whom does the butterfly please in thus flying from flower to flower? Itself. The butterfly flies about whenever *it pleases.* And when the dog runs about or lies down to sleep, whom is he pleasing? Himself. Then the dog moves about whenever *he pleases;* what then can you say that both these animals do? They move about as they please.

But now think a little about these vegetables, and tell me how in this respect they differ from the animals. The vegetables cannot move about. Did you never see a tree move? Yes; when the wind blows. In what then is its moving different from the moving of an animal? The animal moves about when and where it likes, but the tree does not move from place to place; its branches move when the wind blows them. But think what vegetables do. If I wished to have a crop of wheat in my field, what must I do? Sow some seed. Yes; I must put the little seed into the ground; and what then? It will spring up. And what will it become at last? Wheat. Yes; a plant of wheat with a *stem,* and *leaves,* and a *head.* But what must have happened to the vegetable when, from being a little seed,

* Of course it is impossible to anticipate the exact answers of children, but the points here dwelt upon are those to which the teacher should direct observation by questions.

it has become a large plant? It must have grown. What then do vegetables do? They grow. Yes; vegetables grow. Do animals also grow? Yes. Tell me how you know that animals grow. We had a little kitten, which is now a great cat. What can you say of animals? That they grow, and move about where they please. What can you say of vegetables? That they grow.

But now think about minerals; supposing I put this piece of flint into the ground, as I might a seed; if I came in a fortnight, might I expect to see any part of it above the earth? No. Why not? If I had put in a seed I should expect to see a little shoot coming up. Yes; because the vegetable grows, but the mineral does not grow. Well, then, you have found out that animals *grow*, and *move about as they please;* vegetables *grow;* minerals neither *grow* nor *move* from place to place.

LESSON VIII.

SKETCH OF A LESSON ON THE MASSACRE OF THE CHILDREN OF BETHLEHEM.

Intended for Children of nine or ten years of age.

I. *Picture examined.*—Get the children to examine the picture, telling what they see; as, a man, a woman, a child. The man looks strong and fierce, holds a knife or dagger in one hand, a child in the other by one of its legs. The infant seems frightened; its mouth is open; it is crying. The woman is kneeling at the feet of the man, stretching out her arms toward the child; she looks frightened and im-

ploring. What does this mean? What does it appear the man is about to do with the infant? Why is the woman so imploring?

Thus introduced, endeavor to make the children picture to themselves the distressing scene recorded in Matthew ii, 16–18; how wretched the poor mothers must have been to see their helpless infants torn from them, and murdered before their eyes, by brutal men sent for that purpose—and probably in every house a murder; expressed in the language of Jeremiah, "lamentation, and weeping, and great mourning."

II. *Narrative told.*—Here read or detail to the children the circumstances that led to this general massacre of poor unoffending babes; questioning them, to ascertain that they are following the teacher. The wise men's visit—they apply to Herod for information as to the birthplace of the King of Israel, who hears them with astonishment—he consults the scribes, who point out Bethlehem as the place of Messiah's birth—he is moved with jealousy, fearing that his throne will be taken from him—under a mask of hypocrisy he directs the wise men to find out the new-born Prince, and requests them to return to him with tidings, that he may go and worship Him also—an angel tells them to return to their own country another way—Herod's disappointment—he orders the slaughter of all the children of a certain age, both in Bethlehem and the neighborhood, that among them the Saviour might fall—with fearful exactness his commands were carried out—an example of which we see in the picture before us.

III. *God's Providence.*—Lead the children to consider how God overruled Herod's wicked design, and preserved the infant Jesus. What did Herod think he had done? Defeated the indications of the star, and accomplished his own will in opposition to that of the Almighty. But had he done so? Remark that whatever crafty, cruel devices were in his heart, the counsel of the Lord must stand. This event formed another accomplishment of the words of the prophet Jeremiah (xxxi, 15–17). Thus, also, the date of Christ's birth was publicly marked, and all others who could have pretended to be the Messiah, as having been born at Bethlehem about the same time, were cut off. Lead the children next to see that Joseph knew neither the danger the Child was in, nor, if he had known it, was he aware of any way to escape; but an angel appears and tells him of both. "Take the young Child by night, and flee into Egypt." Thus the infant Jesus was rescued. How vain is it for man to contend against the Almighty!

IV. *Practical application.*—Direct the children, by questions, to observe the main ideas in the preceding parts of the lesson, and to make a threefold application: 1st, What the cruelty of Herod suggests. 2d, What the workings of God's providence. 3d, The preservation of the infant Jesus.

1st. From the cruelty of Herod we learn to what lengths wicked men will go when they give way to evil passions, and how guarded we should be against envy and jealousy.

2d. From the working of God's overruling providence, we see how He can thwart and baffle the wicked designs of men, and make their wrath to praise Him. But can the

Messiah, Who is to be the consolation of Israel, be introduced with all this lamentation? Yes; 1st, for so it was foretold; and 2d, if we look further, we shall find that the weeping in Ramah was but a forerunner to the greatest joy; for it follows: "Thy work shall be rewarded, and there is hope in thy end;" "Unto them a child was born," sufficient to repair their losses.

3d. From the preservation of the Saviour, we learn the security of God's people, which may be also seen in the case of David, who said: "I will not be afraid of ten thousands of people that have set themselves against me round about."

LESSON IX.

A QUILL.

This subject is taken as it brings up many terms previously developed.

Parts.	*Qualities.*
The quill.	It is long.
shaft.	stiff.
ends.	useful.
feather.	natural.
laminæ.	animal substance.
inside.	The barrel is transparent.
outside.	hard.
groove.	elastic.
surface.	bright.
faces.	yellowish.
pith.	cylindrical.
skin.	hollow.
	light.
	The shaft is feathered.

Qualities.

The shaft is white.
stiff.
hard.
opaque.
solid.
angular.
grooved.

Children may be led to remark the difference which fire produces on animal and vegetable substances, both as to appearance and smell.

The teacher now requires the class to give an explanation in their own words of the terms they have used.

LESSON X.

A PENNY.

Idea to be developed in this lesson—*metallic.*

Parts.	*Qualities.*
The surface.	It is round.
faces.	flat.
edges.	mineral.
milling.	metallic.
impression.	opaque.
image.	bright.
superscription.	reddish white.
date.	fusible.
	hard.
	artificial.*
	heavy.
	durable.
	uneven.

* The class should be led to remark that, though the workmanship is artificial, the substance is natural.

LESSON XI.

MUSTARD SEED.

Ideas to be developed by this lesson—*indigenous, pulverable, spherical.*

Qualities.

It is pungent.
yellow.
hard.
pulverable.
indigenous.
spherical.
stimulating.

It is dull.
opaque.
dry.
natural.
vegetable.
solid.

LESSON XII.

AN APPLE.

Idea to be developed—*membranaceous.*

Qualities.

It is spherical.
odorous.
colored.
opaque.
natural.
vegetable.
juicy.
hard.
solid.
pleasant.

The eye is dry.
brown.
shrivelled.

The seeds are brown on the outside when ripe.
white in the inside.
hard.

The core is membranaceous.
stiff.
yellow.
hard.
semi-transparent.

LESSON XIII.

GLASS OF A WATCH.

The ideas to be developed by this lesson—*concave* and *convex.*

*Parts.**	*Qualities.*
	It is artificial.
	transparent.
	brittle.
	bright.
	thin.
	hard.
	clear.
	curved.
	The upper face is convex.
	The under face concave.
	The edge circular.

Uses.—To preserve the hands of the watch from being injured, and to keep the works from dust.

LESSON XIV.

BROWN SUGAR.

The idea to be developed by this lesson—*native.*

Qualities.

It is brown.	It is useful.
granulous.	vegetable substance.
sweet.	artificial.
soluble.	native.
fusible.	sticky.
opaque.	moist.

* The children should be asked whether there are any parts to this object peculiar to it; and when, as in the watch glass, there are not, the naming of the parts had better be omitted.

Use.—To sweeten our food.

Obtained from the sugar cane, which is cultivated in the East and West Indies, and some of the Southern States.

LESSON XV.

AN ACORN.

Ideas to be developed—*oval, scaly.*

Parts.	*Qualities.*
The cup.	It is vegetable.
berry.	natural.
nut.	hard.
point of the nut.	green.
scar.	opaque.
scales.	The nut is oval.
surface.	bright.
edges.	solid.
	The cup is dull.
	The inside is concave.
	smooth.
	The outside is rough.
	brownish.
	scaly.
	The edge is circular.

LESSON XVI.

A PIECE OF HONEY COMB.

Ideas to be developed—*compressible, hexagonal, regular.*

Parts.	*Qualities.*
The cells.	It is natural.
divisions.	animal production.

Parts.	*Qualities.*
The edges.	It is light.
base of cells.	fusible.
corners.	sticky.
surface.	dull.
faces.	semi-transparent.
	yellowish.
	thin.
	compressible.
	brittle.
	The cells are hexagonal.
	regular.
	hollow.

LESSON XVII.

REFINED SUGAR.

The ideas to be developed by this lesson—*crystalline, amorphous, refined.*

Parts.	*Qualities.*
The surface.	It is white.
edges.	sweet.
middle.	sparkling.
crystals.	crystalline.
grains.	solid.
pores.	fusible.
	soluble.
	shapeless or amorphous.
	hard.
	refined.
	nutritious.
	crumbling.
	opaque.
	artificial.
	vegetable substance.
	brittle.

Brought from the East and West Indies or the Southern States in its raw state. Refined by sugar bakers, and sold by grocers in loaves of a conical form.

LESSON XVIII.

A CORK.

Parts.	*Qualities.*
The ends.	It is light.
surface.	compressible.
faces.	elastic.
edges.	opaque.
	dry.
	light brown.
	solid.
	porous.
	smooth.
	cylindrical.
	dull.
	inflammable.
	vegetable.
	The form is artificial.
	The substance is natural.

Uses.—To stop bottles, to buoy people up in the water. Children to determine what qualities fit it for its use.

LESSON XIX.

GLUE.

Idea to be developed—*tenacious.*

Qualities.

It is translucent.
mahogany brown.
When melted, it is tough.
adhesive.

Qualities.

It is hard.
solid.
animal substance.
artificial.

When melted, it is sticky.
elastic.
tenacious.

LESSON XX.

PACKTHREAD.

Ideas to be developed—*twisted, slender.*

Qualities.

It is dry.
dull.
twisted.
flexible.
tough.
opaque.
fibrous.
artificial.

It is durable.
light brown.
vegetable substance.
inflammable.
soft.
slender.
solid.
rough.

LESSON XXI.

HONEY.

Qualities.

It is sweet.
fluid.
thick.
liquid.
yellow.
sticky.

It is a vegetable substance.
natural.
nourishing.
healing.
opaque.

LESSON XXII

BUTTER CUP.

Parts.

The petals.
margins or edges.

Qualities.

It is vegetable.
concave.

Parts.

The cup.
leaflets of cup.
stamens.
pistils.
stalk.
place of insertion.
inside.
outside.
surface.

Qualities.

It is natural.
odorous.
The petals are yellow.
glossy in the inside.
dull on the outside.
circular.
pointed at the place of insertion.
striped.
opaque.
pliable.
The leaflets are greenish.
thin.
membranaceous.
semi-transparent.
pointed.
The stalk is green.
grooved.
angular.
stiff.
fibrous.

LESSON XXIII.

A LADY BIRD.

Ideas to be developed—*hemispherical, fragile, jointed.*

Parts.

The head.
eyes.
feelers or palpi.
horns, or antennæ.
wings.
wing cases, or elytra.
thorax.

Qualities.

It is animal.
natural.
hemispherical.
The wing cases are red.
spotted.
bright.
hard.

Parts.		*Qualities.*
The legs.	The wing cases are	brittle.
body.		opaque.
back.		stiff.
spots.	The outside is	convex.
surface.	The inside is	concave.
claws.	One margin	straight.
	The other	curved.
	The wings are	membranaceous.
		pliable.
		thin.
		transparent.
		fragile.
	The body is	oval.
		black.
	The legs are	jointed.
		short.
		black.

LESSON XXIV.

AN OYSTER.

Ideas to be developed—*marine, pearly, irregular.*

Parts.		*Qualities.*
The valves.	It is	animal.
hinge.		opaque.
outside.		marine.
inside.		natural.
margin.	The valves are	circular.
impressions.		hard.
mollusk.		stiff.
scales or laminæ.		pulverable.
	The outside is	rough.
		scaly or laminated.

	Qualities.
The outside is	irregular.
	dull.
	dingy brown.
	uneven.
The inside is	pearly.
	bright.
	smooth.
	slightly concave.
The mollusk is	soft.
	edible.
	nutritious.
	cold.
	smooth.
	slippery.

LESSON XXV.

A FIR CONE.

Ideas to be developed—*conical, tiled or imbricated, keeled.*

Parts.		*Qualities.*
The scales.	It is	brown.
seeds.		opaque.
top.		hard.
place of insertion.		vegetable.
fibres.		natural.
surface.		conical.
stalk.		tiled or imbricated.
		inflammable.
		odorous.
	The scales are	stiff.
		dull.
	The outside is	light brown.

Qualities.

The outside is pointed at the top.
rough.
irregularly conical.
The inside of scales is chestnut color.
shaded.
keeled.

LESSON XXVI.

FUR.

Ideas to be developed—*tubular, inanimate.*

Parts.	*Qualities.*
The skin.	It is an animal substance.
hair.	It is hairy.
surface.	inanimate.
points of hair.	The hairs are flexible.
	slender.
	soft.
	tubular.
	straight.
	The hairs are pointed.
	The skin is stiff.

The color and other peculiarities to be decided by the specimen presented.

LESSON XXVII.

A LAUREL LEAF.

Parts.	*Qualities.*
The upper face.	It is oval.
under face.	smooth.
edge or margin.	pointed.
point or termination.	vegetable.

Parts.	*Qualities.*
The veins.	It is odorous.
midrib.	opaque.
base.	bitter.
stalk.	stiff.
	long.
	The rib is straight.
	raised, or keeled on the under side.
	grooved on the upper side.
	The veins are curved.
	The margin is curved.
	slightly toothed.
	The upper face is bright.
	The under face is dull.

LESSON XXVIII.

A NEEDLE.

Parts.	*Qualities.*
The eye.	It is a mineral.
shank.	metallic.
point.	artificial.
	opaque.
	bright.
	tapering.
	pointed.
	slender.
	useful.
	gray or steel color.
	hard.
	brittle.
	solid.
	steel.

Made of steel, which is a preparation of iron, having been subjected to great extremes of heat and cold.

LESSON XXIX.

A PLANT AND A STONE.

To develop the ideas of *organs*, *organized*, and *inorganized.*

To give the class an idea of *organized* and *inorganized*, a plant and a stone may be shown; and questions given, such as the following:

Teacher.—If I put these two into the earth, and visit them in a month, what great difference might I expect to perceive in them?

Children.—The plant will have grown; the stone will have remained of the same size.

Teacher.—How did the plant increase?

Children.—It absorbed moisture.

Teacher.—By what means?

Children.—Through its roots and pores.

Teacher.—Did this nourish only the roots?

Children.—No.

Teacher.—You are right; the sap was produced which circulated through the plant by means of vessels. Now those parts of vegetables and animals which do something are called organs? What do animals hear with? What do they smell with? What do they see with? What do they taste with? What then may you call the ears, noses, eyes, and mouths of animals?

Children.—Organs.

Teacher.—Name some other organs of animals.

Children.—Hands, feet, heart, and veins.

Teacher.—Name some of the organs of vegetables.

Children.—Roots, stems, leaves, and pores.

Teacher.—A body possessing organs is called *organized.* Name some organized bodies.

Children.—A tree, an insect.

Teacher.—Bodies that do not possess any organs are called *inorganized.* Name some inorganized bodies or substances.

Children.—A stone, water, sugar, lead, and salt.

The teacher names miscellaneous substances, and the children decide whether they are organized or inorganized. She then calls upon the children to name all the organized bodies they can think of, which are written on the board in one column.

Another column may be made in the same way of inorganized substances.

Qualities of Stone.

It is hard.	It is cold.
inorganized.	opaque.
mineral.	solid.
natural.	irregular in form, or amorphous.

LESSON XXX.

A BELL.

Ideas to be developed in this lesson—*sonorous* and *the peculiar parts.*

Parts.	*Qualities.*
The barrel.	It is metallic.

Parts.	*Qualities.*
The ears, cannon.	It is artificial.
handle,	hard.
according to the sort.	elastic.
clapper.	sonorous.
rim.	cold.
surface.	hollow.
inside.	concave.
outside.	heavy.
	rim circular.
	clapper spherical.

Different kinds of bells.

House bells, pulled by wires passing from one part of a house to another part where they are rung. *Church bells*, suspended at the upper part of the building, pulled by ropes;—when there are several bells of different tones, they form a peal or chime;—when one is rung slowly, it is said to be tolled. *Hand bells*, swung by the hand—some used in houses, some by milkmen, &c. *Cow bells*, hung on the neck of a cow.

Uses of Bells.—To give notice of different things—in the house, of different people arriving, servants wanted—in a church, the time of divine service is marked, deaths and funerals announced by tolling, marriages and happy events by a peal. The cow bell is used to tell where the cow is. Horse bells to give warning to people on the street of the approach of a sleigh.

LESSON XXXI.

A WHEEL.

Ideas to be developed in this lesson—*circular, diverging, and the peculiar parts.*

Parts.	*Qualities.*
The nave.	The rim is circular.*
box.	divided.
spokes.	wooden.
arm of the axletree.	thick.
linchpin.	The tire is circular.
rim composed of felloes.	entire.
tire or band.	iron.
rivets.	thin.
centre.	The spokes are straight.
circumference.	equal in length.
	wooden.
	diverging from the nave.

The relative position and proportion of the different parts should form a part of the exercise.

The nave is in the centre; the spokes diverge from the nave to the rim, and are all of equal length, if not, the rim would not form a perfect circle; the tire is outside the rim, and forms, of course, a larger circle than the rim which it encloses; the arm of the axle fits into the box; the felloes are parts of a circle, and are joined together, forming the rim.†

The children should also be led, as an additional exercise, to see the use and adaptation of the different parts. The box to receive the arm of the axletree upon which the

* The children will probably say, round. They should be led to see that this is a very indefinite term, which they apply to a ball as well as to a shilling; their observation should be directed by questions to the perception of how a sphere and a circle differ, and the term circular, given and applied to the wheel before them, and to absent objects of a similar shape.

† These parts are mentioned in 1 Kings, vii. 33.

er; the collision of flint and steel occasions sparks that will set fire to any inflammable material; but lucifer matches, which are tipped with a very combustible substance, are now generally used to produce fire. The fuel that feeds fire is either coal, wood, or peat.

Effects of fire.—Some substances, as coal, wood, &c., it consumes, reducing them to ashes. Some, as butter, metals, &c., it melts or changes from solids to liquids. Some, as water, quicksilver, &c., it changes into steam, or vapor. Some substances, as dough, clay, &c., it hardens. It expands bodies, penetrating through their particles and loosening them. Some substances, as metals, it refines, driving away impurities.

Uses.—1. In domestic life. It warms our houses and gives light to us when the natural light of day is removed. It cooks our food, thus enabling us to profit by the animals and vegetables which God has given us.

2. In manufactures. By fire, metals are fitted for various purposes. Glass, porcelain, brick making, indeed all our manufactures, require the aid of fire. It is also fire that furnishes us with the steam that enables us to travel with such rapidity by sea and land, and which lights our streets and houses at night.

*An emblem.**—There are many instances in the Bible of fire being used as an emblem. Thus God is spoken of as a "consuming fire." His wrath, when kindled by sin, destroys like fire. Our Saviour is compared to the refiner's fire, purifying His people, purging them from the dross of sin, as fire acts upon metals.

* An emblem is a picture which represents one thing to the eye and another to the understanding.

LESSON XXXIV.

AN ANCHOR.

Parts.	*Qualities.*
The shank.	It is iron.
cross-bar or stock.	heavy.
arms.	hard.
flukes.	cold.
ring.	opaque.
	metallic.

The shank is perpendicular to the beam.

The beam is straight.
horizontal to the shank.
smaller at the ends.
sometimes iron.
sometimes wooden.

The arms are curved.

The flukes are pointed.
sharp.

The ring is circular.

The largest kind of anchor is called the *sheet* anchor, and is only used in times of great danger or in heavy gales.

The anchor is an instrument of iron attached by a cable, which passes through the ring to the bows of ships; when the latter are to remain stationary, the anchor is let down or cast into the water, and is thrown by the stock into such a position that one of the flukes is sure to enter the ground perpendicularly; this keeps the vessel fixed, for any strain acting nearly horizontally would rather tend to root the arm deeper in its moorings. This operation is called *cast-*

ing anchor, and the ship is then said to be *riding at anchor;* when the anchor is heaved up, the expression used is *weighing anchor.* When the anchor finds good moorings and takes firm hold, the vessel is in safety; it cannot be driven to and fro by the storm, or dashed against rocks by the hurricane.

When the children clearly understand what an anchor is, and the office it performs, they should be led to trace the analogy between hope and an anchor. The former is thrown out from us, and is fixed upon something, and if it has a firm grasp it will keep us steady; we shall remain unshaken, whatever may assail, as long as the anchor of hope retains its hold. The children should be referred to Heb. vi., where the anchor is used as the emblem of hope, which is described as having entered into that within the veil, that is, into the Holy of Holies, the type of Heaven, where our great High Priest is for us entered; anchored on Him, the rock of our salvation, we shall be kept immovably fixed amidst all the trials and temptations of life. We often speak of a person or thing being our sheet anchor, which means that on which we altogether depend as our last and best resource.

LESSON XXXV.

A BALANCE.

Parts.

The lever, or beam.
pivot or fulcrum.
scales.
chains connecting the scales with the beam.

The qualities depend upon the kind of balance used in the lesson.

The balance is an instrument used to ascertain the exact weight of anything. It is most essential in trade; without such a help barter and exchange would be guesswork, and dishonest dealings could not be easily detected. When one scale perfectly balances the other, what is held in each is equal in weight, and if in one scale standard weights are placed, the substance in the other can be accurately determined.

The children should endeavor to find out why the balance is employed as the emblem of justice, and why, whenever justice is represented as a person, she always holds a pair of scales in her hand. They will be able to trace the analogy between testing a substance as to its weight in scales and the exercise of justice, which consists in impartially weighing conduct or opinions against a lawful standard, in order to arrive at a just and right judgment. They will also understand the metaphor used to set forth the conduct of Belshazzar: "Thou art weighed in the balance, and art found wanting." His life and character were in one scale, God's holy law and requirements in the other, and the former fell short—was altogether deficient.

At this step some exercises would be well introduced on the connection of different qualities. The children will easily be led to discover that all absorbent objects are porous, that all brittle substances are hard, that all adhesive ones are tenacious, all sonorous ones are elastic; that to be malleable and ductile they must be tenacious, their particles cohering; to be elastic, an object must be either extensible, flexible, or compressible.

Children may also with profit exercise their conceptive powers in drawing, out of the treasures of their memory, examples of objects in which any particular quality is found, and classifying them according to the different degree in which they possess the quality. Thus objects may be remembered, furnishing a regular gradation from the most impenetrable opacity to the clearest transparency; the same may be done with hard and soft—from soft as butter to as hard as flint, &c.

FOURTH STEP.

INTRODUCTORY REMARKS.

The chief aim proposed in this Step is, to exercise the children in composing, arranging, and classifying objects, and in tracing analogies; thus developing a higher faculty than that of simply observing their qualities. The complex operation of connecting things by their points of resemblance, and at the same time of distinguishing them individually by their points of dissimilarity, prepares for one of the highest exercises of our reason; yet it may be carried on in children at a much earlier period than is usually imagined, if they are trained to arrange their ideas. With this view the spices, liquids, and metals have been chosen as forming a connected series of objects.* The different woods, grains, &c., are good subjects for similar instruction.

In the early lessons, the perceptions simply exercised the intuitive faculties, which, being stimulated and directed, furnish the mind with ideas. At this point, the process commences of regarding them, not simply, but in series and relationship, and lessons are given to cultivate the discernment of analogies between physical and moral or spiritual

* A few lessons on Animals, as also in Geography, have been added.

qualities. The information given should be reproduced by the children on their slates or on paper.*

SPICES.

LESSON I.

PEPPER.

Qualities of Pepper.

It is hard.	It is dry.
vegetable.	dull.
foreign.†	sapid.
tropical production.	pungent.
wrinkled.	odorous.
spherical.	aromatic.
rough.	wholesome.
black.	stimulating.
preservative.	

* The leading qualities of the objects are still put down in connection with each lesson, for the convenience of the teacher, if she finds it desirable to use any of them. As fast, however, as the children become sufficiently familiar with any particular quality, and the term expressing it, it is better not to continue to repeat it, but only call out those qualities that awaken new thoughts and require new terms, or that are peculiarly characteristic of the object. This remark applies to previous as well as succeeding lessons. No good can result by the constant repetition of qualities and terms already familiar to the children.

† *Teacher.*—If it comes from a foreign country, how do we get it?

Children.—It comes in a ship.

Teacher.—This is called importing; and sending out of our own country is called exporting. What do we call this exchange of production?

Children.—Trade or commerce.

Teacher.—And what are the people called who carry it on?

Children.—Merchants.

The pepper plant is a creeping shrub, much resembling the vine, and is often called the pepper vine. It is generally planted near some thorny bush, among the branches of which it entwines itself like ivy. It produces berries in clusters: if the fruit is intended for black pepper, it is not allowed to ripen, but is collected while green, and rubbed by the hands or feet, till the seeds, several of which are contained in each berry, are separated. These are exposed on mats to the rays of the sun during the day, and are collected at night in jars, to preserve them from the dew. When the berries are intended to be converted into white pepper, they are allowed to ripen, and they then become red. They are rubbed in a basket, the pulp is removed by washing, and the seeds, which are white, are dried.

LESSON II.

NUTMEG.

Qualities of Nutmeg.

It is sapid.	It is foreign.
hard.	tropical production.
oval.	pungent.
dingy brown.	preservative.
dull.	pulverable.
opaque.	agreeable to the taste.
dry.	aromatic.
vegetable.	odorous.
natural.	Surface uneven.

The nutmeg is the kernel of a fruit which is the produce of a tree resembling our cherry tree, both in size and growth. It is found in the East Indies. The external covering of the fruit is a husk; this opens when ripe, and displays a thin scarlet membrane, called mace; this being carefully removed, there still remains a woody shell which surrounds the nutmeg. The nuts are first dried in the sun, and then placed on a frame of bamboos over a slow fire, until the kernels, on being shaken, rattle in their shells.

REMARKS ON WORDS.

Teacher.—Why is nutmeg said to be odorous?

Children.—Because it has a smell.

Teacher.—Why aromatic?

Children.—Because it has that pungent smell distinguished by the name aromatic.

Teacher.—Are all things that are aromatic also odorous?

Children.—Yes.

Teacher.—Are all things that are odorous also aromatic?

Children.—No.

Teacher.—Is an onion odorous?

Children.—Yes.

Teacher.—Are these smells alike?

Children.—No.

Teacher.—Which of these terms includes every kind of smell?

Children.—Odorous.

Teacher.—If you were to put all odorous substances into one class, and all aromatic into another, what would you say of the two classes?

Children.—That the class containing all odorous objects would be much the largest; it would include the aromatic substances.

Teacher.—A term which includes all the varieties of one

kind or quality of substance, is called a *generic* term, while that which marks one of the species, is called a *specific* term. Which is the generic term, odorous or aromatic?

Children.—Odorous.

Teacher.—Why is this a generic term?

Children.—Because it includes every variety of odors.

Teacher.—What kind of term is aromatic?

Children.—A specific term.

Teacher.—Why?

Children.—Because it applies only to one particular kind of smell.

Give examples of generic terms and of a specific term applicable to each of them.

Children.—Odorous, fragrant; colored, red; foreign, Chinese production.

The class should determine, in succeeding lessons, what terms are generic and what specific.

LESSON III.

MACE.

Qualities of Mace.

It is pungent.	It is natural.
agreeable to the taste.	inflammable.
aromatic.	medicinal.
orange red.	dry.
dull.	pulverable.
opaque.	membranaceous.
thin.	preservative.
fibrous.	imported.

It is brittle.
foreign.
tropical.

It is sapid.
stimulating.

Mace is the covering between the shell of the nutmeg and its external husk.

REMARKS ON WORDS.

Teacher.—"Foreign." Should you call mace a foreign production if you were in the place where it grows?

Children.—No. It is only foreign to the countries where it does not grow.

Teacher.—Where would you call it pungent and aromatic?

Children.—Everywhere.

Teacher.—Can it be mace without being foreign?

Children.—Yes.

Teacher.—Can it *be* mace without being pungent and aromatic?

Children.—No.

Teacher.—Which then of these qualities belong to mace as mace?

Children.—Pungent and aromatic.

Those qualities which determine anything *to be* what it is, are called *essential.*

Qualities which are not essential are called *accidental.*

What qualities of mace are essential?

What qualities of mace are accidental?

Why are pungent and aromatic said to be essential qualities?

Why is it that its being foreign is said to be accidental?

LESSON IV.

CINNAMON.

Qualities of Cinnamon.

It is light brown, and gives name to a color.
thin.
brittle.
preservative.
aromatic.
pungent.
agreeable to the taste.
opaque.
hard.
sweet.

It is inflammable.
dry.
vegetable.
natural.
foreign.
light.
pulverable.
medicinal.
stimulating.

Cinnamon is in the inner bark of the branches of a kind of laurel tree, growing in Ceylon and Malabar. The branches of three years old are selected as furnishing the best cinnamon; the outside bark is scraped off; the branches are then ripped up lengthways with a knife, and the inner bark is gradually loosened, till it can be entirely taken off. Exposure to the sun causes it to curl up. The pieces of bark so curled are called quills, and the smaller ones are inserted into the larger.

LESSON V.

GINGER.

Qualities of Ginger.

It is fibrous.
knotty.
sapid.

It is solid.
hard.
preservative.

Qualities.	*Qualities.*
It is rough.	It is light.
jagged.	yellowish brown.
vegetable.	pulverable.
tropical.	medicinal.
foreign.	stimulating.
aromatic.	wholesome.
pungent.	opaque.
dry.	inflammable.
dull.	

Ginger is the root of a plant resembling a reed, which grows both in the East and West Indies. The root does not strike to any considerable depth in the earth, but spreads out far in every direction. When first dug up, it is soft, and eaten by the Indians as a salad. If intended for exportation, it is placed in bundles, and dried in the sun.

LESSON VI.

ALLSPICE.

Parts.	*Qualities.*
The skin.	It is aromatic.
seeds.	odorous.
partition of seed vessel.	pungent.
point of insertion.	spherical.
	brown.
	speckled.
	organized.
	natural.
	vegetable.
	dry.
	opaque.
	tropical.
	dull.

Qualities.	*Qualities.*
It is stimulating.	It is hard.
inflammable.	friable.
sapid.	wrinkled.
conservative.	

Allspice or pimento is the dried berry of a species of myrtle, indigenous in the West Indies; it is a most beautiful and fragrant tree, producing numerous bunches of white flowers, to which succeed the berries; these are gathered by the hand and spread out in the sun to dry. In this operation they lose their former color, and become brown. When the seeds rattle in the shell, they are known to be sufficiently dry, and are packed in bags for exportation. The flavor of pimento is considered to unite that of the other spices; hence the name of allspice.

LESSON VII.

A CLOVE.

Parts.	*Qualities.*
The calyx or cup.	It is aromatic.
tube.	odorous.
leaflets of cup.	pungent.
points of leaflets.	brown.
bud.	organized.
edges.	natural.
	vegetable.
	dry.
	opaque.
	tropical.
	imported.
	dull.

Qualities.	*Qualities.*
It is stimulating.	The bud is spherical.
hard.	The tube is long.
inflammable.	The leaflets are pointed.
preservative.	

Cloves are the unexpanded flower buds and calyx of a species of laurel which grows in the West Indies. At a certain season of the year, the clove tree produces a profusion of flowers in clusters; they are gathered before the flower opens, when the four points of the calyx project, and the petals are folded one over the other, forming a bud about the size of a pea. After they are gathered, they are exposed for some time to the smoke of a wood fire, and then to the rays of the sun.

At the conclusion of the lesson on spices, the children should be called upon to mention those qualities which they have found common to all; as aromatic, pungent, dry, tropical, stimulating, vegetable. Then let some other similar substance be presented to them, such as mustard.

Teacher.—Is this a spice?

Children.—No.

Teacher.—Why not?

Children.—It has not the qualities of a spice.

Teacher.—If I showed you a substance with which you were not previously acquainted, and you found that it possessed the *essential* qualities of the spices you have examined, what would you consider it to be?

Children.—A spice.

Teacher.—To what then do you apply the term spice?

Children.—To a set of natural productions possessing certain qualities.

Teacher.—When a number of things are arranged together, each having similar qualities, what would you call the collection? What would you call a number of boys who are placed together because they are nearly equal in knowledge?

Children.—A class.

Teacher.—What, then, would you call a collection of substances that possess the same qualities?

Children.—A class.

Teacher.—What may you call all substances which are aromatic, pungent, tropical, &c.?

Children.—A class.

Teacher.—And what is the name of that class?

Children.—Spice.

Teacher.—What, then, does the term spice express?

Children.—A class of substances, possessing the qualities aromatic, pungent, &c.

Teacher.—Tell me all the substances belonging to that class.

Children.—Pepper, nutmeg, mace, cinnamon, ginger, allspice, cloves.

Teacher.—Are all the substances of this class alike in all respects?

Children.—No.

Teacher.—How can you tell one spice from another?

Children.—By each having some qualities peculiar to itself.

Teacher.—Name something in each spice which distinguishes it.

Children.—Ginger is a root; pepper is a seed; nutmeg is a kernel; mace is the membranaceous covering of that kernel; cinnamon is a bark; pimento is a seed vessel; the clove is a cup and flower bud.

ON LIQUIDS.

LESSON VIII.

WATER.

Qualities of Water.

It is fluid.	It is wholesome.
transparent.	tasteless.
clear.	cold.
colorless.	inodorous.
liquid.	natural.
useful.	solvent.
bright.	refreshing.
incompressible, except by immense power.	penetrating.
	cleansing.
effective.	cooling.
drinkable.	fertilizing.

Some waters are medicinal.

Different kinds of Water.

Rain.	Medicinal.
spring.	hot spring.
sea, or salt.	stagnant.
river.	

Different states of Water.

Ice.	Fog.
snow.	cloud.
hail.	vapor.
rain.	dew.
mist.	steam.

Natural Collections of Water.

Oceans.	Lakes.
seas.	ponds.
rivers.	springs.

Operations of Water.—It purifies, evaporates, freezes, quenches thirst, cools, finds its own level, penetrates, fertilizes, is a solvent, extinguishes fire, separates easily into portions which assume a spherical form.

Movement of Water.

Teacher.—In what way do oceans and seas move?

Children.—In waves.

Teacher.—When you are on the sea shore, what difference do you observe in the waves during the course of the day?

Children.—At one time they are coming in; at another going out.

Teacher.—This is called the ebb and flow of the tide. What is the movement of a river?

Children.—It flows.

Teacher.—What eventually becomes of its waters?

Children.—They are lost in some ocean or sea.

Teacher.—What is that which with us is always flowing on?

Children.—Our life.

Teacher.—To what does it conduct us?

Children.—To eternity.

Teacher.—Of what, then, is a river a fit emblem or representation?

Children.—Of life.

Teacher.—Find some passages in the Bible where a river is used as an emblem of life.

Teacher.—You find the particles of water run about; will the particles of wood do the same?

Children.—No.

Teacher.—Why will not the particles of wood flow about?

Children.—Because they stick close together.

Teacher.—This is called *cohering.* When one substance is joined to another it is said to adhere (or stick to); when the particles of the same substance stick together, they are said to *cohere.*

The particles of a liquid cohere very slightly, and are therefore easily separated. The particles of a solid cohere closely.

LESSON IX.

OIL.

Qualities of Oil.

It is fluid.	It is light.
yellowish.	thick.
semi-transparent.	inflammable.
soft.	oleaginous.
liquid.	Some oils are vegetable.
penetrating.	Some are animal.
emollient.	When bad, it is rancid.
greasy.	odorous.

The vegetable oil is expressed from olives, and is imported chiefly from Italy and the south of France. It is also obtained from nuts and some other fruits, and from seeds.

The animal oil is procured from the blubber or fat of the whale and seal.

Birds are furnished with little bags containing oil; with this they plume their feathers, and it causes rain and moisture to trickle off. Without this provision, the feathers of water fowl would imbibe so much moisture, that they would become too heavy to float on the water.

LESSON X.

BEER.

Qualities of Beer.

It is liquid.	It is artificial.
fluid.	odorous.
orange color.	semi-transparent.
wholesome.	slightly intoxicating.
fermented.	strengthening.

Beer is composed of malt, hops, and water, boiled together. Hops are the blossoms of a creeping plant, cultivated in many portions of this country; the place where they grow is called a *hop yard.* The tub in which the malt is first steeped is called a *mashing tub;* that which holds the beer when made, a *vat;* when wanted for consumption, or sale, it is put into *barrels.*

Malt is made of barley, by the following process. A quantity of barley is soaked in water for two or three days; the water being afterward drained off, the grain heats spontaneously, swells, bursts, becomes sweet, and ferments. Vegetables, during decomposition, undergo several degrees of fermentation; the first (that above described) is called the *saccharine fermentation*, from the sweetness it produces; sacchar-*um* being the Latin for sugar. In consequence of this decomposition, which is similar to that which takes place in seed in the ground, the barley begins to sprout, but this vegetation is stopped by putting it into a kiln, where it is well dried by a gentle heat.

LESSON XI.

FOREIGN WHITE WINE.

Qualities of White Wine.

It is yellowish.
bright.
fluid.
liquid.
fermented.
spirituous.
intoxicating.
heating.
vegetable.

It is artificial.
semi-transparent.
sapid.
medicinal.
stimulating.
clear.
strengthening.
yielding to the touch.

Wine is made from the grape, the fruit of the vine, which is cultivated in *vineyards*. The season of its gathering is called *the vintage*. The grapes, when gathered, are placed in a *wine press*, by which the juice is expressed; this juice undergoes a fermentation, and becomes wine. This is the second fermentation which vegetable matter undergoes; it is called the *vinous fermentation*, from its producing wine; *vinum* being the Latin word for wine.

LESSON XII.

VINEGAR.

Qualities of Vinegar.

It is acid.
orange-brown color.
liquid.
fluid.
yielding to the touch.
penetrating.
stimulating.

It is vegetable.
artificial.
medicinal.
odorous.
preservative.
semi-transparent.
fermented.

Uses.—To flavor food; for pickling; for medicine.

LESSON XIII.

INK.

Qualities of Ink.

It is black.
useful.
opaque.
artificial.
liquid.

It is astringent.
fluid.
yielding to the touch.
poisonous.

Ink is made of galls, sulphate of iron, gum, and water. Galls are found upon the oak; they are occasioned by a little insect, which pierces the bark of the tree, and lays its eggs in the hole which it has formed. The torn vessels of the tree discharge a portion of their contents; this hardening, forms at first a defence for the eggs, and subsequently food for the caterpillars they produce; these latter eat their way out of their confinement, before they change into the perfect insect. Iron dissolved in sulphuric acid is called *sulphate of iron;* when this is applied to the acid of the galls it becomes black, upon which quality the utility of ink depends. A little gum is added, to cause the ink to adhere to the paper.

LESSON XIV.

MILK.

Qualities of Milk.

It is white.
fluid.
liquid.
wholesome.
sweet.
An animal substance.

It is natural.
opaque.
yielding to the touch.
emollient.
nutritious.
When fresh, it is warm.

Uses.—For animals to feed their young; for making cheese and butter; to drink.

The milk of cows is that most generally used by man. Invalids drink the milk of asses. In Tartary the milk of mares is used; in Switzerland that of goats; in the northern countries that of reindeer; in Arabia that of camels.

The teacher will find it a very improving and interesting exercise, to take two substances and compare them together—as water and milk—requiring the class to find out in what respects they are both alike. They are both fluid, liquid, cool, incompressible, penetrating, natural, &c. The qualities by which they are distinguished from each other should then be mentioned. The water is transparent, the milk is opaque; the water is colorless; the milk is white; the water is tasteless, the milk is sweet, &c.

Liquids possess qualities by which they are very clearly distinguished from other substances. They may all become solid; they are all fluid and incompressible; their parts easily separate, forming into spheres or drops; they penetrate into the pores of substances; and they find their own level. The last circumstance can easily be proved to the pupils by means of a siphon. Having named the properties *common* to *all* liquids, the class should also be required to mention the qualities *peculiar to each*, as in the lessons on spices.

Water is transparent, colorless, tasteless, inodorous, bright.

Oil is yellowish, thick, emollient, semi-transparent, greasy, inflammable.

Beer is orange colored, bitter, spirituous, artificial, fermented.

White wine is bright, yellowish, intoxicating, stimulating, fermented.

Vinegar is acid, orange colored, semi-transparent, fermented.

Ink is black, bright, opaque, artificial.

Milk is white, opaque, sweet, nourishing, natural.

The children might determine which of these would form a particular class within the general class of liquids; as beer, wine, vinegar, united together, because they are fermented liquids.

ON METALS.

GENERAL OBSERVATIONS ON THE METALS.

Occurrence.—The metals form a class of bodies belonging to the mineral kingdom. They are seldom found in a pure or uncombined state, but are almost always united to various other substances. The compounds so formed have not the distinguishing characters of metals, and they are termed ores,—as lead ore, iron ore, &c. Some of the metals are found in a pure state, when they are termed native, as native gold, native mercury, &c., &c. In their pure state metals are supposed to be simple substances, or elements,—that is, not to be compounds, or mixtures of other bodies. Iron, for example, is regarded as an element, because it cannot be made by the union of other substances, nor can any substance different from itself be obtained from it.

Distinguishing Characters.—The metals are distinguished from all other bodies by possessing the following characters:—They have (when the surface is clean and untarnished) a peculiar brightness, termed the metallic lustre; they are good conductors of heat, so that, if heat is applied to one part of a piece of metal, it is rapidly conveyed to every portion; and they are also conductors of electricity, hence the employment of copper rods to convey the lightning (which might otherwise destroy a building) safely into the ground. Many compound mineral bodies that are not metals also possess metallic lustre, but are not conductors of heat or electricity.

Reflectors of Light.—The lustre of metals depends upon their power of reflecting or throwing back the light which falls upon them. The light from the sun, or any other source, may, when it falls upon a substance, pass through it, as is the case with glass—the body is then termed transparent; or it may be absorbed by it, as is the case with a dull black board, or with velvet—the substance is then said to be opaque; or it may be thrown back again, or reflected. This power of reflection is possessed by metals to a much greater degree than by any other bodies; therefore, when it is wished to throw as much as possible of the light of a flame in one particular direction, a reflector of metal is employed, as in carriage lamps, lighthouses, &c.

Reflectors of Heat.—The heat which accompanies the light of the sun, or that thrown out by a fire or any heated body, is reflected by polished metals in precisely the same manner as light; therefore bright metallic surfaces are used in reflecting-ovens, meat screens, &c. When metals are employed as reflectors of heat or light, it is requisite that they should be brightly polished, as it is only when in that state that they reflect well.

Conductors of Heat.—The metals are better conductors of heat than any other solid bodies, a circumstance which occasions several of the peculiar effects produced by them. If the hand is placed upon a piece of metal somewhat cooler than itself, the natural warmth is rapidly abstracted and conveyed to all parts of the metal; hence metals are frequently spoken of as cold substances; if, on the contrary, the hand is placed on a piece of metal warmer than the body, it imparts its heat with equal facility, the portion cooled having its temperature rapidly restored by the heat from the surrounding parts; it follows that metals slightly warmer than the hand feel hot, and will inflict more severe burns than non-conducting substances at a much higher temperature.

Conductors of Electricity.—The power of conducting electricity exists in metals to an infinitely greater degree than in any other substances. It is one of their properties most important to man. The natural electricity of the thunder clouds is safely conveyed into the ground by a lightning conductor of copper, and the electricity artificially produced is conveyed instantaneously thousands of miles by the wires of the electric telegraph, which, by causing the points of two magnetic needles to be directed as required to either side, produces signs which stand for letters, and thus conveys messages immense distances in an infinitely short space of time.

Opacity.—The metals are more opaque than other bodies. Even when beaten into thin leaves, they do not allow light to pass through. Silver leaf, for example, only $\frac{1}{100000}$ part of an inch in thickness, is perfectly opaque. The gold leaf of commerce, which is about $\frac{1}{150000}$ of an inch in thickness, is transparent. On looking through it against the light, all objects are readily seen, having the same appearance as if looked at through green glass.

Specific Gravity or Weight.—The weight of the metals varies greatly; some of them are the heaviest bodies known, while others are so light that they will float on water. These latter, however, are not common, being only known to experimental chemists. In the following list,

the specific gravity of the more important metals only is given:

Platinum,	22.069
Gold,	19.250
Mercury,	13.600
Lead,	11.381
Silver,	10.470
Copper,	89.00
Iron (wrought),	78.00
Tin,	73.00
Zinc,	71.00
Aluminum,	25.00

The weight of a cubic foot of the common metals is as follows:

Lead, one cubic foot weighs,	710 lbs.
Copper (cast),	549
Brass,	523
Steel,	490
Wrought iron (closely hammered),	485
Wrought iron,	475
Cast iron,	450
Zinc,	439

Hardness—The metals vary very much in hardness. Some of the more uncommon are sufficiently soft to be moulded easily by the fingers. Lead can be scratched by the nail; tin, zinc, gold, and silver may be cut with a knife; copper is harder, and iron greatly surpasses all common metals in this respect.

Brittleness.—Some few of the metals, as antimony and bismuth, are so brittle that they may be powdered, and cast iron and cast zinc are readily broken.

Malleability.—Others, on being hammered, spread out into thin leaves. Gold possesses this property in the highest degree. It may be beaten into leaves so thin that, although quite free from visible holes, sixty square inches will not weigh one grain; and 300,000 of the leaves, if piled on each other, would not exceed an inch in thickness. In addition to gold—silver, platinum, copper, zinc, and lead furnish examples of malleable metals.

Ductility.—The malleable metals are also ductile—that is, they can be drawn out into wires. Gold is one of the most ductile of the metals,—a single grain may be drawn out into a wire 550 feet long. Silver, platinum, iron, copper, zinc, tin, and lead are also ductile. The method adopted for drawing metals into wires is to form the metal into a bar or cylinder: this is drawn by great force through a hole in a steel plate, somewhat smaller than itself, and is consequently lessened in size and increased in length by the operation. It is then drawn through a still smaller hole; again through one still less, and so on, until the wire is of the degree of fineness required.

Tenacity.—The strength of wires does not, as might be imagined, correspond with the ductility of the metals of which they are formed. Iron, when made into steel, is by far the most tenacious metal; its wire is stronger than one of equal size formed from any other metal, although, in point of ductility, it is surpassed by gold, silver, and platinum. The tenacity of some of the metals greatly surpasses that of all other substances. The following list shows the number of tons which a rod one inch square is capable of holding up before breaking:

Lead, about	¾ of a ton.
Tin, "	2 tons.
Cast iron, nearly, ...	9 "
Copper, ...	15 "
Bar iron, ...	25 "
Steel, ...	59 "

Fusibility.—All the metals are capable of being melted or fused by heat, although they vary very much in their degrees of fusibility. The heat that always exists in temperate climates is sufficient to melt one metal—mercury; but in the colder regions of the earth, where the temperature is low, it assumes the solid form. Of the other common metals, tin, lead, and zinc melt below a red heat; copper, silver, and gold require a strong red or white heat; cast iron melts at a bright white heat; pure wrought iron is one of the least fusible, and requires the greatest degree of heat that can be obtained from a smith's forge to melt it.

Volatility.—Several of the metals are volatile, rising in vapor when heated. Mercury slowly evaporates at all temperatures above the natural heat of the human body, and boils away rapidly below redness; zinc also is volatile at a high red heat; the other common metals are fixed in the fire.

Compounds of the Metals.—The metals can be united not only with each other, but with several of the nonmetallic elements, as sulphur, carbon, &c. When the metals are melted together, the compounds are called ALLOYS. These possess the characters of metals, and are of great use in the arts. The most important alloys are—brass, formed of copper and zinc; pewter, of tin, copper, &c.; German silver, of nickel, copper, and zinc; solder, of tin, lead, &c. When mercury is present, the name amalgam is given to the compound; the most important amalgam is one of tin, used for silvering looking glasses. It is one of the most remarkable properties of alloys that they generally melt more readily than either of the metals of which they are formed. The use of solder by plumbers and workers in tin, zinc, &c., mainly depends upon its being more easily melted than the metals which it is employed to unite.

The compounds of the metals with the non-metallic substances are very important. When the metals unite with the oxygen of the air, compounds are formed termed rusts or oxides. Some metals have little disposition to unite with oxygen—that is, to rust; hence they remain untarnished: as gold, silver, and mercury. Others, as zinc and lead, form a thin layer of rust on the surface, which protects the metal beneath from further change. Others, as iron, rust or oxidize only in damp air.

Many of the metals unite with sulphur, forming, as before observed, compounds called sulphurets, or sulphates. The common ores of lead and copper are sulphurets of those metals. Silver, although it does not rust in pure air, unites quickly with any sulphur that may be present, either from the escape of coal gas or from any decaying animal substances, and becomes tarnished by the formation of a thin layer of black sulphuret of silver.

General Conversation on the Metals.

REMARK.

In giving the following lessons, it is desirable to present the specimens to the class in their several natural and artificial states. The teacher should be particularly careful to direct the attention of the children to those qualities in the metal under consideration, upon which its uses depend, leading them to trace the adaptation of qualities to certain uses.

LESSON XV.

GOLD.

Qualities of Gold.

It is a perfect metal.	It is pliable.
malleable.* 1.	compact.
ductile. 2.	yellow.
tenacious. 3.	solid.
heavy. 4.	opaque.
indestructible.	brilliant.

* A solid piece of gold and some leaf gold should be presented to the class, and the extreme lightness and thinness of the leaf may be felt.

Teacher.—How was the gold made so thin?

Children.—It was beaten out.

Teacher.—With what, do you think?

Children.—With a hammer.

Teacher.—All things that can be thus extended by beating are called *malleable.* Could glass be thus beaten out? Could chalk? Camphor? What qualities prevent them from being malleable?

Children.—Glass is brittle. Chalk is crumbling.

Teacher.—What qualities in gold do you think render it malleable?

Children.—Its being tenacious.

Teacher.—What other quality in gold depends upon its being tenacious?

Children.—It is ductile.

Teacher.—Ductile means capable of being drawn out.

It is fusible.
incombustible, except by electricity.
soft, compared with other metals.
It is reflective.
sonorous.
Not affected by any acid but aqua regia.*

It is considered a perfect metal, because it does not lose any of its weight when fused, nor suffer any change. Most metals become oxydated.†

When the children understand fully the different qualities, the teacher may mention to them the facts that prove the extraordinary degree in which the peculiar qualities exist in the metal.

1. Malleable. A grain of gold, the size of a pin's head, may be beaten out to cover a space of fifty square inches.

2. Ductile. A grain of gold can be drawn out to cover a wire of 352 feet in length; a guinea can be drawn out to reach nine miles and a half.

3. Tenacious. A wire one-tenth of an inch in diameter will support 500 pounds without breaking.

4. Heavy. It is nineteen times heavier than water of the same bulk.

Uses of Gold.

When alloyed‡ with copper, gold is used as coin, and

* Aqua regia (royal water) is a mixture of muriatic acid and nitric acid.

† Substances are oxydated when they are combined with a certain portion of oxygen.

‡ The combinations of metals with each other are called, in chemistry, *alloys;* but this term is commonly employed to designate those substances that lessen the value of any with which they are united.

for ornamental purposes; for the latter it is fitted by its brilliancy and beauty, and also because it is not liable to tarnish.

The gold used in coinage, called standard gold, consists of a combination of about twenty-two parts of gold, and two of copper.

Gold thread is made by covering silk or silver with gold beaten very thin.

Gilding is the art of covering the surface of a substance with gold; this is effected by applying it in a state of leaf, or liquid gold, to a surface covered by a cement.

Quicksilver unites with gold, communicating to it a portion of its own fluidity; it has from this circumstance been used in gilding buttons—an effect which is produced very rapidly by the following process: The metals are mixed together, and the buttons immersed in the compound. They are then exposed to a great heat, by which the quicksilver is evaporated, and the gold is left upon the buttons.

The purple color used in painting porcelain is obtained from gold.

Gold is beaten into leaves upon a smooth block of marble fitted into a wooden frame, about two feet square; on three sides there is a high ledge, and the front has a flap of leather attached to it, which the workman uses as an apron to preserve the fragments that fall off. There are three kinds of animal membrane used in the operation. For interlaying with the gold at first, the smoothest and closest vellum is procured; and when the gold becomes thin, this is exchanged for much finer skin, made of the entrails of oxen prepared for this purpose, and hence called *goldbeaters' skin:* the whole is covered with parchment, to prevent the hammer from injuring it. After the gold has been reduced to a sufficient degree of thinness, it is put between paper which has been well smoothed and rubbed with red bole, in order to prevent it adhering to the gold.

Geographical and Geological Situation of Gold.

Gold is found principally in hot climates, either native or as an ore. A metal is called *native* when it occurs in nature pure, and an *ore* when mixed with other substances. Gold is found in mines, in Brazil, Peru, Mexico, and California. Part of the western coast of Africa is called the Gold Coast, from the gold dust brought down by the natives to trade with. A great quantity of gold is obtained in the form of fine sand, from American and African rivers; and in small quantities from the Danube, the Rhine, and the Rhone. It is supposed to be carried down by the mountain torrents. The wandering tribes of gypsies employ themselves in washing it from the beds of European rivers. The Himalaya mountains in Asia are rich in gold. It sometimes occurs in the veins which run through mountains, and sometimes in rounded masses in soils that are evidently the ruins of rocks. The mines which formerly yielded the largest quantities of gold were those of Peru and Lima; the principal in Europe are those of Hungary and Saltzburg. There have been discovered large quantities of gold in California and in Australia, which has caused a comparative abundance of this metal. The mode of ex-

tracting gold from the ore is by reducing the whole to a fine powder, and mixing it with quicksilver. The latter unites with every particle of gold, but, being incapable of forming a combination with any but metallic substances, it separates the gold from the earth with which it is intermixed. The quicksilver, which has absorbed the gold, is then evaporated by means of heat, leaving the pure metal in the vessel.

LESSON XVI.

SILVER.

Qualities of Silver.

It is malleable. 1.	It is white.
ductile. 2.	solid.
tenacious. 3.	compact.
heavy. 4.	natural.
indestructible.	brilliant.
fusible.	reflective.
soft.	sweetly sonorous.
flexible.	not affected by common acids.
a perfect metal.	
opaque.	

1. Malleable. Silver can be reduced to a degree of thinness nearly equal to that of which gold is capable.

2. Ductile. It can also be drawn out into the finest wire.

3. Tenacious. A wire one tenth of an inch in thickness will support 377 pounds without breaking.

4. Heavy. It is about eleven times heavier than water.

Uses of Silver.

Silver is used for coin, and is then combined with copper, to render it harder and better adapted to receive a fine and sharp impression on being cast. It does not lose its white color by its mixture with copper. The same alloy is employed for ornamental purposes.

Silver is much used as a casing to copper utensils, to render them more pleasing to the sight, and also to prevent the formation of the poison extracted by acids from copper. The most permanent plating is effected by taking two thin plates of silver and copper, the former in the proportion of one to twelve of the latter; a little powdered borax is placed between the two metals to promote their fusion; and then, after being exposed to a white heat, they will be found firmly united. The substance is passed between rollers till the whole is of the proper thickness for the intended manufacture.

Silver dissolved in aquafortis (nitric acid) yields crystals, which, being afterward melted in crucibles, form what is called *lunar caustic.* This preparation is of considerable value in surgical operations, being employed to burn away diseased flesh, and also for consuming warts, wens, and other excrescences of the skin. Indelible or permanent ink, used for marking linen, is made by dissolving nitrate of silver (lunar caustic) in water, and adding gum. The yellow color employed in painting porcelain is obtained from silver.

Geographical and Geological Situation of Silver.

Silver is found, both native and as an ore, in mines and veins. South America is the country richest in silver mines. It is also found in Saxony, Bohemia, Norway, Hungary, and England; but the mines of Mexico and Peru furnish annually ten times more than all those of Europe together. So poisonous are the exhalations from the mines of Peru, that many thousands of Indians have perished in them, and the cattle that graze on the outside are affected by their malignant vapors. This metal is also found in several localities in our own country, the most important of which are the Washoe region (on the borders of California and Nevada Territory), Lake Superior, Arizona, North Carolina, and from the gold of California and Colorado.

The ores of silver are very numerous, and various methods are employed in different countries to separate this metal from its ore. In Mexico and Peru the mineral is pounded, roasted, washed, and then mixed with mercury in vessels filled with water, a mill being employed for the purpose of more perfectly agitating the liquid. This causes the silver to unite with the mercury, and then, being submitted to heat, the latter is evaporated. The pure metal is afterward melted and cast into ingots or bars of 80 or 90 lbs. each.

LESSON XVII.

QUICKSILVER, OR MERCURY.

Qualities of Quicksilver, or Mercury.

It is heavy. 1. It is cold. 3.
fluid. 2. divisible. 4.
7

It is volatile when heated.
- white.
- brilliant. 5.
- opaque.
- least tenacious of all bodies.

It is dilatable by heat.
- medicinal
- natural.
- mineral.

1. Weight. Nearly fourteen times heavier than water. It is the heaviest known fluid.

2. Fluid. It always retains its fluidity in our temperature; but near the poles it congeals, and then is malleable, ductile, and tenacious.

3. Cold. It is the coldest of all fluids, and the hottest when boiling.

4. It is capable of division, by the slightest effort, into an indefinite number of particles, which are of a spherical shape.

5. The peculiar brilliancy of metals has given rise to the term *metallic lustre*.

Uses of Quicksilver.

Quicksilver penetrates and softens other metals, losing its own fluidity, and forming a kind of paste called *amalgam*. This affinity or attraction that it has for other metals makes it exceedingly useful in separating them from substances with which they are found combined; they are drawn from their ores and unite with the mercury, and the latter being volatilized, the pure metal remains. Quicksilver is easily affected by the atmosphere, and is on this account used in thermometers and barometers. The Thermometer is an instrument constructed in the following manner: A tube of glass, terminating in a

hollow ball which contains mercury, is plunged into boiling water, which causes the mercury to expand and rise to a certain height. At this point, which is called boiling heat, the tube is broken off and hermetically sealed;* the freezing point is then ascertained and marked, and the intervening space graduated. The thermometer, by marking the expansion and contraction of the quicksilver, indicates the increase and decrease of heat and cold in the atmosphere.

To form the barometer, a glass tube, open at one end, and filled with quicksilver, is plunged with its open end downward into a bowl containing some of the same fluid. Part of the mercury in the tube flows into the vessel, leaving a space to which the air cannot gain access. A vacuum being thus formed, the atmosphere acts upon the mercury in the bowl; when heavy, causing it to rise in the tube, and when light (the pressure being decreased), allowing it to descend. The barometer, by thus showing the weight of the air, indicates the probability of wet or dry weather. For when the atmosphere is light, it no longer supports the vapor and clouds which float in it, and they consequently descend toward the earth; but when the air is more dense, they are borne up, and we have fine weather. The elevation of mountains is also ascertained by means of the barometer; for as it is known that the rarity of the

* In order to seal anything hermetically, the neck of a glass tube is heated till on the point of melting, and then with a pair of hot pincers it is closely twisted together, by which means the air is excluded. Hermetically is derived from *Hermes*, the deity of ancient mythology who was thought to preside over the arts and sciences, particularly chemistry.

atmosphere increases in proportion to the ascent, the height is easily calculated.

Quicksilver is also used for coating mirrors. The process is effected in the following manner: a sheet of tin foil the size of the plate of glass is placed evenly on a smooth block of stone; over this is poured some quicksilver, which is carefully spread upon it with a feather or rubber of linen. Tin, in amalgamating with mercury, quickly forms an oxide of a black appearance; this being removed, more of the fluid is poured upon it. The glass is then held horizontally, and carefully spread over the amalgam, sweeping before it the superfluous mercury, and any more oxide that may have formed. Weights are then placed upon the glass, and after having remained several days, the mixture adheres firmly and forms the mirror.

Vermilion, used in coloring sealing wax, and the medicine called calomel, are preparations of this metal.

Geographical and Geological Situation of Quicksilver.

Quicksilver is found in the native state, as globules, in the cavities of mines; but it is most frequently combined with sulphur, forming the mineral called Cinnabar, which is of a red color. It is found in considerable quantities in some parts of California; the mines yielding 2,000,000 lbs. avoirdupois annually.

The quicksilver mines of Idria, in Austria, are said to yield annually 100 tons; those of Spain still more; but the mines of Peru are the richest.

The mines of Idria were accidentally discovered about three hundred years since. That part of the country was

then much inhabited by coopers; one of the men, when retiring from work in the evening placed a new tub under a dropping spring to try if it would hold water, and when he came in the morning he found it so heavy that he could scarcely move it. On examination he perceived a shining, ponderous fluid at the bottom, which proved to be quicksilver. When this circumstance was made known, a company was formed to discover and work the mines from whence the mercury had issued. In some parts of the mine it flows in small springs, so that in six hours as much as thirty-six pounds have been collected; in other parts it is found diffused in small globules.

LESSON XVIII.

LEAD.

Qualities of Lead.

It is heavy. 1.	It is solid.
fusible. 2.	sometimes amorphous.
bright when first melted or cut.	sometimes crystallized.
malleable.	opaque.
ductile.	mineral.
very soft. 3.	liable to tarnish. 4.
pliable.	inelastic.
livid, bluish gray.	natural.
easily calcined, that is, reduced by heat to a crumbling substance.	It makes a gray streak on paper.
	boils and evaporates at great heat.

1. **Heavy.** It is eleven times heavier than water; rather heavier than silver.

2. It melts at a much lower temperature than the other metals.

3. It is the softest of all metals.

4. Lead is not much altered by being exposed either to air or water, though the brightness of its surface is soon lost. Probably a thin stratum of oxide is formed on the surface, which defends the rest of the metal from corrosion.

Uses of Lead.

The calx * of lead is the basis of many colors, which are obtained from it by different degrees of heat. Red lead and white lead, so much used in paints, are the calces of lead. They are soluble in oil, are very poisonous, and occasion the ill health to which painters are subject. The oxide of lead also enters into the composition of white glass, rendering it clearer; it is also used in the glazing of common earthenware vessels. Any acid will extract a poison from lead, and therefore the use of it should be avoided in culinary operations. It is employed in glazing pottery.

It is also used for gutters and pipes of houses, and for cisterns and reservoirs of water, because it does not rust, and is very durable.

The great softness of lead, and the ease with which it is fused, are the properties which have brought it so much

* Calx is the dross formed on the surface of lead when fused. This name is applied by chemists to those substances which have been reduced by burning to a friable state. The operation by which this effect is produced is called *calcination*. It is more general now to term metallic bodies when calcined, *oxides*.

into use. The persons who work it are called *plumbers*.* The solder they use as a cement is an alloy of lead and tin, in the proportion of two parts of the former to one of the latter.

Great quantities of lead are consumed in making shot. The metal for this purpose is alloyed with arsenic, to render it more hard and brittle, and capable of assuming a perfectly spherical shape. Shot are formed by dropping the melted alloy into water from a considerable height, through an iron or copper frame, perforated with round holes, which are larger or smaller according to the required size of the shot. Mixed with antimony, lead is used for printing types; and with tin and copper, it forms pewter.

Geological and Geographical Situation of Lead.

The largest and perhaps most important lead mines in the world are found in England and Wales. It is supposed, from relics and inscriptions found in these mines, that they were worked by the Romans when in possession of Great Britain.

The principal mines in the United States are found in Missouri, Illinois, Wisconsin, and Iowa. It has been found in several of the Atlantic States, but the mines, proving unprofitable, have mostly been abandoned.

Lead is plentiful in Scotland, Ireland, Spain, France, and Germany.

It is very doubtful whether it is ever found native; it occurs frequently combined with sulphur, when it is called *galena*.

* Plumb-*er*, from the Latin plumb-*um*, lead.

When the ore is brought out of the mines it is sorted and washed, to free it from dirt and rubbish; it is then spread out, and the best pieces separated. After the ore, by picking and washing, has been sufficiently cleansed from extraneous matter, it is roasted * in a kind of kiln, to free it from the sulphur usually combined with it. The next process is to mix it with a quantity of coke, and submit it to the *smelting* furnace. In this there are tap holes, which, when the lead is melted, are opened, to allow it to run in a fluid state into an iron vessel. The dross which floats on its surface is skimmed off, and the metal is taken out by ladles, and poured into cast-iron moulds with round ends. It is then called *pig lead*, and is fit for use.

LESSON XIX.

COPPER.

Qualities of Copper.

It is heavy. 1.
tenacious. 2.
very sonorous. 3.
fusible. 4.
elastic. 5.
capable of extreme divisibility. 6.

It is mineral.
sometimes crystallized.
sometimes amorphous.
brilliant.
reflective.
sapid.
nauseous to the taste.

* *Roasting* is the process by which the volatile parts of an ore are evaporated. *Smelting* is that by which the pure metal is separated from the earthy particles combined with it in the ore. This is done by throwing the whole into a furnace, and mixing with it substances that will combine with the earthy parts; the metal, being the heaviest, falls to the bottom, and runs out by the proper opening in its pure metallic state.

Qualities of Copper.

It is malleable.
ductile.
compact.
opaque.
orange-brown color.

It is hard.
unpleasantly odorous.
solid.
medicinal.
easily corroded.

1. Heavy. Copper is eight times heavier than water.

2. Tenacious. A wire one tenth of an inch in thickness will support two hundred and ninety-nine pounds and a half without breaking.

3. It is the most deeply sonorous of all metals.

4. It is more easily fused than iron, but less so than gold or silver.

5. It is the most elastic metal, next to iron.

6. A grain dissolved in ammonia will give a perceptible color to more than 500,000 times its weight in water.

The Uses of Copper.

The uses of copper are numerous and important. When rolled into sheets between iron cylinders, it is used to cover the roofs of houses, especially arsenals and manufactories, where there is liability to fire. The bottoms of ships are coppered in order to make them sail faster, and to prevent shell fish from perforating the wood. Copper is much used for cooking utensils, but great care is necessary, for should any acid or even water be allowed to stand some time in the vessels, a poison is extracted; but while boiling this evil does not arise. It is customary, in order to prevent any danger, to line copper vessels with tin. Copper is used in the manufactories of gunpowder, because it does not, like iron, give out sparks by collision. Having no effect upon the magnetic needle, copper is found to be the best material for the boxes and supports of this delicate instrument. Plates of copper are sometimes engraved with a sharp instrument called a *burin;* sometimes they are corroded with aquafortis;* in the latter case, the copper is covered with wax, on which the design is sketched with a pointed instrument, the aquafortis reaches the copper just in those places where the wax has been removed by the sketching, and eats into it. Verdigris is a rust of copper, usually made from that metal by corroding it with vinegar. There is a large manufactory at Montpelier, in France, where verdigris is prepared in the following manner: Copper plates and the refuse of grapes are placed alternately one upon another; the latter speedily corrode the surface of the metal. The verdigris thus formed is scraped off as it collects on the copper; it is afterward dried, and packed in casks or bags. It is chiefly employed in dying, and is a most virulent poison. The alloys of copper are numerous and valuable. Brass is the most important; it is compounded of zinc and copper, in the proportion of three parts of the former to one of the latter. This is a very beautiful and useful substance; it does not rust so easily as copper; it is more ductile than either that metal or iron, and is therefore used in the construction of musical and mathematical instruments, and in clockwork. Sieves and blinds are woven of brass wire of extreme fineness. Brass is used both for purposes of ornament and use. Copper alloyed with tin forms bronze; it is remarkable,

* Aquafortis (strong water) is nitric acid diluted with water.

that when these two metals are melted together, the compound so produced is heavier than the weight of the two metals taken separately. Bronze is very useful from its being extremely hard, durable, and sonorous; it is made into cannon balls, statues, &c. The metal of which cannon are made is also an alloy of copper with tin. Bell metal consists of three parts copper and one tin. Copper is the principal ingredient in German silver and Chinese gongs; and in small proportion it is used to give hardness to silver coin and plate.

Geographical and Geological Situation of Copper.

Copper is found in Sweden, Saxony, Great Britain, America, and Australia. The copper region of Lake Superior contains almost the only mines of this metal that are profitably worked in the United States. The worn tools found in immense numbers in some of these mines, prove that they have been worked at a remote period by an unknown people. It was one of the metals earliest known; the Bible mentions workers in brass before the Flood.

It is found in great variety of forms; sometimes in masses of pure metal, but more frequently combined with other substances, particularly sulphur. The copper mines of Anglesea are very productive; they are situated on the top of a mountain, and form an enormous cavity more than 500 yards long, 100 broad, and 100 deep. The ore is obtained from the mine, either by pickaxes or by blasting the rock with gunpowder. It is then broken with a hammer into small pieces, an operation which chiefly employs women and children. After this, it is piled on a kiln, to the upper part of which flues are attached, that communicate with sulphur chambers. The kiln is covered, and the fires lighted in different parts, that the ore may undergo the process of roasting. The whole mass gradually kindles, and the sulphur which is combined with the ore, being expelled in fumes by the heat, is conveyed through the flues to the sulphur chamber. This process occupies from three to ten months, according to the size of the kilns. When the operation is complete, or the ore is freed from the sulphur, it is submitted to the smelting houses, where, by the intense heat it undergoes, the pure metal is forced off in a fluid state.

LESSON XX.

IRON.

Qualities of Iron.

It is elastic. 1.
ductile. 2.
heavy. 3.
tenacious. 4.
hard. 5.
malleable.
liable to rust.
sonorous.
mineral.

It is fusible.
livid gray color.
solid.
susceptible of a high polish.
cold.
sometimes amorphous.
sometimes crystallized.

1. In the state of steel, it is the most elastic of all metals.

2. Iron is more ductile than gold; it may be drawn into a wire as fine as human hair.

3. It is the lightest of the common metals, except tin; between seven and eight times heavier than water.

4. The most tenacious of the metals. A wire about one tenth of an inch in diameter will support 500 pounds without breaking.

5. Its hardness exceeds that of most other metals, and this is increased by its being converted into steel.

Uses of Iron.

Iron is the most useful of all metals, and man very early became acquainted with its value. Moses speaks of furnaces of iron, and of the ores from which it was extracted. By means of this metal the earth has been cultivated, houses and cities built, and without it few arts could be practised. Iron is very abundant in nature, but it is always found mixed with some other substance. It is then called *iron ore.* Sometimes it is combined with clay, at other times with lime, or with flint. In order to separate the iron from its ore, intense heat is required; either pure clay, lime, or silex, remain stubborn in the hottest fires, but when mixed in proper proportions, the one assists in the fusion of the other; therefore there is always thrown into the furnace with the iron ore some earth that will combine with that in the iron ore. The intense heat of the furnace is kept up by means of a continual supply of air, rushing into it from immense bellows, worked by machinery. The lime, clay, or flint, unite and form a kind of slag, which floats on the surface. At the same time the carbon, or pure charcoal of the fuel, aided by the limestone, melts the iron, which, being heavier than the other substances, falls to the bottom of the furnace, and remains there till the workmen let it out by a hole made at the bottom of the furnace, and plugged with sand. When the workman judges that there is a sufficient quantity of the iron fused, he displaces the plug with an iron rod, and the melted iron runs out like a stream of liquid fire, and is conveyed into furrows made in sand, where it cools; the pieces formed in the principal furrows are called sows, those in the smaller furrows branching from them, pigs. In this state it takes the name of *cast iron*, and from the process it has undergone, it is become extremely hard, and having lost its tenacity, it resists the hammer and the file, and is very brittle; it is of a dark gray or blackish color. It is used for the backs of chimneys, grates, boilers, pipes, railroads, common cannon balls, &c.

Cast iron contains a large proportion of carbon, and is probably saturated with it. It is converted into steel by taking away a portion of its carbon. It is converted into wrought iron by removing the carbon, and as far as possible other impurities, as sulphur, phosphorus, &c. The value of wrought iron for machinery, and tools of all descriptions, is very great. Steel is also much employed for ornamental purposes, on account of the elegant polish it is capable of taking.

Plumbago, or black lead, which is employed in the manufacture of pencils, is an ore of iron, containing nine parts of carbon to one of the metal. The bronze color used in porcelain painting is an oxide of iron. Meteoric stones, which have been the subject of so much conjecture, and which are sometimes believed to be ejected from volcanoes in the moon, are native iron.

Iron is very valuable from the magnetic properties it

may acquire. By these it enables the mariner to steer across the ocean, the traveller to direct his course with safety in the pathless desert, and the miner to guide his researches after subterraneous treasures. The loadstone, or natural magnet, is an oxide of iron; it communicates its power to bars of iron or steel when placed in contact with them. The artificial magnet is now always used, as it possesses and retains all the properties of the loadstone. The qualities which render it useful, are, its attraction for iron, and its polarity, or the power by which it points to the poles when freely suspended. One end invariably turns to the north, and the other to the south, except when it approaches the poles; there the directive power ceases altogether, which circumstance constitutes one of the great difficulties in navigating the Arctic Sea.

Geographical Situation of Iron.

Iron is the most universally diffused of the metals. It is found in every country, in greater or less quantities. It is very rarely met with in a native state, but generally as an oxide, or in combination with sulphuric or carbonic acid.

LESSON XXI.

TIN.

Qualities of Tin.

It is heavy. 1.	It is very little elastic.
soft. 2.	pliable.
malleable. 3.	easily calcined.

Qualities of Tin.

It is ductile.	It is natural.
fusible.	mineral.
white.	reflective.
opaque.	sonorous, makes a crackling noise.
solid.	dilatable by heat.
brilliant.	

1. It is seven times heavier than water; yet the lightest of the ductile metals.

2. It is softer than silver, but harder than lead.

3. Tin may be beaten into sheets the one thousandth part of an inch in thickness.

Uses of Tin.

Tin is chiefly employed in the manufacture of culinary utensils; they are not, however, made of solid tin, but of what is called *tin plate*, which is thus prepared: Thin iron plates are first well cleansed, by washing them in water and sand; they are then dipped into melted tin, and afterward steeped in water acidulated with sulphuric acid. This process causes the tin not only to cover the surface of the iron plate, but to penetrate it, so that the whole mass becomes of a whitish color. Pins are made of brass wire, tinned. When the pin is formed, a vessel is filled with strata or layers of tin plates between the brass pins; the vessel is then filled with water and some tartaric acid, by means of which the tin is dissolved; after five or six hours' boiling, the pins are found uniformly tinned. It is the zinc of the brass which has an affinity for the tin, and forms the union which takes place. The pins are afterward polished; they are thrown into a tub containing a quantity of bran, which is set in motion by the turning of a shaft in the centre; the friction which the pins thus undergo renders them perfectly bright. The uses of tin for domestic purposes are very various, particularly when laid over other metals, as in stirrups, buckles, &c. The oxide of tin is used in dyeing.

Tin foil is used for coating Leyden jars, for enclosing small packages of tobacco and spices, and for covering the tops of champagne bottles, &c., to exclude the air. Large sheets are used for silvering looking glasses.

Tin forms alloys with several other metals. These compounds have been mentioned before; as bell metal, pewter, bronze. Tin leaves, amalgamated with mercury, are used for silvering and plating other metals.

Geographical Situation of Tin.

England, Germany, Chili, and Mexico, produce the largest quantities of this metal. The tin mines of Cornwall were well known to the ancients; and the Phœnicians are said to have traded with the Britons for it long before the birth of our Saviour. Native tin is never found, and its ore is of less common occurrence than that of iron. It occurs as an oxide, or mixed with sulphur and copper; chiefly in veins running through granite and other rocks. When it is taken from the mine, it is broken into small pieces, and streams of water are passed over it, to free it from the earthy particles with which it is intermixed; it is then roasted and smelted, when the metal is poured out into quadrangular moulds of stone, and receives the name of block tin.

LESSON XXII.

COMPARISON OF METALS.

GOLD, a perfect metal, is the most precious.
most compact.
heaviest.

Its weight is between nineteen and twenty times that of water.

SILVER, a perfect metal, is next in value to gold, and more useful; its weight between ten and eleven times that of water.

QUICKSILVER is fluid.
easily volatilized.
immalleable.

Its weight is between thirteen and fourteen times that of water.

COPPER is the most sonorous.
most elastic, except iron.

Its weight is between eight and nine times that of water.

IRON is the most elastic.
most tenacious.
most useful.
most ductile.

Its weight is between seven and eight times that of water.

LEAD is the softest.
most easily fused.

Its weight is between eleven and twelve times that of water.

TIN, next to lead, is the softest of the metals; it dilates most by heat; it is the lightest, its weight being only seven times that of water.

LESSON XXIII.

ON METALS IN GENERAL.

Metals are simple elementary bodies, distinguished by being heavier than all other substances; by possessing a peculiar lustre, which is called *the metallic lustre*; by reflecting light and heat; by their being opaque, fusible, malleable, tenacious, ductile, and generally elastic. Upon this last quality seems to depend their fitness for exciting sound, or sonorousness. Metals are capable of uniting with each other in a state of fusion; this union is called an *alloy*. It is remarkable that by these combinations metals undergo a considerable change in their properties, and acquire new ones not belonging to either of them when not united. Thus the weight of the alloy, or the two metals in combination, is sometimes very different from the weight of both the metals taken separately; an alloy of silver with copper or tin, or one of silver or gold with lead, is heavier than the same quantities of those metals uncombined. Their ductility and malleability are changed and generally impaired, the alloy becoming brittle. This is very remarkably the case with gold and lead when united, the latter of which, even in the trivial proportion of half a grain to an ounce of gold, renders the mass quite destitute of tenacity.

The hardness of metals is varied by combination. Gold being united with a small quantity of copper, and silver, with a minute proportion of the same metal, acquire such an increase of hardness, that these additions are always made to gold and silver which are exposed to wear. By a small addition of gold, iron is said to gain so much hardness as to be even superior to steel for the fabrication of cutting instruments.

Change of color is a common effect of the union of metals with each other. Arsenic, for example, which resembles steel, and copper, which has a red color, afford by their union a compound which has nearly the whiteness of silver.

In order to ascertain how far the children have retained the knowledge acquired in these lessons, the following questions may be given to them to answer in writing:

QUESTIONS ON THE METALS.

GOLD.

1. What are the chief qualities of gold?
2. What is its weight?
3. Give a proof of its ductility.
4. tenacity.
5. malleability.
6. Upon what other quality does its malleability depend?
7. What qualities are directly opposed to malleability?
8. What is an alloy?
9. Why is gold alloyed for the purpose of coinage?

10. What metal is used as its alloy? and in what proportion?
11. How are buttons gilded?
12. Describe the manner of forming leaf gold.
13. In what state is gold found?
14. What is an ore?
15. What is meant by a native metal?
16. In what countries is gold found?
17. What people employ themselves in separating it from the sands of the European rivers?

SILVER.

1. What are the chief proportions of silver?
2. What is its weight?
3. What degree of tenacity does it possess?
4. What are the chief uses of silver?
5. Upon what qualities do the uses of silver depend?
6. Describe the operation of plating.
7. What is lunar caustic? and what are its uses?
8. Give the geographical location of silver.
9. Why are gold and silver called perfect metals?

QUICKSILVER.

1. What are the uses and properties of quicksilver?
2. What is its weight?
3. In what respect is it remarkable as a liquid?
4. What effect does heat produce upon it?
5. Under what circumstances does a change in its qualities take place? and what is the change?
6. What is an amalgam?

7. Mention the uses of quicksilver.
8. What are the properties that fit it for a barometer?
9. What for a thermometer?
10. How is a barometer made? and what is its use?
11. How is a thermometer made? and what is its use?
12. What color is obtained from quicksilver?
13. Where is quicksilver found?
14. What circumstance led to the discovery of the mines of Idria?

LEAD.

1. What are the remarkable qualities of lead?
2. What is its weight?
3. What are the different effects which heat produces on lead?
4. What are the chief uses of lead?
5. Why is it used for reservoirs of water?
6. How are shot made?
7. What is the use of the oxides of lead?
8. What are its alloys?
9. In what state is lead found?
10. What is lead called when found united with sulphur?
11. Where is lead most abundant?
12. Describe the process of roasting and smelting.

COPPER.

1. What are the chief qualities of copper?
2. What is its weight and what its degree of tenacity?
3. How is it proved to be capable of extreme divisibility?
4. What are the uses of copper?

5. What is verdigris? and how is it made?
6. What is the danger incurred by employing copper in kitchen utensils?
7. What are the alloys of copper?
8. In what respect is brass preferable to copper?
9. Where is copper found? and in what state?
10. Describe the copper mines in Anglesea, and the manner of extracting the metal from the ore.

IRON.

1. What are the chief qualities of iron?
2. What quality does it possess in a higher degree than any other metal?
3. What is its weight and tenacity?
4. What are the different states in which iron is used?
5. How is cast iron prepared?
6. What are its qualities and uses?
7. How is wrought iron prepared?
8. What are its qualities and uses?
9. How is steel prepared?
10. What are its qualities and uses?
11. What is meant by the temper of steel?
12. What is plumbago? and what quality makes it useful?
13. What is the geographical situation of iron? and with what is it found combined?

TIN.

1. What are the qualities of tin?
2. What are the uses of tin?

3. How is it prepared for use?
4. How are pins tinned?
5. What is block tin?
6. Where is tin found?

LESSON XXIV.

A BEE.

For Children from ten to twelve years old.

DESCRIPTION OF A BEE.

I. *Examination of the Bee.*—The children should be directed to examine a bee very minutely, and the following description, as far as it can, should be drawn from them; and what they cannot observe, they should be told.

The bee possesses a horny covering, which is harder than the internal parts, thus serving as an external skeleton. The body is divided into three distinct parts—head, thorax, and body. The jaws are four in number—two upper ones, and two under ones; the under ones are lengthened, and form, as it were, a sheath to the tongue. The tongue is very long and slender, and admirably adapted for clearing the honey out of the deep nectaries of flowers, and also for curling up inside the mouth. Their attention should then be directed to the fact, that there is a membranous bag folded under the tongue. They should be told that this bag is capable of being greatly distended, and is used for receiving the honey before it is swallowed and consigned to the honey bag. The bee has four wings—two upper ones and two under—the latter are much more delicate than the former. It has six legs; on the broad

surfaces of the hind legs are two small cavities, which have a covering or lid of hairs. The children should be told that these are used for containing the bee bread, with which it feeds the young, and which it obtains and prepares at the same time it is gathering honey, and that when the honey also is safely deposited in its appropriate place, the bee, quite loaded, flies home. The children's attention should then be directed to the eye; but before speaking of it they should be shown a piece of glass, of the shape of a double convex lens, be told its name, and that in the front part of our eye there is a very small capsule, or bag, filled with a transparent fluid, which is of the same shape—that in passing through this the rays of light meet in a point, or focus, which causes the reflections to be clear and distinct. When the children thoroughly understand this, they should be told that the eye of the bee is always immovably fixed, which they might consider a great defect, but that full compensation is made in the numerous lenses with which it is filled, each, they will see, acting as a single eye, consequently the bee would not require to move its eye. The children should then be told that the bee was not always in the same form in which they see it, but that it had undergone three changes; that on its first appearance from the egg it was something like an earth worm, and was called the larva; in the second change it is called a chrysalis, when it is quite torpid; and in the third it is the perfect insect or bee.

From knowledge previously acquired, the children will be able by this examination of the bee to state that it is a *true insect*, and also to give the three proofs: 1st. It consists of head, thorax, and body, while some insects (improperly so called), such as the spider and scorpion, consist only of head and body, the thorax being united with the head. 2d. It has *six* legs—whereas the so-called insects have never less than eight—such are the spider and scorpion. 3d. The spider and scorpion, and all the so-called insects, never undergo the changes for which the bee and all true insects are remarkable.

After having thus dwelt upon the *particular group* to which the bee belongs, the children should be desired to name the *great class* in which it is included, and also to give the reasons why so placed; viz., the bee belongs to the class "Articulata," because, 1st. It possesses what may be considered an external skeleton in its horny covering; 2d. Its body is divided into several segments, or parts, which are joined or articulated together.

II. *Habits of the Bee.*—They are social insects, each individual working for the good of all; they are remarkable for their great industry and carefulness, and for the instinct they possess, as seen in the construction of their habitations—a subject which should be taken up in a separate lesson.

LESSON XXV.

HONEY COMB.

For Children from eight to twelve years old.

CONSTRUCTION OF COMBS, ETC.

I. *Examination of the Comb.*—Several pieces of honey comb should be presented to the children. On examining the combs the children will discover that they are chiefly made of wax, but not exclusively, being smeared over with a gummy substance. They should be told that this is called "propolis," and is obtained from the bark and buds of some trees, and serves to strengthen the combs.

II. *Examination of Cells.—Classes of Bees.*—The cells should then be examined as to their size; the children will soon see that there are three varieties in their size. They should then be told that there are three distinctions among the bees:—1st. There is the *queen bee*, who is the most important personage, and the mother of all; who, with the royal larvæ, occupies the largest cells, termed "royal chambers." 2d. The male bees, who are a little smaller in size; the next sized cells contain larvæ that will produce these. 3d. There are the workers, or the female bees, which are the smallest kind; eggs that will produce these are deposited in the smallest cells.

III. *Uses of Cells.*—The children should then be led by questioning to tell the three uses of cells. By referring to what had just been dwelt upon, they see that the first use was, *to contain eggs*. By asking what was done with all the honey that was gathered, they will give the use, *to serve as storehouses for honey*. By questioning them as to what else the bee gathers from flowers, besides honey, and what was done with it, they will see that the cells also serve as receptacles for bee bread.

IV. *Description of the Construction of Combs and Cells.*—After all this is quite clear to the children, the manner in which the combs and cells are constructed should be described to them, stopping at intervals in order to question them, that all may follow; thus, The wax makes its appearance in the form of eight scales upon the bee previous to the making of a comb. A bee ascends to the top of the hive, and attaches itself by the hind legs to the roof; another follows, and by its hind legs fastens itself to the first bee; a third follows the second, and so on, till a long string is formed, the last bee of which also fastens itself to the roof, so that a kind of festoon is produced; this festoon is filled up by many more bees: several such festoons are made in each hive. In this state the bees remain quite still, until the scales appear. A bee then separates itself from the rest, and by its hind legs removes one of the scales, which is carried to the mouth by the fore legs, where it is masticated and mixed with a frothy liquid, by which it becomes whiter and firmer; it is then attached to the roof of the hive: the remaining scales are treated in precisely the same manner; and then the bee retires, making way for another bee. Thus they continue to work until the whole block is formed. Before proceeding to the construction of the cells, the children should be well questioned on the preceding; as, How does the wax appear?—In what way do the bees arrange themselves before commencing the combs?—How is the festoon commenced?—What is the next movement of the bees?—What process does the wax undergo before being attached to the hive, and what are the benefits? &c., &c.

The manner of constructing the cells should then be described, as follows:—As soon as sufficient of the comb has been made to admit of the work of excavation, a bee commences making a cell; and as the comb increases in

size, the number of cells multiplies rapidly, more bees being able to join in the work.

V. *Lessons of Instruction.*—The children should next be assisted to draw lessons of instruction from what has been noticed respecting the bee.

First, They afford us a striking example of industry and carefulness—They do not lose one hour of the summer's sunshine, but are always busy gathering honey, and storing it up for the winter's use, when they cannot leave their hives—From this we should learn never to idle away our time in youth, but embrace every opportunity of laying by stores of instruction, for our comfort in old age, when we are not capable of so doing.

Secondly, The examination of this wonderful little insect should also enlarge our ideas respecting the infinite wisdom and goodness of God, who giveth one of his smallest creatures such powers as are not only necessary to its own well-being, but can also contribute to the comfort of man; showing that the very smallest, as well as the largest of God's works, demands our highest admiration.

LESSON XXVI.

SKETCH OF A LESSON ON THE COVERING OF BIRDS, AND ITS ADAPTATION TO THEIR WANTS.

For Children under twelve years of age.

In order that the children should determine what is necessary in the covering of birds, refer to their *habits*, motion, and the *element* in which they move; and from a consideration of these, lead them to deduce the necessity for *great* warmth; by comparison of the blood of birds with that of other animals, speak of the rapid changes of temperature to which they are exposed in passing from one country to another—in ascending and descending in the atmosphere. (Instance *Vultures.*) The vulture descends from the limit of perpetual snow to tropical plains in a few moments. Also, call attention to their long and sustained flight—the energy they possess in consequence of their quick circulation, which is the cause of the warmth of their bodies—and how their covering prevents it from escaping.

Great *strength* combined with *lightness.*

The children led to see why the feathers should be strong, by reference to the organs of flight. Why light and also smooth, by reference to the element through which the bird moves.

II. *Examination of the structure of a feather.*—Children name and describe the parts of a feather:—the quill or barrel—the shaft—vane, or beard—the qualities of the quill mentioned:

Lightness.—Result of form—a hollow cylinder much stronger than if the same quantity were made into a solid cylinder. Should be illustrated to the children by comparing the weight borne by a hollow cylinder made of a piece of paper, with the weight borne by the same piece of paper made into a solid cylinder.

Strength.—Composed of two sets of fibres, one acting longitudinally, the other circularly—effect of this—cut a quill as when a pen is made, and show the children that the latter set are scraped off, the former separated by the slit.

The *shaft* examined and described. Lead the children to see how the form adapts it to the shape of the body—speak of the manner of flight, and show the necessity of the groove and curve beneath, in striking the air; and of the great strength above, necessary to resist the stroke.

Vane, or beard.—Examined—of what composed—shape of the barbs, and their position with respect to the shaft—their arrangement with respect to each other—why the flat sides are turned toward each other, and edges upward and downward—a large unruffled quill presented, and the children shown that the barbs are firmly held together—when pulled asunder, they again unite on being smoothed—how is this? Mention with what each barb is provided—position, office, and use of barblets—call attention of children to the beauty of this complicated arrangement, by supposing the beard formed of a single piece, or the barbs glued together—the consequence in either case?—an injury once sustained could never be repaired by the bird—how the bird restores any feathers unfitted for flight through the violence of a storm, by contact with prey, or other accident.

(What has been said here refers chiefly to the feathers of the wing and tail.)

Children led to see how admirably the structure and arrangement of the body feathers are adapted to secure the warmth required for the bird.

The feathers of the body compared with those of the wings, and the class led to observe how each part of the former is modified to suit a different purpose. Refer to the swan, to show the provisions made when *great* warmth is required. Direct attention to what are called warm substances—they are non-conductors, and prevent the escape of heat—how feathers effectually accomplish this for the bird.

Arrangement of feathers in wings and tail—wind can scarcely ruffle them.

Refer to the goodness and wisdom of God in the beautiful adaptation of structure to wants, and call for a suitable text.

LESSON XXVII.

SKETCH OF A LESSON ON THE ADAPTATION OF FEATHERS TO THE HABITS AND WANTS OF BIRDS.

For Children under twelve years of Age.

I. THE OWL.—*Habits and food.*—Call the children's attention to the habits and food of the owl.

1. *Habits.*—Nocturnal, passing the day in obscurity, but on approach of evening coming forth in search of prey.

2. *Food.*—Mice, and other small animals, which are naturally very timid, and likely to be disturbed by the least noise, therefore only to be approached with great caution.

3. *Adaptation of plumage.*—Refer to the noise usually made by birds in flying—how prevented in case of the owl? Plumage of owl examined, and the children led to see that the feathers are soft, loose, downy, yielding to every breath of air.

Wings provided with quill feathers, deficient in strength and elasticity. Children led to deduce the necessity for this, by reference to the nature of the animals on which they prey.

Extent of wings compared with the body. Children led to see the provision made to prevent tardiness of flight.

The edge of the outer feather of the owl compared with that of a pigeon, or any other bird, for the purpose of showing how admirably they are modified to secure noiseless flight.

II. The KINGFISHER.—Direct attention to its locality and food.

1. *Locality.*—Inhabits the margins of lakes and rivers.

2. *Food.*—Preys on small fish. The manner of obtaining food described, and the children led to see the kind of plumage necessary to resist the action of water during its sudden plunges.

3. The kingfisher's *plumage* examined—adaptation of bright hues and metallic lustre shown.

4. *Habits* of owl compared with those of kingfisher, to show the necessity of a different kind of covering. What would be the consequence had the kingfisher feathers like the owl?

III. The DUCK.—Children called upon to say all they know of the *habits* and *food,* where seen, &c.

Refer to the habits and food of duck—to the chilling and softening effects of water—and then lead the children to see the necessity for such covering as will resist these effects. Compare the different effects of rain on the feathers of a duck, and on those of a hen.

The reason of this difference may be illustrated by reference to the various ways in which oil is used where resistance to the influence of water is desired. Examine the plumage of a duck: use of thick, downy under-coat—to prevent the escape of heat from the body; smooth, polished outer feathers—to keep out wet.

Habits of duck and kingfisher contrasted, to show the necessity of different modification of feathers.

IV. The OSTRICH.—Refer to the country where it is found—its food and habits—show that flight is not necessary—refer to the heat of the country inhabited by the ostrich—the kind of protection needed; and lead the children to see how the plumage is fitted to afford this.

LESSON XXVIII.

SKETCH OF A LESSON ON THE BEAKS OF BIRDS.

For Children from eight to ten years of age.

I. Commence by questioning the children as to the organ by which birds obtain their food; how it differs from our mouth, and how it is a substitute for teeth; and draw from them all they may have observed as to the habits of birds, supplying information where necessary, and leading them to see that some birds, as the swallow, spend their time chiefly on the wing, darting with short and rapid flights in every direction; and some, as the duck, spend the greater part of their time in swimming; others, as the heron, are seen standing generally in the soft mud in the neighborhood of pools and lakes; some, as the hen, may be seen constantly scratching up the ground; and others again, as the owl, stealthily flitting about at night.

Question as to how all these are employed, and lead them to see that the difference of habits arises from the different kinds of food that they require, and the different elements in which they seek for it.

II. Present the beaks of the several birds above mentioned—Children examine them, and trace their adaptation to the wants of the bird.

1st. *That of the Swallow.*—Thin—soft—very wide at the base, and coming quickly to a point. Why soft?—Inferred from the nature of its food, insects captured while on the wing. The necessity for the great width of the beak in proportion to the size of the bird, may also be inferred from the difficulty of securing these insects in the air.

2d. *The Duck's.*—Broad, flat, and spoon-shaped, having a fringe at the edge of each mandible. Use of the fringe—Serves as a strainer. The reason of this shaped beak will be seen by reference to its food—small fish and insects. To the manner of obtaining them—dipping its head under water and straining the mud through the serrated edges of its beak, and retaining what is necessary.

3d. *The Snipe's.*—Long and slender, serrated like the duck's. By reference to the food and habits, lead the children to see how this long and slender beak is fitted for entering the soft mud, and how admirably the serrated edge is suited for retaining the insects contained in the mud.

4th. *The Hen's.*—Hard, strong, straight and blunt. By considering the habits of the hen, lead the children to see the necessity for hardness and strength, from the frequency with which it comes in contact with clay, stones, and other hard substances, also the hardness of the food;—the bird could not well pick up any grains without a hard instrument. Refer to the force with which it pecks, and show the necessity for bluntness—If sharp, would soon be worn away, and enter the ground by the force of the blow.

5th. *The Owl's.*—Sharp, strong, and curved. The necessity for these qualities again inferred from the nature of its food,—birds and other small animals; it requires the sharpness and strength it possesses to destroy its prey and tear it asunder.

Before concluding the lesson, require the children to state how the beak of each bird mentioned is suited to its food, and then draw from them the conclusion, that the beaks of all birds are suited to their habits and wants, showing the goodness of God in thus providing them with what is best for them.

LESSON XXIX.

SKETCHES OF A LESSON ON THE MOLE.—TO BE GIVEN TO CHILDREN OF TEN YEARS OF AGE.

No. I.—*Intended simply for the Teacher's own use.*

I. *Animal described.*—The *body* in form cylindrical—Compact, and strong in the fore part. The *snout* elongated, terminating in bone rather than gristle. The *eyes* small, and sunk in the fur. No external *ears*, but a simple opening concealed under the covering. The *skin* tough, and covered by an extremely close, fine, short *fur*—having no determined direction, but, like the nap of velvet, presenting a smooth surface, incapable of being ruffled. The *limbs* short—The *front pair* thick, strong, and muscular, ending in broad *hands*, spade-like in shape, obliquely inclined so as to make the inner edges the lowest part—The extremities of these organs, five fingers, scarcely distinct, but furnished with hard, flat nails—The hind limbs small, and the feet comparatively feeble.

II. *Habits described.*—The mole subsists chiefly on worms, and the larvæ of insects found in the greatest abundance under the surface of the earth, where the mole has its habitation beneath those miniature hills so frequently found in rich meadows, and cultivated fields. Its nest is of a conical form, carefully lined with vegetable fibre, and makes a most comfortable nursery for its young, which are reared with extreme care and tenderness. Leading to the nest are always several subterraneous galleries, furnishing roads of egress and ingress.

III. *Adaptation of the Organization of the Animal to its Habits.*—Structure, and habits of the mole carefully recapitulated.

From the peculiar construction of the front limbs, infer that they are essentially necessary in administering to the wants of the animal. Means the little creature has of excavating the passages in which its food is to be found. *Has* no other, and *needs* no other than those spade-like instruments the nails, the extremities of which loosen the soil, and render it capable of being collected in the hands; from whence it is thrown to the sides, and a little behind the animal. The nails, aided by the pointed long snout, admirably adapted for working its way in the earth, and detecting worms, grubs, &c.—directed to these by the acute senses of smelling and hearing. Little power of vision required; little given. God makes nothing which has not some distinct end to answer. The goodness of the Creator manifest in withholding an external ear and a fully developed eye;—if given, sources not of pleasure but of pain, on account of their liability to injury from the mould in which the animal is constantly employed.

Covering exactly suited to an animal destined to lead a subterraneous life. Thick, short, and incapable of being displaced, it does not impede the animal in its progress—Does not retain the wet and mud. Well might the Psalmist exclaim, "O Lord, how manifold are Thy works, in *wisdom* hast Thou made them all.

LESSON XXX.

No. II.—*The Method of giving the Lesson on the Mole is here Detailed at length, to show not only what is Taught, but how it is Taught.*

I. *Structure described.*—A specimen of the mole being presented to the children, get them carefully to observe and describe its *principal organs*, directing their attention by means of questions, comparisons, &c.

Ask if they know any form which the *body* nearly resembles?—What things having the form of a cylinder are said to be?—What then may be said of the body of the mole?—"The body of the mole is cylindrical"—This should be simultaneously repeated and written by the teacher on the black board.

Next, let the children compare the *fur* of the mole with

that of some animal in which the hairs are scattered and stiff. Call upon them to state the difference, and if unacquainted with the term that expresses the quality of the mole's covering, tell them that, "when things are made to lie closely together, and so as to occupy a smaller space than they otherwise would, they are said to be compact, or compactly arranged"—Let this be repeated more than once if necessary.

Inquire whether they know any manufactured article used in dress to which the covering of the mole bears a resemblance. The obvious qualities of the fur, such as short, thick, fine, will be quickly seen; but probably not one child will discover that, like the nap of velvet, it has no fixed direction, and is incapable of being ruffled, until told to stroke the animal from the head to the tail, and from the tail to the head, and a cat in the same way—Then to state what they observe. The children should describe the fur, and the teacher add to the account on the board, "and covered by a fine, short, compact fur, which has no particular direction, and cannot be ruffled."

Next ask, What animal has a *head* something like the mole?—When they had a lesson on the pig, what did they say of its *snout?*—How it terminated?—Let them feel the extremity of that organ in the mole, and then describe the head. "The head of the mole is small, tapering into an elongated snout, which ends in bone rather than gristle."—This should be repeated simultaneously, and written on the board.

Other parts of the head named and described by the children—The *eyes* very small, and sunk in the fur. Should the children assert that the mole has no *ears*, tell them that it has no *external ears* that can be seen, but that it possesses the sense of hearing to a considerable degree. Question—With what do they hear?—Touch their ears—Do they think they would hear were that flap removed?—Not so well, certainly, but they would be far from deaf; for they have an *internal ear*, and the mole has this also; the entrance to which they may discover if they look carefully. Add to the notes on the board, "The eyes are small, nearly hidden by the fur; there is no outer ear, but a simple opening, concealed under the covering."

Inquire if there is anything remarkable about the *limbs*? They are very short; the *front pair* are strong and muscular, terminating in broad *hands*. Do the hands remind them of any tool used by gardeners, ditchers, &c.? Yes, they are spade-like; when they compare the *fingers* of the mole with their own, what difference do they observe? what have they at the ends of their fingers? what has the mole? Desire them to describe the front limbs, and say what shall be written on the board. "The front limbs of the mole are strong, muscular, and terminate in large, broad, spade-like hands, ending in five fingers, scarcely divided, and furnished with hard, flat nails." By causing the children to compare the position of the hands of the mole with that of their own, lead them to observe the oblique, downward, and outward direction of the former. Desire them to feel that portion of the body to which the limbs are attached, and contrast it with the fore parts of a rabbit, that they may perceive not only that the arms are strong, but that that part of the frame which supports them

is so also. Question as to the difference observable between the front and hind limbs. The latter are small and slender, lying close to the body, the feet are furnished with claws, yet are feeble compared to the spade-like hands.

II. *Habits described.*—Inform the children that the mole cannot endure more than six hours' fast without great exhaustion. That it subsists on worms and the grubs of insects, found in the greatest abundance under the surface of the earth.

If the pupils are not acquainted with the interior of mole hills, represent to them on the board the galleries and miniature hills made by the excavations of the little miner. Speak of the lining of the nests of birds. Tell them that the nest of the mole is lined with vegetable fibre, and made a most comfortable nursery for its young, which are reared with extreme care and tenderness. That leading to the dormitory of the mole there are always several subterranean passages, dug out by the creature as means of going in and coming out. That he is an expert swimmer; appears to enjoy the water; and requires to drink frequently; and that there is usually a colony of these little miners in possession of one common passage to the nearest stream or ditch.

III. *Adaptation of the organs to the habits and locality shown.*—Let the children, with the assistance of the notes on the board, and the occasional use of the ellipsis, recapitulate the description of the organization and habits of the mole. Ask them to what the first part of the lesson related, and to what the second. Question them as to what connection there is between the organs, and the habits and locality of animals. Require examples of animals having their organs exactly adapted to their mode of life. Question: What organ fits the monkey for its life amid trees? What part of the bat is adapted for flight? What enables the hedgehog to burrow in the earth? What organ do they observe varies most to meet the wants of animals? Draw from them the general rule, that "God, who formed animals, not only fixed the bounds of their habitation, and gave them their peculiar propensities, but also caused that the one should be fitted to the other." This is to be repeated. Question: Did they observe anything peculiar in the construction of the limbs of the mole? What then do they expect to find? That they are essentially necessary in administering to its wants. Where is its food found? What means has it of getting at worms below the surface of the earth? Have they ever seen men making sewers? What implements had they? The mole has similar work to do. What has it corresponding to a spade or shovel? Desire the children to imitate with their own hands the position of the hands of the mole, and say if they were to throw anything from them, holding their hands in this position, in what direction with respect to their bodies it would go? What would be the consequence if the mole could only use its feet in throwing soil *behind* it? Are the feet of animals ever used in any other operation? Think of the monkey, the cat, the parrot. But the mole does not convey its food to its mouth by means of its hands. What other organ could it use? What senses in the mole would they expect to find very acute? Does it need much light in its underground work? What sense would not as-

sist it in discovering its prey? What have they observed when animals have not required a sense or organ? Remark: They see that God makes nothing that has not some distinct end to answer, some work to perform. Question: Do they see any reason why an external ear was not given to the mole? If it had one, what must happen? What must be the result of the dirt and dust entering into the ears and eyes? Hence if bestowed they would be sources not of pleasure but of pain. What shall we say of the Creator of this little miner? He is indeed *kind* as well as *wise*. "His tender mercies are over all His works." Question: If they were to thrust a hand into some newly dug earth, how would it feel? What kind of covering then would be the best for one living under ground? How is the fur of the mole adapted to keep in the heat of the body? What other advantage arises from its fineness and thickness? In what direction does a cat like to be stroked? What would be done by pressing the hand the reverse way? When told that sometimes moles pass each other in their very narrow galleries, or in their passage to a reservoir of water, and that not unfrequently a single mole can only just move with ease along a newly-excavated road, the children will readily see the suitability of a covering incapable of being ruffled, and of a body compact and cylindrical. What do they observe in all its organs? What said David respecting God's works? Let us also say, "Lord, how manifold are thy works; in wisdom hast Thou made them all."

The lesson to be recapitulated, and condensed into a simple summary containing the principal ideas. To be written at home from memory, and brought the following morning.*

LESSON XXXI.

Two Sketches of Lessons on Fur.

SKETCH I.

I. *What it is, and how fitted for the clothing of animals.*—Pictures, or stuffed specimens, such as can be procured, brought before the children, that they may be led to determine what fur is, and observe its great variety and beauty, owing to the difference in the color, length, and thickness of the hairs. Use to the animal. State to the children the changes which it undergoes at different seasons of the year; in winter becoming *thick*, *close*, and *abundant*, and in some the color changing to white; in summer partly shed, and much more loose and open. The reason for these changes—the modifications observable in the fur of animals inhabiting different climates—the adaptation to the requirements of the animals, manifesting the wisdom and goodness of God.

II. *Qualities.*—Soft—formed of hairs, therefore said to be hairy—the difference between the skin and the fur—the one soft and flexible, the other stiff and somewhat harsh—in what way it is fitted for the wants of the animals of which it forms the covering—why we say it is warm? Lead them to observe that it is neither hot nor cold to the touch, but that as it does not allow the warmth of the body to pass away, we say it is *warm*, and so of other objects.

* It is the design of this lesson that either the mole itself, or a stuffed specimen, should be presented to the class. If a picture is used, the form of the lesson must be changed somewhat to correspond.

III. *Uses to man.*—Made into muffs, capes, cloaks, caps, &c. The qualities which fit it for such uses—warmth, softness, and flexibility.

SKETCH II.

I. *Fur producing countries.*—These pointed out on the map, as Hudson Bay Company's territory; Russian America; Siberia, the most important—the wild, dreary, and desolate character of these countries—the animals inhabiting them alone rendering them of any commercial importance—refer especially to the Hudson Bay Company's territory; the extent and character of their possessions; the time and manner of establishment; the factories and their situations. (All this described to the children.)

II. *Hunting season and hunters.*—Hunting season—why at a particular time? Question here as to the changes necessary in clothing on the approach of winter; and lead the children to see, that as this is the season when animals require most warmth, so it is the season when fur is the thickest; hence the time when it is most valuable, and hence also the hunting season. Speak of hunters, and the preparation for hunting—qualities of a good hunter—cautious in disturbing, dexterous, and fertile in invention, bold and courageous in attacking and securing—why are these qualities essential to a good hunter?

III. *Contrast Furs of Arctic and Tropical Regions.*—Contrast the fur of animals found in northern latitudes with those met with in the tropics and warmer regions: in the first it is rich, fine, close, silky, and warm; in the second, although beautiful in appearance, yet thin and scattered, neither adapted for warmth, comfort, nor general use—contrast northern and tropical climates, to lead the children to see the necessity for this difference of covering—show that the difference in fur of northern and tropical climates, arises from the same cause as that which marks a difference in the fur of the same animals at different seasons—a beautiful evidence of design in the seal—inhabiting the arctic regions, great warmth necessary—under the skin of the common seal a thick layer of fat; in the fur seal no such layer found, but the animal is covered with a rich, curly, silky down, among which is scattered long coarse hair—the uses to which this fur is applied—the preparation it undergoes, and beauty of its appearance.

IV. *Uses to man, and qualities which render it useful.* Enumeration of uses to which fur is applied, and the children led to observe the qualities which render it so extensively useful. (The children are supposed to have been previously made acquainted with fur.)

V. *Processes which Fur undergoes to fit it for use.*

1. The state in which the skins are received by the furrier.

2. Cleansing—use of saw-dust—effect—state of skin—difference between the skin of arctic and tropical animals—manner in which it is softened and made thinner—preparations for making it up into the articles required—laid in the saw-dust—why?—effect—advantages taken of the pliability of the skin in this state.

3. Dyeing—how the appearance of the darker furs is obtained in this operation—difference between the dyeing of the fur seal and beaver, and that of other animals—the simplicity of the first operation—tedium of the second, and skill necessary for the performance.

LESSON XXXII.

THE PIG.

I. Get the children to name the parts of the pig, and give a description of each—as its head, small and tapering—its ears, large and flat, hanging down on each side of its head like two flaps—its eyes, small, round, and sleepy-looking—the snout, which connects the nostrils and the mouth, is large and armed with strong teeth, and terminates in a hard, gristly substance—the neck, short and thick—the body, cylindrical, and covered with long coarse hairs called bristles—the legs, short and thin—the feet, cloven—the skin, coarse and thick.

II. The habits of the pig spoken of—as that it eats all kinds of vegetable and animal substances, even in a putrid state; also, bran and meal, and, indeed, anything that comes in its way—its habits dirty and disgusting—it is fond of rolling itself about in the mud—why?—to get rid of the vermin with which it is infested—and spends all its time in eating and sleeping—it never attacks other animals but in self-defence—it seems to know when a storm is approaching, for it runs toward its sty screaming violently, and gathers all the straw into a heap to hide itself—the pig is subject to a disease from its gluttonous habits—it lives for 18 or 20 years, and is found in almost every country of the world.

III. Question the children as to the adaptation of its parts to its habits, &c., by comparing the one with the other, the children making the conclusions—the large ears, which flap about on a hot day and prevent the flies from getting into them and teasing the animal—does not require very strong sight—its small eyes are sufficient for the circumstances in which God has placed it—also the long flexible snout, terminating in a ring of gristle, fitting it for grubbing in the mud for its food, and rooting up vegetables; were it furnished instead of this with a soft, fleshy mouth, the animal would not be able to do this without pain and inconvenience—the large, strong teeth, which help it in mastication—it is covered with stiff bristles; were it covered with hair or fur, it could not roll about in the mud without collecting much dirt on its body—also, that its hard, thick skin makes it almost insensible to the blows it so often receives—ask who made the pig, and lead the children to see and admire the wisdom and goodness of God, in making all its parts so beautifully adapted to their various uses.

As the children are describing the parts, write the name and description of each on the board, that they may be aided when they consider the adaptation of the parts to the wants of the animal. The children should state this afterward on their slates.

ON SOLUBILITY.

LESSON XXXIII.

REMARKS.

Lessons on objects may be followed by instruction on qualities with which the children are familiar. The following lesson will explain what is here recommended:

LESSON ON SOLUBILITY.

The teacher develops the ideas for which she afterward gives terms, by means of simple experiments. First she fills half full with water three glass tubes; she then adds to one a pinch of Epsom salts, to another a few grains of sugar, to the third some powdered marble, and shakes each for a few moments.

Teacher.—I wish you to describe the changes which have taken place in the mixtures.

Pupils.—1st. The salts and the sugar have disappeared. 2d. Melted in the water. 3d. Dissolved in the water. The marble remains the same.

Teacher.—Right; the salt and sugar have dissolved in the water; the marble is not dissolved. Do you know what those substances are termed that dissolve in water?

Pupils.—Soluble.

Teacher.—What are those termed which do not dissolve?

Pupils.—Insoluble.

Teacher.—Tell me the names of several soluble bodies?

Pupils.—Sugar, Epsom salts, gum, salt.

Teacher.—Tell me some that are insoluble.

Pupils.—Marble, stone, wood, tin, slate.

Teacher.—What has become of the sugar that dissolved? Is it destroyed?

Pupils.—No; it is in the water?

Teacher.—How do you know that it is in the water?

Pupils.—We can taste sugar when it is dissolved in our tea, or in water.

Teacher.—Would it be useful to give a particular name to a liquid that has dissolved any substance, in order to distinguish it from another that has not any substance dissolved in it?

Pupils.—Yes.

Teacher.—Such liquids are called *solutions;* what, therefore, is formed by the experiments made?

Pupils.—A solution of Epsom salts in water, and another of sugar in water.

Teacher.—Is there a solution of marble formed?

Pupils.—No; for the marble would not dissolve.

Teacher.—Does the water, or the sugar, or both together, form the solution?

Pupils.—Both together.

Teacher.—A liquid used to dissolve a solid is termed a *solvent.* What can we say of water?

Pupils.—It is a solvent of Epsom salts, sugar, &c.

Teacher takes two equal portions of Epsom salts and places each in a tube, with equal quantities of water. One is left undisturbed, while the other is heated in the flame

of a spirit lamp. The pupils are required to state what result they observe.

Pupils.—The water that has been made hot has dissolved the salts very quickly, and also in greater quantity. (The experiment should be made with the sugar also.)

Teacher.—What would you say of the effects of hot liquids on soluble bodies?

Pupils.—Hot liquids dissolve substances more quickly and in greater quantities than cold ones.

Teacher.—This is generally, but not invariably, true. There are some bodies upon which cold and hot water has the same effect. Common salt is an example.

Teacher makes another experiment; placing two equal quantities of sugar in water, allowing one to remain undisturbed, and shaking or stirring the other. Pupils to tell the result observed.

Pupils.—The sugar in the shaken tube dissolves first.

Teacher.—Try and explain why this is so.

Pupils.—When the tube is shaken, every part of the solid is affected by the solvent which dissolves it; but when the sugar lies at the bottom, the water at the top does not help to dissolve it.

Teacher then places a large lump of sugar in a spoon, and puts it into a tumbler of water, holding it near the top; and then, placing the tumbler between the pupils and the light, requires them to say what they observe.

Pupils.—Little wavy lines fall from the spoon.

Teacher.—Can you tell what causes this? Consider what is happening to the sugar.

Pupils.—It is dissolving.

Teacher.—What, then, is being formed?

Pupils.—A solution of sugar.

Teacher.—What becomes of the solution, as it is formed?

Pupils.—It is that which we see falling through the water.

Teacher.—Right; but why does the solution sink in the water?

Pupils.—It must be because it is heavier than water.

Teacher.—It is so; every solution formed by a solid in water is heavier than water. Knowing this, can you tell me why men swim more easily in the sea than in fresh water, and even more easily still in the Dead Sea?

Pupils.—Sea water is a solution of salt, and being heavier than fresh water, a man would not so easily sink in it.

Teacher next places a quantity of common salt in a tube, and pours over it about twice its weight in water, shaking it for some time—then asks what has happened.

Pupils.—Part of the salt is dissolved, and part is left—the water does not dissolve it all.

Teacher.—You are correct; water will not dissolve more than one-third of its weight of salt; and when it refuses to dissolve more, it is said to be *saturated.* What kind of a solution is then formed?

Pupils.—A saturated solution.

Teacher.—Water, as we have seen, will dissolve more of some bodies, as Epsom salts, when it is heated. If we were to heat a cold solution of Epsom salts, what do you think would happen?

Pupils.—It would then dissolve more salts, showing that it would not be saturated by the same quantity of salt as it was when cold.

Teacher puts some powdered sealing wax into two tubes, and pours into one cold water, into the other spirits, and then shaking them, asks the pupils to say what difference they observed in the two.

Pupils.—The sealing wax has dissolved in the spirits, and not in the water.

Teacher.—Is sealing wax a soluble or insoluble body?

Pupils.—It is both; soluble in spirits, insoluble in water.

Teacher.—What kind of liquid is a solvent to sealing wax, and other resinous bodies?

Pupils.—Spirits.

Teacher repeats the last experiment, substituting gum for sealing wax.

Pupils.—The gum, contrary to the sealing wax, dissolves in the water, but not in the spirit; it is also soluble and insoluble.

Teacher.—It is so; but when no particular solvent is named, it is always understood to be water; hence, in ordinary language, gum is said to be soluble; sealing wax insoluble; the solvent, water, being understood. India rubber is an example of a solid, insoluble in all ordinary liquids, but soluble in coal tar, naphtha; the solution thus obtained is used for making waterproof (Macintosh) clothing, by employing it to cement together two thin layers of cloth.

The pupils then should be required to mention all the new terms they have learnt, or any like them; as soluble, insoluble, solve, solvent, solution, dissolve, dissolving, solubility, insolubility, saturated.

Teacher.—Do you observe a resemblance in these words?

Pupils.—Yes; they all, except saturated, have *solve* or *solu* in them.

Teacher.—The meaning of that root, as it is called (for it is like the root of a plant, the part from which the other parts spring), is to *loose;* it comes from a Latin word *solvo,* to loose—the *v* being changed into *u;* the word soluble then means, being able to be loosed, or to have particles separated by the action of a liquid. What would insoluble mean?

Pupils.—*In* stands for not, therefore it means not soluble.

Teacher.—I wish you now to sum up the various parts of the lesson, so as to connect the whole together.

Bodies that are capable of *dissolving* are called *soluble;* those not capable of doing so, *insoluble.* When we speak of a body possessing *solubility,* we say it will *dissolve.* A liquid that dissolves a solid is termed a *solvent;* and a *solution* is a *solid dissolved in a liquid.* When the solution will hold no more of the substance dissolved in it, we say it is *saturated.*

Teacher.—These terms are sometimes used metaphorically—that is, applied to what is of a different nature; try and remember some examples.

Pupils.—To solve a question.

Teacher.—Which means, to take it to pieces or un-

loose it. What similar use of any of these terms do you recollect?

Pupils.—Dissolution of partnership.

Teacher.—What does this mean?

Pupils.—That it is unloosened; the partners are no longer united together.

Teacher.—And what do we mean when we call death a dissolution?

Pupils.—That the body crumbles to pieces; its parts are all loosened or separated.

ON THE SENSES.

LESSON XXXIV.

The children having been already exercised in determining by which of the senses they discover the presence of any quality, may be led to consider more fully the senses themselves. The first two lessons are drawn out for the use of the teacher; the substance only of the others is given.

Teacher.—Do you understand how you gained the knowledge of various qualities?

Children.—By our senses.

Teacher.—How do you know when a thing is red or blue?

Children.—By sight.

Teacher.—How, if you were blind, could you form a correct idea of color? What other means is there of gaining this knowledge?

Children.—None.

Teacher.—True; and to ascertain this point, a blind man was once questioned as to what notion he had of scarlet; he said he thought that it must be like the sound of a trumpet. It is obvious that he had no correct idea of a quality discoverable by the sight, and he could only compare it with one that he had acquired through the medium of another sense. Can you tell me the reason why persons born deaf cannot speak?

Children.—They cannot imitate sounds, because they never heard any.

Teacher.—Since, then, deaf persons have no correct ideas of sound, nor blind persons of color, how do we acquire our ideas of sound and color?

Children.—By the means of the senses of seeing and hearing.

Teacher.—How, then, do we suppose our minds become stored with ideas?

Children.—By the exercise of our senses.*

Teacher.—Yes; and if you had once had the idea of a dog formed in your mind, by seeing such an animal, when a dog is mentioned you can recall the idea, and fancy one immediately, as if it were present; your mind will also perform the same operation when a quality is spoken of, which you have previously seen in some object. Again, if you see a dog unlike any you have observed before, you compare it with the species with which you are acquainted, and mark the difference between them. If I say that I

* It is probable that children would not at once arrive at this conclusion. The teacher must, in that case, lead them to it by easy questions.

have some green paper, cannot you immediately conceive the color of which I speak?

Children.—Yes.

Teacher.—Did you, then, exercise your sight?

Children.—No.

Teacher.—How, then, could you have the idea of green?

Children.—We remembered it.

Teacher.—By what means did you first obtain the idea?

Children.—By seeing something green.

Teacher.—What power of the mind do you exercise in recalling an idea?

Children.—Our memory.

LESSON XXXV.

FEELING OR TOUCH.

Teacher.—What part of your body is the organ of touch?

Children.—It seems all over our body.

Teacher.—Tell me some parts that do not possess the sense of feeling.

Children.—Our hair, nails, and teeth.

Teacher.—And in other animals, what parts are found destitute of sensation?

Children.—The hoofs, horns, claws, feathers, wool, hair, &c.

Teacher.—What other word do we use to express the presence of sensation?

Children.—Sensibility.

Teacher.—What word would you use to express the absence of sensation? What syllable prefixed to a word gives it a negative meaning?

Children.—*In.*

Teacher.—Well, what word will express the absence of sensation?

Children.—Insensibility.

Teacher.—The parts then that you have named are insensible, and, with the exception of these, the sense of feeling exists everywhere throughout the body; but what part of it is particularly adapted, by its form, to become the organ of the sense?

Children.—The hand.

Teacher.—Tell me what qualities we can discover in objects by this sense?

Children.—That they are hard, soft, rough, smooth, long, short, sharp, blunt, round, square, cylindrical, conical, heavy, light, fluid, liquid, dry, wet, hot, cold, &c.

Teacher.—By what general term would you express such qualities as round, square, conical, &c.?

Children.—By *shape.*

Teacher.—By what general term would you express such qualities as large, small, &c.?

Children.—By *size.*

Teacher.—By what general term would you express such qualities as rough, smooth, &c.?

Children.—By *kind of surface.*

Teacher.—By what general term would you express such qualities as hard, soft, fluid, tenacious, &c.?

Children.—By *kind of substance.*

Teacher.—By what general term would you express such qualities as heavy, light, &c.?

Children.—By *weight.*

Teacher.—Now arrange the qualities which you discover by your feeling under five general heads, *i. e.*, *shape, size, kind of surface, kind of substance, weight.*

The children having performed this exercise, the teacher may mention the following facts.

Teacher.—The quickness and accuracy of the sense of feeling is, we find, much increased by exercise, as is exemplified in blind persons, the defect of whose sight is frequently compensated, in a great measure, by an exquisite sensitiveness of touch. Bats also appear to possess this sense in a remarkable degree. They have been observed, even after loss of sight, and with their ears and nostrils stopped, to fly through intricate windings and passages, without striking against the walls, and also to avoid lines and cords placed in their way. The expanded membrane that serves them for wings is probably the seat of this delicate sense of feeling, which so admirably fits them for their nocturnal and dark abodes. The palpi, or feelers of insects, possess the same quality very acutely, and this enables them to explore the surface of bodies in search of food, and warns them also of the approach of danger.

The class should be required, at the conclusion of the lesson, to draw up some account of this sense, mentioning where it resides, what qualities fall within its cognizance, and to recapitulate any incidental information received during the lesson.

LESSON XXXVI.

SIGHT.

The eyes are the organs of sight, and are beautifully adapted for the office they have to perform. They are so constructed as to allow us to see things near, or at a distance; to confine ourselves to the inspection of one object, or to take in at once a large sphere of vision. The part of the eye which admits the light may be expanded or contracted, according as the rays are more or less powerful. This fact is remarkably exemplified in the eyes of the cat and of the owl. Indeed nothing affords a more striking proof of the kind providence of God than the beautiful adaptation of the eyes of animals to their peculiar modes of life; those of moles, fishes, and birds, are remarkable illustrations of this fact.*

Of all the senses, that of sight is in most frequent and continual exercise. It fills the mind with the greatest variety of ideas, which it gathers not only from the objects of nature and of art, but from the writings of the wise and good of all ages.

The qualities we discover by this sense are: transparent, semi-transparent, translucent, opaque, glimmering, bright, dark, sparkling, dull; and the various modifications of color, size, and shape. Many may be ascertained either by touch or sight; as those of size, form, kind of surface, and substance.

* The teacher should here fully explain to the class the circumstances referred to, and give other similar instances.

LESSON XXXVII.

HEARING.

The ears are the organs of this sense. In many animals the ear has externally the form of a trumpet, and is well adapted for gathering sound and bringing it to a focus; in man it contains many convolutions and channels, which receive the vibrations of air in every direction, and convey them to the part called the drum, which is the actual seat of this sense.

The formation of the ears of animals is beautifully accommodated to their peculiar habits of life. In beasts of prey the trumpet part is inclined forward, easily to catch the sound of those they are pursuing. But animals whose chief means of protection is flight, have these organs turned backward, that they may be readily apprised of the approach of their enemies.

The ears are the medium through which all sensations of sound reach the mind; without them, we should be deprived of the advantages of verbal instruction, the pleasures of conversation, and the charms of music.

The motion of the parts of a body, or the collision of one body against another, occasions a vibration in the air, which is similar to the effect produced on water when a stone is thrown into it. Circle succeeds circle, till the power of motion is exhausted; and just as any light substance within the influence of these undulations is agitated by them, so, when our ear is within reach of these vibrations of air, the sensation of sound is produced.* The

* This account may appear, at first sight, above the comprehension of

chirping note of the cricket is occasioned simply by the constant friction of a little membrane against its wings. When two bodies are rubbed or struck together, we may in most cases be able to determine, by the sounds emitted, the nature of the substances brought into contact. Very different sounds are occasioned by the collision of metals from that which wood gives out; and the sound produced from hollow bodies is very unlike that resulting from solid ones. There are various kinds of sounds; as shrill, deep, grating, harsh, loud, soft, harmonious, sweet. Animals produce different sounds. The cat mews, the dog barks, the lion roars, the ass brays, the cow lows, the horse neighs, the rook caws, the goose cackles, the cock crows, the fly buzzes, the bee hums. Man speaks, laughs, cries, shouts, groans, whistles, sings.

LESSON XXXVIII.

SMELL.

The nose is the organ of this sense; its cavities are lined with a thin membrane supplied with nerves connected with a principal one, which is essential to the perception of smell.

By means of this sense we derive all our ideas of odor. Though not so important to man as the other senses, yet it adds much to his pleasure; and to many animals it is essential, directing them in search of their food. The

children; a class, however, which had gone through the preceding exercises, was found fully capable of understanding it.

scent of dogs is peculiarly fine, and on this account they are employed in the chase.

Odor is produced by exceedingly small particles called effluvia, which escape from odorous bodies; these diffuse themselves in the atmosphere, and whenever they reach the olfactory nerves they occasion the sensation of smell. Heat promotes the escape of these particles, which are of a volatile nature; hence, when the sun shines brightly, the flowers are more fragrant.

LESSON XXXIX.

TASTE.

The mouth is the organ of taste. The skin within the mouth is finer and more delicate than that of the rest of the body, it is supplied with a great number of blood vessels, and covered with innumerable papillæ. Sapid bodies, however, before they excite the sensation of taste, require to be moistened by the saliva. In graminivorous animals the papillæ are defended from the action of the stiff bristles of grass and corn by a strong skin, which being perforated, allows the dissolved juice to reach the seat of taste. The principal qualities discoverable by the taste are bitter, sweet, acid, pungent, acrid, luscious. There are many others, which derive their names from the substances in which they exist: as salt, spicy, &c.

Many animals have some one of the senses in great perfection, but in none are they all found in the same degree as in man.

FIFTH STEP.

INTRODUCTORY REMARKS.

The following lessons may be advantageously used as a first exercise in composition. The object should be presented to the children, and they should continue, as before, to make their own observations upon it. Questions should then be addressed to them, calculated to elicit their knowledge of its natural history, manufacture, or composition: and further particulars should afterward be communicated by the teacher, to render their information more complete. After having rearranged and repeated the matter so obtained, the teacher should examine the class, and require a written account. Children from ten to fourteen years of age may derive great improvement from this exercise in composition. It will stimulate their attention, furnish a test of their having well understood the lesson, and lead them to arrange and express their ideas with clearness and facility. Artificial substances should be exhibited, both in their raw and manufactured state. Thus, in the lesson on flax, the plant itself, the fibres when separated from the stem, the thread when spun, and the various articles into

which it is manufactured, may be brought before the class, and likewise pictures of the machinery employed in the manufacture.

Many of the lessons in this Step will contain too much matter to be presented at one time to the pupils, and must therefore be divided.

The information given is exclusively for the use of the teacher, as reference in the preparation of lessons.

Many of the lessons have been taken, with some modifications, from "Information on Common Objects." Much aid has also been derived in their preparation from the "New American Cyclopædia," and, in a few instances, passages have been literally incorporated. This is a work which teachers would do well to consult where accessible.

The following sketches, three on glass, and three on silk, are given as specimens of the way succeeding lessons may be treated.

LESSON I.

I. *Different kinds of Glass compared.*—Bring together several pieces of different kinds of glass, and ask the children to name each—as, crown glass, plate glass, sheet glass, flint glass, bottle glass. These pieces should be examined by the children, that they may point out the difference. They should name the various uses to which they have seen glass applied, and the particular use of each kind; as, for windows, mirrors, drinking glasses, decanters, ornaments, bottles, watch glasses, &c.

Qualities of Glass.—The class should be called on to name the qualities in glass which render it useful; as transparency, hardness, durability, not being affected by weather or acids, &c.

Glass contrasted with substances used in former times. Other substances possessing the same qualities, but in a less degree, should be shown the class, named, and a contrast drawn, for the purpose of proving the superiority of glass over these substances. Thus, horn has not the same degree of transparency; parchment is not so durable; mica does not admit the light so freely; and none of the three have the same bright, cheerful, beautiful appearance that glass has.

II. *Various substances used in the manufacture.*—The various substances used in the manufacture of glass should then be produced and named—as, sand, an alkali (as pearl-ash), nitre, oxide of lead, oxide of manganese, oxide of arsenic, lime, &c.; and the children should be led to see that each ingredient imparts a particular quality to glass. Pearlash, which is much used in flint glass, imparts much clearness. Oxide of lead is used to cause it to vitrify at a much lower temperature than it otherwise would; to increase the density, and to impart tenacity.

III. *Origin and history of the manufacture.*—Information should be given to the children with respect to the progress of the manufacture, and of its supposed origin. They should be told of the glass beads and imitations of precious gems found in Egypt with mummies more than 3,000 years old, and of hieroglyphics that must be as old as the sojourn of the Israelites in Egypt; the relics found in the ruins of Nineveh, and other facts which seem to point to the ancient inhabitants of that country as the first

manufacturers of glass; the many fine specimens of glass in urns and vases which are seen even at the present day, and which show to what an extent the manufacture was carried. They should be told of the introduction of glass making into Europe—first into Italy, finally into England; from thence into the United States by deserters from the British army in the time of the Revolution; but that glass was used very much in England long before the art of making it was known to the English; for even as far back as the time of the Druids, we find glass beads and amulets worn, which were procured in barter with Syrians, who came to Great Britain for tin.

Recapitulation.—After receiving this information, which should be thoroughly worked into the children's minds as the teacher proceeds, they should reproduce the matter on their slates.

LESSON II.

I. *Glass house and tools used.*—In this lesson the children should (after recapitulating the last lesson) give a description of any glass house which they may have seen, and also of the different tools used by those who work in glass. If they have not seen one, a small model or picture may be shown, representing the different parts. They should describe the conical shaped building—the furnace in the centre, with the working holes at the sides—the pots, which are made of the finest clay—their position and number—tools used by the glass blower, as iron tube, shears, punting rod, tongs, &c. They should then be asked as to how the men on the premises are generally employed; some in glass blowing; others in attending to the furnace, carrying coals, and others watching the pots, &c.

II. *Processes gone through in the manufacture of Glass.* The children, having noticed how the workmen were employed, will be prepared to learn the different processes gone through in the manufacture of glass. As a difference exists in the making of each kind, the children may be led to speak of window glass only, as they are better acquainted with that than with the others, and more frequently see how that particular kind is used. They should first be told that window glass is that which is generally used for window panes; and should say what qualities window glass requires that are not of so much importance in other kinds; as hardness, transparency, and durability; and they should then be led to see that in order to give the glass these qualities, a slight difference must be made both in the quality and quantity of the ingredients used. The children should be told that such substances as lead, or metallic oxides, make glass soft and plastic; and they will at once see that very little of these must be used in making window glass, in which greater hardness is requisite. They should be told of the different processes gone through—first, the preparation of the sand by water, for the purpose of removing any impurities—next, the making of frit, and what frit is—the process of melting it down after having kept it for some time. The metal in a liquid state should be spoken of—the time allowed to pass before skimming the metal. The children should be told that broken glass is very useful at this stage of the manufacture. The glass thus used is known by the name of cullet, and is thrown in

with the boiling metal. They should be told next of the workman—the tube which he uses—his mode of forming the mass of metal—first, to a pear shape—then, to a flat surface. A description should be given of the process of annealing—what is its object—why it is necessary—what qualities it will impart to the glass.

This lesson should be reproduced in writing.

LESSON III.

I. *On Stained Glass.*—Several pieces of glass of different colors should be brought before the children. They should examine and describe them, and ascertain whether the colors are merely external, or whether they are such as cannot be removed without destroying the glass. They should be asked where they had seen glass of different colors?—If they had seen figures represented on glass by means of colors—and where? They should be led to name the kind of buildings in which colored glass is generally seen; such as churches, or ecclesiastical edifices of any kind; particularly in those where the object is to make an imposing appearance. Many churches and cathedrals have very fine windows of stained glass.

II. The teacher under this head will describe the process of glass staining, dwelling on the following points:—The pattern, or drawing of the figures to be represented, which is first made. The mode of placing this behind the glass for the purpose of painting the pattern, the materials being prepared beforehand. A description should be given of the muffle, or iron box, in which the glass is burned. The care necessary on the part of the glass stainers should be noticed. The fusing of the glass and its absorption of coloring—the time allowed in the furnace—the removal of the loose particles of paint. The class should be told that the color is produced by fusing gold, silver, and copper with the glass; and that gold is used in producing rose color and ruby; copper in producing blue, green, and lemon; and silver and lead in producing yellow and orange; they will easily see what colors in glass bring the most money, which are most expensive.

LESSON IV.

SKETCHES OF A SERIES OF LESSONS ON SILK AND ITS MANUFACTURE.

For an Advanced Class of Children.

INTRODUCTION AND NATURAL HISTORY OF THE SILK WORM.

I. *Object examined.*—A piece of silk is given to the children, which they carefully examine, and are then called upon to describe its *appearance;* as, smooth, soft, glossy—next, they discover and name the *qualities* upon which its use and beauty depend, viz.: its strength, which is great, considering the fineness of the fibres of which it is composed—its lightness—lustre—capability of taking the finest dyes—it resists fire better than cotton fabrics do—is beautifully soft to the touch, and extremely pliable, so that it can be arranged in folds.

[NOTE.—Specimens of the insect in all its stages should be shown to the children, and constantly referred to in the course of the lesson.]

II. *Description of the Silk Worm.*—Insect and its habits described. Show the children that the silk worm is erroneously termed a worm. Why? It is really a kind of caterpillar, and passes through all the changes which insects undergo.

Changes which the insect undergoes.—Many of the children have, perhaps, tried to rear a silk worm, and will therefore know that it is hatched from an egg, in size like a mustard seed; and is, when first hatched, small, and of a dark color; in a few days it becomes gray, then tinged with the color of its food; it attains its full size in about eight weeks, and it has during this period changed its skin four or five times. Children to determine why this is necessary—its continually increasing size. The insect remains in a quiet state before doing this; refrains from eating; then bursts the old skin near the head, and works its way out.

Length, when full grown, from two and a half to three inches. What does it then do? Begins to spin. Tell the children that it selects a corner in which to spin, then moves its head from side to side, and fixes the thread at different points, so as completely to enclose itself—continues to spin for about five days—during this time it has become much shorter—changes its skin, and takes the form of a chrysalis, enclosed in a dark brown case, and is in a torpid state—remains in this state two or three weeks—then changes into the moth or perfect insect. The children will, perhaps, wonder how the moth can escape from the cocoon in which it is so completely enclosed. Tell them that the little creature does this by softening a portion of the cocoon with a fluid which it has the power of forming. It is now, as they will see from the specimen, a moth of a pale cream color, covered with fine down, and furnished with small, comb-like feelers. After a short time it lays its eggs, firmly cementing them to the substance on which they are deposited; and the object of its existence being thus accomplished, it shortly dies. Children should draw a comparison between the animal in its different stages, as to appearance, organs, and habits.

III. *Food.*—On what does the silk worm feed? The leaves of the mulberry tree. Children will know, that as this tree is not an evergreen, the leaves can only be procured at certain seasons of the year. Has this anything to do with the hatching of the eggs? Yes; they must only be hatched in those seasons when the leaves can be obtained?

Means used to prevent the eggs from hatching at a wrong season.—Sometimes the eggs are sent from one country to another. How are they prevented from hatching on the journey? They are first carefully dried; placed in glass vials, closely sealed, to exclude the air and moisture, and then immersed in earthen pots filled with cold water, which is constantly changed. Why? To keep it cool. Why should so much pains be taken to exclude the air from the egg, and to prevent their becoming warm? Because the eggs of the silk worm, like those of the chicken, and other animals with which the children are acquainted, are hatched by heat.

Manner of hatching the eggs.—The children might then be told the different means used to hatch the eggs.

That in some countries the peasants fold them in small paper packets, and keep them in their bosoms until the warmth prepares them for hatching; in others, that the warmth of the sun is employed; but that the plan most generally adopted is to hatch them by placing them in rooms artificially heated.

IV. *Countries of the Silk Worm.*—A warm climate is necessary to the well-being of the silk worm. Children name and point out on the map some warm countries, as France, Italy, India, China, &c. They might then be told that the silk worm is reared in nearly all the southern countries in Europe: to a very great extent in India and China. That it was originally a native of China, from whence articles manufactured of silk were exported in early ages to different parts of Asia and Europe; and that the raw material furnished employment to manufacturers in Persia, Tyre, and other countries. That in the United States many efforts have been made to introduce its manufacture, but with very limited success.

How introduced into Europe.—The silk worm was introduced into Europe A. D. 552, by two Persian monks, who were missionaries, and had travelled as far as China, where they viewed with great curiosity the dress of the Chinese, and carefully watched the manufacture. On leaving China they went to Constantinople, and entrusted the Emperor Justinian with their secret; he encouraged them by promising them a reward if they succeeded in introducing the manufacture into Europe. They returned to China, with much difficulty obtained a quantity of eggs, cunningly concealed them in a hollow cane, brought them to Constantinople, hatched them, tended the insects with great care, and instructed the Romans in the art of manufacturing silk. The children will thus see that the silk manufacture in Europe had a very small beginning—a caneful of eggs being the means of establishing the manufacture, and of furnishing the Europeans with a luxury, for which large sums had hitherto been exacted from them by their Oriental neighbors.

This and the following lessons should be reproduced by the children in writing.

LESSON V.

BRIEF DESCRIPTION OF THE SILK MANUFACTURE.

I. *Different processes in the manufacture.*—How is the silk obtained from the cocoon? What is the first process in the manufacture? The destruction of the chrysalis. How is this accomplished? By placing it in a heated oven. What is next done? The rough, outer floss, which is comparatively useless, is removed, and the cocoons are thrown into a vessel of hot water placed over a fire. Why? To loosen the thread. The whole is now stirred with a little broom, which catches the loose ends of the threads. Several of these threads taken together are wound upon a reel. Why take several together? Because the fibres are so fine that one taken alone would not be strong enough, it would quickly break. The silk wound off is next tied up into hanks ready for the manufacturer, and is known by the name of "*raw silk.*"

[NOTE.—It is desirable that drawings or models of the machines used in the different stages of the manufacture should be placed before the children, and constantly referred to by the teacher while describing the various processes. Except with the most advanced pupils the remainder of this and the next sketch may be omitted.]

II. *Various operations which the raw silk undergoes.*—Briefly describe the various processes which the raw silk passes through, as winding, spinning, twisting, cleaning, weaving, and dyeing; all of which, except the last, are known under the general term "*silk throwing.*"

Winding.—In this operation each hank of silk is extended upon a six-sided reel (*swift*). A number of swifts are arranged side by side, upon an axis, on either side of a frame. Above the swifts are the bobbins, similarly arranged, one bobbin for each swift. The bobbins connected with the swifts by the ends of the hanks of silk are now set in motion, causing the swifts to turn round and wind the silk. The machine requires constant attention. Why? For the purpose of joining the ends broken in winding, putting on the hanks, and exchanging the bobbins.

Spinning.—The silk is now sorted according to its qualities and fineness. The next process is that of spinning or twisting each thread, which is done in a mill, where it acquires that form called "*singles.*" How is this effected? The long thread of silk is unwound from the bobbins on to a long roller, and in its passage from one to the other becomes twisted. How can this be? The bobbins are fixed upright, and the roller is placed horizontally above them; this circumstance alone is sufficient to twist the silk while passing from one to the other. Two or more of these singles are now twisted slightly together in the manner above described; the next operation is to spin these combined threads into a firm, thick thread, which is performed in the same manner as the former spinning.

Cleaning.—One process only remains before the silk is fit for the weaver, viz., the cleaning. How is this performed? The silk is boiled for four hours in a large quantity of water, into which a good deal of soap has been thrown. Why does the silk require cleaning? Because it still retains the gum, with which the insect covers it, which if not removed, renders the silk harsh to the touch, and unfit to receive the dye. By cleaning, however, the silk becomes soft and glossy. It is now sent to the loom, where it is woven into various fabrics. In a long piece of woven silk the long threads are called the "*warp*," and the cross threads the "*weft*," or "*woof*." These words, and any others *new* to the children which may occur in the lesson, should be written upon the board, and the heads of the lesson also, as it greatly assists the children in afterward reproducing it on their own slates. Before concluding the subject of *weaving*, the teacher might show the children the great care and patience necessary on the part of the weaver, in consequence of the fineness of his work; a piece of silk 20 inches in width, often requiring 8,000 threads, all of which must be arranged with the greatest regularity.

Dyeing.—Can the children think of any process which the silk has yet to undergo before it is fit for sale? Of what color is it now? Did the cleaning alter the color?

No; it is still of a bright yellow color. But white silk is sometimes wanted—how is this obtained? The silk must be "*bleached*," made white, and then it is fit also for the dyer, who, by means of his colors, can make the silk of any shade he pleases.

LESSON VI.

SKETCH III.—BRIEF DESCRIPTION OF THE VARIOUS FABRICS COMPOSED OF SILK.

[NOTE.—The required specimens should be procured, and shown to the children.]

I. *Articles made of Silk named.*—Children furnish the list. Velvet—silks, plain and brocaded—Persian—damask—ribbon—satin—sarsnet, and crape. The value of silk inferred from the number of articles manufactured from it, and the great difference in their texture.

II. *Description of the Fabrics.*—*Velvet*—One of the most beautiful productions of the silk loom now manufactured. In addition to the warp and woof, a soft shag or pile is produced by inserting short pieces of silk thread, doubled, under the woof; these stand up in so large a number and so compactly as to conceal the interlacings of the warp and woof. The children will see, from examining a piece of velvet, that it is this silky pile which imparts to velvet its softness and beauty.

Brocade.—Brocaded silks are those adorned with flowers or other figures of silk.

Gauze.—A material in which the smallest quantity of silk is employed for a given size of woven fabric. How can this be done? If the gauze were woven in the usual way, the threads being so fine, it would be very weak. How is this prevented? The threads are made to cross and overloop each other, (something like the threads of a net,) and thus the material acquires the requisite strength. The children to discover this intertwining of the threads by carefully examining a piece of gauze.

Bombazine, Poplin, and Lustre.—Examined, and found to be substances composed of a mixture of silk and worsted, the two latter containing much more silk than the former.

Satin.—A twilled silk, owing its peculiar lustre to the number of threads of warp passed *over* by the woof before it passes *under* one of them. When taken out of the loom, it presents a slight degree of roughness or flossiness. How is this removed? The children can all tell how their aprons look after they have been washed and dried. Are they fit to wear? No; they look rough. How do they feel? Very stiff and uncomfortable. How can this roughness be removed? They must be ironed to make them smooth. Then how do they think satin can be made so nice and smooth? Just in the same manner, it is passed between heated iron rollers, which smooth down the surface, and give to it that beautiful lustre peculiar to satin.

THE VEGETABLE KINGDOM.

REMARKS.

The nature of the objects which we derive from the vegetable kingdom, and their utility to man, depend so much on the structure and living action of the plants, that some introductory account of the latter seems desirable.

The most important parts of a plant are: the root, stem, branches, leaves, buds, flowers, fruit, and seeds.

The root is that part of a plant which grows under ground; it serves the purpose of fixing the plant firmly and of absorbing moisture for its support; it is usually more or less fibrous, and the absorption of moisture takes place almost entirely at the very extremities or points of the fibres.

In some plants the root often serves as a storehouse of nourishment for their growth during the following year. This is the case in those plants which, like the carrot and parsnip, instead of flowering in the first year of their growth, produce and store up nourishment for the second year, when they bring forth flowers and seeds. Plants growing in this manner are termed biennials, and the nutriment stored up during the first year in their large fleshy roots is often used for food by men and animals.

The stem or trunk of a tree consists of three distinct parts; in the centre is a light, soft, cellular substance, termed the pith; which in some plants, as the elder, is sufficiently large to be readily examined; its use appears to be to convey the sap upward to the leaves when the plant is very young, and before other channels are formed for its ascent; as the plant increases in age, the pith becomes dry, is apparently of no further use, and may be removed without injury to the life of the tree.

The pith is surrounded by the wood, which consists of tough, strong fibres, firmly united together, so as to form a solid substance; these fibres are arranged side by side, running in the direction of the stem or trunk: they cause what is termed the grain of the wood, and are cut across when a piece of wood is cut *against the grain*, and torn from each other when it is split *with the grain*.

Every summer a fresh quantity of wood is formed round that previously existing; each season's growth is therefore of necessity a hollow cylinder, inclosing the wood previously formed, and the appearance it exhibits when the tree is cut across is, of course, circular, the whole mass of wood being formed of a series of such circles, each the result of one year's growth; it follows that by counting them we may ascertain the age of the tree; the first year's wood is next the pith, that formed the second year is outside that of the first year, and so on; a fresh circle being deposited each year external to those previously formed.

If a single circle is examined, it will be found that the vessels are larger and more open in that part which is nearest the centre of the tree; this arises from the fact that this is formed in the spring, when growth is more rapid, and the leaves require a larger quantity of sap; in some woods, the great difference between the inner and

outer part of each circle, renders the rings very distinct, as in oak, ash, and elm; in others, as beech and mahogany, the texture is much more uniform; in the wood of the fir tribe, the pores are filled with resinous matter, rendering the circles very evident.

The oldest wood in a tree is toward the centre of the trunk; this is termed the heart wood; the youngest and softest is at the outside, and is called the sap wood, because it is through it that the sap rises to supply the leaves; the sap wood is gradually converted into heart wood as it grows older, the pores and interstices being filled up and darkened in color by the thickened juices, which descend from the leaves through the back, and reach the older circles by means of a series of passages passing inward from the bark to the pith. These medullary passages or rays (termed by carpenters the silver grain, from their giving a glistening appearance to the wood when it is cut parallel to them) are large and readily observed in oak or beech, while in fir wood they are small, numerous, and not easily distinguished. For purposes requiring strength and durability only the heart wood is employed; timber trees should be felled at mature age, when the heart wood is well formed, and before any decay has commenced; the best season for felling is winter, when the sap is present in very small quantities; after having been felled, they should be seasoned by an exposure to dry air for at least two years, otherwise the wood will warp and split when used; well-seasoned timber employed in dry situations is extremely durable; if wholly sunk in water, the durability is much lessened, and, when exposed to alternate moisture and drought, all timber decays rapidly.

In its power of resisting pressure, timber may be regarded as incompressible in the direction of its fibres; but pressed at right angles to the grain, the softer kinds, such as fir, shrink considerably; in resisting a force pulling in opposite directions, timber possesses enormous strength; bars of oak or fir one inch square being capable of supporting upward of five tons; in bearing a cross strain, the different kinds vary considerably, some, as fir, &c., being much weakened by the tendency of the annual circles to separate from each other.

The uses of the wood to the tree are to give firmness and strength to the stem, and to serve as a channel for the ascent of the sap to the leaves and flowers.

Around the wood is the bark. This also is formed in circles, but they are so pressed together by the growth of the wood beneath that they cannot readily be counted. The bark varies much in character in different trees, being sometimes fibrous, as in the bass tree, so much employed by gardeners and nurserymen; leathery, as in the bark of the birch, of which boxes and canoes are made; or corky, as in the cork tree of Spain and Portugal.

In the trees of tropical climates the arrangement of the woody matter in the stems is very dissimilar to that occurring in the trees of temperate countries; there is, as it were, a mixture of pith and woody fibres together, and no trace of circles can be observed. Such trees are easily recognized by their appearance, as they are almost invariably destitute of branches, bearing merely a tuft of large

leaves on the top of the trunk. Of this kind of growth the various palm trees are well known examples.

Leaves are the flat, green, expanded bodies growing on the branches. Each leaf consists of a framework of veins, which is sometimes netted, as in most of the ordinary leaves of this country, and sometimes perfectly parallel, as in our grasses and grains, and in all the trees of the palm tribe; between the veins is the pulp, having numerous air cavities passing through it in every direction; the whole is covered with a skin, extending over both surfaces of the leaf, that on the under surface being pierced with innumerable breathing pores.

The action of the different parts in the living vegetable may be thus briefly described. The roots, by their extreme points, absorb from the soil water containing certain mineral and other substances; this rises through the sap wood, and is conveyed by the branches into the leaves; there it is exposed freely to the action of the sun and air, and a large portion of the water escapes by evaporation: the remainder is, by the influence of the air entering through the breathing pores, converted into the nourishment required for the support of the plant and for the formation of its peculiar products and secretions.

Such portion of the sap as is not required for the growth of the flowers and fruit descends by the bark, and, passing inward by the medullary rays, is stored up in the heart wood, or, as in the case of biennials during their first year's growth, descends to the fleshy root, there to be stored up as nutriment for use during the next season, as in the case of the carrot and parsnip.

When any peculiar substance of a medicinal or other marked character is produced by a plant, it is obvious that we may, in many cases, be so guided by a knowledge of these facts, as to obtain it in the greatest quantity. Thus, when the sap is first absorbed by the roots, it is thin and watery, not possessing any decided properties. The same remark applies to it as it exists in the sap wood, but in its altered state in the leaves it possesses marked and decided properties; hence leaves are frequently employed for medicinal or other purposes, as in the case of tea, and of the sweet herbs used in cookery; as the altered sap descends by the bark, that part becomes charged with the peculiar substances which the plant has the power of forming; and thus bark is very frequently employed in the arts, and also in medicine. Oak and other barks used in tanning, and cinnamon employed as a spice, may be taken as examples.

Should the wood itself be required for the sake of any substances contained in it, the heart wood filled with the altered sap is much more valuable than the sap wood.

The root, also, as in the case of jalap, rhubarb, chicory, &c., &c., is often charged with the peculiar principles of the plant producing it.

The flowers consist of several parts, each distinct in its structure and use; the outer part, usually green in color, which encloses all the others in the flower bud, is termed the calyx or flower cup; it usually consists of several leaf-like parts more or less united at the edges; these are termed sepals.

The more highly-colored and ornamental part of the

flower is termed the corolla; this also consists of several leaf-like parts, which are termed petals.

The corolla surrounds the stamens, which are small bodies, exceedingly variable in number, consisting of an elongated stalk or filament crowned by an enlarged head or anther.

The seed vessel, containing, as its name implies, the young seeds, and protecting them until they have arrived at maturity, is the most important part of the flower; it is variously situated, being in some, as the apple and cucumber, below the flower, and in others, as the cherry, within it.

Seeds of various plants—as grains, pulse, spices, &c.—are largely made use of by man for food and other purposes; as they contain, stored up in small space, a quantity of very nutritious matter for the support of the young plant during the first stages of growth, before it has formed roots and leaves, so as to obtain its own nourishment from the earth and air.

OBJECTS DERIVED FROM THE VEGETABLE KINGDOM.

Bark and Stems.

LESSON VII.

CORK.

Natural History.—Cork is the bark of a small evergreen oak which grows abundantly in Spain, Portugal, the south of France, and north of Africa. When the tree is from fifteen to twenty years' old, a circular cut is made around the trunk immediately below the branches, and another at the surface of the ground; several perpendicular incisions are then made from one to the other, and the cork removed by inserting a blunt instrument underneath it, care being taken not to injure the inner bark, which would cause the death of the tree. The operation is performed in July or August, and is repeated every eight or ten years during the whole life of the tree, usually about 150 years.

The cork, when removed, is slightly charred or scorched; this improves it by closing the pores, and enables it more easily to be flattened by pressure, at the same time giving it the dark color and burnt odor by which it is distinguished.

Uses.—The qualities that render cork so valuable are: its lightness, its being compressible, elastic, and impervious to liquids; its lightness renders it valuable in constructing lifeboats, cork jackets, floats for fishing nets, and other purposes; its being compressible, elastic, and impervious, renders it fitted for closing the mouths of bottles, as, when firmly forced in, its elasticity causes it to press so closely against all parts of the mouth as to prevent the contents from escaping, or the air from gaining access.

Cork is also occasionally used in thin layers to form the inner soles of shoes and boots; it is cut into the required shape for the various purposes for which it is used by means of broad knives, which require constant sharpening. Bungs for casks are so cut that their flat sides correspond to the two sides of the cork, while bottle corks are cut in the opposite direction; the latter are consequently much

less porous in the direction of their length, and afford a more secure fastening.

LESSON VIII.

CANES.

Natural History.—Canes, or rattans, are the long, slender stems of a species of palm which grows wild in the forests of the East Indies, the Malay peninsula, and the adjacent islands; the plants are remarkable for the extraordinary length of their stems, which occasionally reach several hundred feet; they are abundantly furnished with hooked prickles, by means of which they are supported on the tops of the highest trees.

The stems are cut by the natives, and stripped of their leaves, which surround them like a sheath, by being pulled through a notch cut in a tree; they are then dried in the sun, and tied up in bundles for exportation.

Uses.—Canes consist chiefly of tough woody fibres, with a number of open tubes to allow the ascent of the sap with sufficient rapidity to supply the great evaporation that takes place from the leaves; on the outside they are covered with a transparent flinty coating of extreme hardness; canes split readily in the direction of their length, and are used for forming the open lattice work of the seats of chairs, and similar purposes, for which they are well adapted by the toughness and strength of the fibres, and the hardness of the external covering. Those are esteemed the best which are pale in color, very long, thin, and sufficiently flexible to bend without cracking the glazing.

In addition to these uses, the plant yields an edible fruit, and when cut across, a flow of wholesome, refreshing sap takes place from the end of the stem; the young shoots also furnish, when cooked, a pleasant and delicate article of food.

Within the last few years, canes have been much more largely imported than formerly, and they are now employed for coarse basket work which is exposed to great violence; for this their great strength renders them valuable. The large baskets used by grocers, bakers, and other trades, for heavy goods, are now also frequently made of unsplit canes.

LESSON IX.

CHARCOAL.

Preparation.—The term coal, or cole, was originally applied to wood or any substance used for fuel; hence half burned or charred wood received its name of charcoal. Charcoal is prepared by setting fire to a heap of small wood, almost entirely covered with a layer of earth, and when the whole is ignited closing the openings by which air has been allowed to enter, the fire is thus put out and the wood remains in a charred state. The best charcoal is made from hard wood.

Properties.—Wood charcoal is a light black porous solid; showing distinctly the annual rings and structure of the wood from which it was formed; it is brittle and easily reduced to a coarse powder, the small particles of which it is composed being exceedingly hard. It is perfectly unchangeable in air, insoluble in water or in the strongest acids, and also infusible in the fire. Heated to redness in the air, it burns away without smoke, producing an invisible but fatally poisonous gas termed carbonic acid. It is so bad a conductor of heat, that a piece may be held in the fingers within a quarter of an inch of the red hot part.

Uses.—Charcoal is remarkably distinguished by its power of absorbing gases to the extent of many times its bulk; hence it is frequently employed to remove any unpleasant odors arising from putrefying animal substances, which it does by absorbing them. The chief use of charcoal is as fuel; it is much more largely employed for this purpose in cities than in the country; it is also extensively used in the manufacture of gunpowder, that prepared from the black alder being usually selected. Its power of absorbing odor leads to its use in correcting the smell of tainted meat; and it is sometimes spread upon over-crowded churchyards with the same view. Powdered peat charcoal is also used in some European countries to absorb the smell of offensive manures previous to their being spread upon the soil; and water is frequently purified by filtering through a layer of powdered charcoal. It is also used for polishing hard substances, for making crayons, and in medicine. Animal charcoal, which is prepared by heating bones to redness in close iron vessels, is largely used in the sugar refineries, as when syrup made from raw or brown sugar is filtered through a layer of it, the coloring matter is absorbed by the charcoal, and the syrup becomes colorless. (*See Sugar.*)

GRAIN AND PULSE.

GENERAL OBSERVATIONS.

Description.—The plants yielding grain are annuals; the whole plant, including the root, dying when the seed is ripe; their stems, which are termed straw or culm, are hollow, and divided into lengths by partitions across the interior, corresponding with knots or swellings on the outside; this structure is evidently intended to strengthen the hollow stalk; this stem is covered externally with a siliceous or flinty varnish, which gives a peculiar harshness to the straw. The leaves arise from the knots, alternately on opposite sides of the stem; each leaf has a broad, flat stalk, which is rolled around the stem, so as to form a sheath, split up on one side; the blades of the leaves are long, and tapering to a point; their veins run straight, and parallel with each other, from the base to the point, not branching out and reuniting, as is common with most leaves; the last leaf of the stalk forms a sheath, which is securely and closely rolled around the young heads or ears of grain.

The blossoms of the grain plants are formed of small scales, which are at first green, but become yellow when ripe; they enclose a one-seeded fruit termed a grain; the blossoms are usually arranged in close heads, termed ears or spikes; grains and grasses belong to the same tribe of plants, differing only in respect to size; the seeds of all grasses might be used for food if they were large enough to answer the purpose, as no grass plant, except the common darnel, is unwholesome when in a healthy state. The grains contain a very large proportion of starch (see *Starch*), a considerable quantity of a very strengthening food known as gluten, a variable amount of oil or fat, and small quantities of sugar, gum, fibre, and other substances.

The native country of the common grains is unknown; with the exception of barley, which is indigenous in Sicily and the interior of Asia, they are not found anywhere in a wild state; but are probably grasses which have been increased in size and value by cultivation; when allowed to grow wild, they soon degenerate and cease to bear seed sufficiently large to be available for the food of man.

LESSON X.

BARLEY AND MALT.

Cultivation.—Barley, next to wheat, is one of the most important grains cultivated in this country. Like most of the grains, its native country is unknown, and, if allowed to grow wild, it rapidly degenerates.

Two distinct kinds are cultivated—winter barley and spring barley.

Barley is a very hardy grain, capable of resisting both heat and drought, and may therefore be more profitably grown upon poorer soils than wheat; it comes quickly to maturity, and ripens perfectly in short northern summers, which are not long enough to admit the ripening of wheat; it is the latest sown and the earliest reaped of all our summer grains; in warm countries two harvests of barley are reaped each year—one from the winter, the second from the spring sown. This fact explains the passage in Exodus ix, 31, where the plague of hail is mentioned:—"The flax and the barley were smitten, for the barley was in the ear;" "but the wheat and the rye were not smitten, for they were not grown up." This plague happened in March; the first crop of barley was, therefore, nearly ripe, having been sown the previous autumn.

In this country barley is usually sown from the middle of April to the middle of May, although the time varies somewhat in different localities, and is sown broadcast by hand, or with the drilling machine. It thrives best in dry seasons; if there is much rain it becomes sickly, and in very wet seasons each grain will sprout in the ear, and the whole is rendered worthless.

Winter barley, as its name implies, remains in the ground during that season, and is usually sown in October.

The quantity of barley produced on an acre of land is, on an average, from twenty-five to thirty-five bushels.

Each grain of barley ends in a long awn or beard, which is broken off in threshing; the shape of a grain is doubly conical, being pointed at the ends, and there is a groove on one side; from its tolerably uniform length, it has given its name to one of our divisions of the inch, namely, one-third, it being reckoned that three barley corns placed end to end make one inch in length.

Uses.—The great use of barley is to make malt for brewing beer and distilling spirits. The malting of barley is performed by steeping it in water until it has become soft and swollen; it is then taken out and allowed to drain, and remain in heaps for about forty hours, during which time each grain begins to grow or germinate, sending out a small root, as it would if planted in moist earth; to check this growth, the barley is spread out to dry on floors, and afterward heated in a kiln; the color of the malt varies with the heat at which it is dried; the darker kinds are used for brewing porter, and the lighter for ale. After having been kiln dried, the root is broken off by stirring the malt with spades, and, when separated by sifting, forms the substance known as malt dust or malt culm, which is used for sheep feeding, and sometimes as manure.

During malting, barley undergoes the changes that happen to all seeds during germination; the starch matter is converted into sugar, which is capable of being dissolved in the juices of the growing plant and nourishing it; hence the taste of malt is sweet, and it is the sugar which, dissolved by boiling water, changes during fermentation into the spirituous part of the beer.

Barley does not form a palatable bread when ground into flour, as it is coarse, dry, and apt to become sour. It is sometimes used for food, especially by invalids, in the form of pearl barley; this is formed by grinding off the outer husks in mills adapted for that purpose.

It is used as food for poultry, and, when ground into meal, for fattening pigs, turkeys, and other animals.

Barley straw is of considerable value as fodder for cattle and horses.

LESSON XI.

RYE.

Cultivation.—Rye is a grain capable of growing on lighter and poorer soils, and in colder latitudes than the other varieties of grain. It is, therefore, the prevailing grain in a portion of Siberia, the North American Russian possessions, the northern part of the New England States, and the north of Europe. It requires less care in the preparation of the ground, and a less amount of manure than is given to either wheat or barley; but the value of the produce is proportionably small. Rye is usually sown in the autumn after a crop of wheat, although the nature of the previous crop is not of great importance. It is supposed to be a native of the desert countries round the Caspian Sea.

Uses.—Rye is cultivated for several distinct purposes. The ripe grain, ground into meal, is largely used by the poorer class of people in Russia, and other parts of the Continent, for making a coarse, heavy kind of bread, which is very dark in color, and unpalatable. In Holland the ripe grain is fermented, and a distilled spirit obtained from the liquid. Rye straw forms the best material for thatching, and is much used for making straw plait for hats and bonnets.

In this country, rye is not largely used for food, and but a limited amount of it is raised.

It is only on the poorer and more barren soils that it is cultivated for the sake of the grain; but in some situations near poultry yards a belt of it is sown around fields of other grains, to protect them from fowls, as they do not relish rye as food. One circumstance that renders rye less desirable as food for man, is the occasional occurrence of a disease in the grain, rendering it extremely unwholesome; in this affection, the grains en-

large very considerably, and become somewhat like the curved spur of a cock; hence the name spurred rye, or ergot of rye. From this diseased grain a very useful medicine (secale cornutum) is extracted.

LESSON XII.

OATS.

Cultivation.—The native country of oats is not known with any degree of certainty. The plant flourishes in colder climates and seasons than any other grain, and is therefore largely cultivated in high mountainous countries, as Scotland, Norway, and Sweden. In appearance it differs strikingly from the other grains, the flowers being arranged in loose bunches, so that each hangs with the open part of the husk toward the earth, an arrangement which prevents the access of wet to the grain.

Several varieties are known in this country, such as the white, red, black, &c.

Oats are usually sown in April or May, being scattered broadcast by hand, at the rate of from four to six bushels an acre, and the average produce is from thirty to fifty bushels.

Uses.—Oats form an exceedingly wholesome and, at the same time, very nutritious article of food; when kiln dried and ground into coarse meal, they form the food of a very large proportion of the people of Scotland and the north of England, being used both in the form of oaten cakes and porridge.

When the seeds are deprived of the husks they are called oat grits, and form a very palatable and nutritious food for the sick. Except in this form, it is but little used for food in the United States.

The great consumption of oats, however, is as food for horses; for this purpose they are employed both whole and ground; they are also used for feeding geese, ducks, and other poultry, &c.

The ripe straw of the oat is regarded as more nutritious than any other, and is preferred as fodder for cattle; and the chaff or husk of the grain is often used for stuffing mattresses among the Scotch peasantry, as it is soft, elastic, and inexpensive.

LESSON XIII.

RICE.

Cultivation.—The native country of rice is undoubtedly Asia, in the warmer parts of which it is even now found growing wild, and the seeds collected for food; from Asia it has been carried by man, and spread over the warmer and more marshy parts of Europe, America, and Africa; its introduction into America has taken place within the last one hundred and fifty years.

The great peculiarity in the cultivation of rice is the quantity of moisture it requires. In this country, for example, it is sown in the spring, in rows or trenches eighteen inches apart, and the ground is flooded with water for several days; when the plants are four inches high, the flooding is repeated, and continued for a fortnight; and again a third time, shortly before the grain ripens, the fields are

inundated, and remain so until the rice is ripe. From the swampy state of the soil in rice-growing districts, the cultivation of rice is a most unhealthy occupation, and in this country it is left almost entirely to the care of negro slaves. On the grain becoming ripe, the water is drained off, and the reaping performed with a sickle, the laborer sinking deeply in the soft ground in which the plants grow.

Rice is cultivated in very much the same manner in Italy, Lombardy, and Spain, and to an immense extent in India, China, and Ceylon. In all countries the best rice fields are the low swampy grounds through which the large rivers run; in other situations the waters of the small streams are collected in reservoirs, and used for irrigating the grounds.

In fertility rice much exceeds our common grains; in India two crops a year, of thirty to sixty bushels each, are the ordinary produce of an acre. In Lombardy, three bushels of seed are sown to an acre, and the usual return is fifty bushels.

It is often shipped in the state of rough rice, that is, with the hulls on, as it is thus more easily protected from damage in transportation. Its preparation is completed in mills made for this purpose, both in this country and in Europe.

Rice, although not spoken of by name in the Holy Scriptures, must have been well known to the sacred historians; it is probable that its cultivation is alluded to in Eccles. xi, 1, and Isaiah xxxii, 20.

Uses.—Rice forms the chief food of a greater number of persons than any other substance; the people of India, China, and part of America, live chiefly upon it; with a mixture of spices termed curry, it forms almost the entire food of whole races of men in India; and it is estimated that it supports upward of one hundred millions of people.

As a diet it is light, wholesome, and readily digested; but, from consisting almost entirely of starch, it is not so nutritious as the other grains; it is used with more advantage as a partial article of food than alone; in the latter case the quantity necessarily eaten is very large.

In India a species of strong spirit termed arrack is distilled from fermented rice, and the straw is also used for making plait for bonnets. Large quantities of rice are used in England in the manufacture of starch.

LESSON XIV.

INDIAN CORN OR MAIZE.

Cultivation, &c.—The native place of maize is undoubtedly America, where it was found growing both wild and cultivated by the Spanish discoverers of the New World. In appearance the Indian corn differs much from other grains; the stalk is strong, jointed, and reedy, growing from seven to ten feet in height, and covered with broad alternate leaves; the top of the stem bears a bunch of barren flowers, termed the *tassel;* and lower down are the ears, generally about three in number, each enclosed in a sheath formed of several thin leaves; the ears consist of a pithy, cylindrical stem, called the *cob*, on which are closely arranged the rows of seeds; from each seed proceeds a

long silky filament, which issues from the sheath at the top of the ear; after a time both the tassel of barren flowers, which forms a fertilizing powder necessary for the protection of the grain, and the silken filaments which receive it as it falls, dry up and drop off.

The color of Indian corn varies from a rich golden yellow, or even white, to a deep red chocolate color.

The cultivation of maize is very simple. The grains are planted in rows about three feet apart, care being taken that the season is so far advanced that the young plants shall not be destroyed by the frost. The return varies greatly, according to the quantity of manure used, and the nature of the ground, but it is always very great, in some instances even several hundred fold.

Uses.—Indian corn forms the staple article of food in many parts of the United States, and among all classes of persons in Mexico; in Africa, where it has been introduced and is largely cultivated, it is said to be as much used as rice.

In those warm countries where it grows to perfection, it is the most profitable grain that can be cultivated, its produce being so much greater than that of any other grain; it forms, in consequence, a cheap, and, at the same time, exceedingly wholesome article of diet. It contains a larger proportion of fat or oil than any other grain, and is, therefore, possessed of remarkable fattening properties.

From consisting in great part of starch, Indian corn flour is not well adapted for making bread, unless mixed with wheat flour; it is most frequently used in the form of thick porridge, puddings, and cakes.

Corn is used extensively in the United States in the manufacture of starch. The largest manufactories are at Oswego, N. Y., and Glen Cove, Long Island. At the former place more than 200,000 bushels of corn are made into starch annually, which is used both in cooking and by the laundress

LESSON XV.

WHEAT.

Cultivation, &c.—The native country of wheat is not known with any degree of certainty; it has in fact been so changed by cultivation that it is unknown in its natural state; in Europe, where it has been long cultivated, many varieties exist, the most important being the spring or summer, and the winter or lammas wheat. Spring wheat, so termed from its being sown at that season, has a more slender head than the winter kind; it is also awned or bearded; the grain itself is smaller, and the whole plant more delicate and less productive; it is, therefore, less cultivated.

Winter wheat is a vigorous and hardy plant. The ear is destitute of any awn or beard. Two distinct kinds of it exist, which are distinguished by the names red and white wheat. The latter is more delicate in its growth, and is better suited to lighter lands than the red. It is preferred for producing fine flour, and consequently sells at higher rates. The red wheat, on the contrary, is hardy, and better adapted to the cold, strong clay soils. Winter wheat is sown in the autumn, usually in September or October,

the young plants standing during the winter, and ripening their seeds the following autumn.

The sowing is either broadcast by hand, or performed with the drill or sowing machine; the latter causes a much more advantageous arrangement of the seed in furrows. Wheat *tillers* freely; that is, each seed produces several stalks, the usual number being about five or six.

The produce of wheat is, on the average, about twenty-six bushels an acre; but in districts where manure is abundant and agriculture carried to a high state of perfection, much larger quantities are obtained; forty bushels to the acre, are not unfrequent. From the United States and Canada large quantities of flour are annually exported to Europe.

Wheat is subject to a disease called smut, which may be described as a sort of black mildew, affecting the ripening grain. A few diseased grains will contaminate a large quantity of seed, and the plants produced from such seed will be affected; fortunately this disease may be almost entirely destroyed, even when largely present in seed wheat, by steeping it in various solutions, as, for example, strong brine, or, what is still more effectual, a solution of sulphate of copper, or blue vitriol; or a weak solution of arsenic.

Uses.—Wheat furnishes, when ground, one of the most nutritious and valuable of all kinds of flour; in temperate countries, where the poverty of the inhabitants does not preclude its use, it forms the chief article of food. From the tough character of the dough (obtained by mixing wheat flour with water) it forms a more spongy, and, therefore, lighter kind of bread than any other flour.

LESSON XVI.

PULSE.

The term pulse is applied to the seeds of plants resembling more or less in their structure the common pea; they are characterized by highly developed and ornamental flowers, the corolla consisting of petals which are irregular in form, and which, in some species, as the sweet pea, so much resemble a butterfly, that they have been termed butterfly-shaped, or papilionaceous, a term which is applied to the flowers of the whole group.

The ripened seed vessel is also very peculiar in these plants. It consists of two halves, or valves, usually convex externally and concave internally; these separate when ripe, and disclose a row of seeds attached to each valve. Such seed vessels are popularly termed pods, and are known to botanists as legumes; hence the plants bearing them are frequently termed leguminous plants. In this country peas and beans form the most frequently used leguminous seeds.

It should be remembered that all leguminous seeds are not wholesome; those of the Laburnum tree, for example, often give rise to serious illness when eaten by children.

LESSON XVII.

BEANS.

Natural History.—Beans are the produce of a plant which originally came from the East, but which is now extensively cultivated in all the temperate parts of the world.

The plant is an annual, from two to four feet in height; the leaves are divided into leaflets; and the flowers, which are of that kind termed butterfly-shaped, are white, with a black spot on the centre of each wing, and exceedingly fragrant; each flower is succeeded by a broad thick pod, smooth externally and woolly internally, containing several seeds.

Beans require a heavy clay soil, and are planted in hills or sown in drills, either with a hoe or with a drilling machine. The crops are ready to be gathered in the autumn. The formation and growth of a bean may be readily examined if it is soaked in water for a few hours. It will be found to consist of a thick outer skin or covering, inclosing two parts, joined together by a small curved, doubly pointed portion; the two halves are the seed lobes, or leaves; these contain the nourishment for the young plant, and, rising above the surface of the ground, form its first leaves; the connecting parts consist of the young stem and root; the uses of the different parts may be readily ascertained by moistening a few beans and examining them from day to day.

Uses.—Beans constitute a very hearty food, and the better sort are much used for the table. They are extensively used for rations in the army, and as ship stores. In England they are employed as food for hard-working horses, for which purpose they are usually crushed and mixed with cut hay, straw, bran, oats, or other food; they are also used in fattening pigs, but are regarded as making the flesh hard and tough; bean meal is also sometimes mixed with the flour of new wheat for making bread.

LESSON XVIII.

PEAS.

Natural History.—The plant yielding the common pea is a native of the south of Europe, but it is now cultivated in all temperate climates. It is a climber, with compound divided leaves, the main stalks of which proceed beyond the last pair of leaflets, and form the spirally twisted tendrils, by means of which the plant clings for support to other objects. Few circumstances show more evidently the design and wisdom of the Creator than the numberless instances of compensation. Animals, for instance, denied the possession of some one sense, are compensated for it by the great perfection of another, which answers their wants more perfectly; or, as in the present case, a plant destitute of the power to raise its leaves and flowers from the ground, and expose them to the genial influences of the sun and air, is compensated for its weakness by a contrivance which enables it to borrow the needful support from other plants.

The flowers of the pea consist of five dissimilar petals, forming that kind of flower termed butterfly-shaped, or papilionaceous, which is only found in the plants of the pea tribe. Each flower is followed by a pod, which divides when ripe into two parts, both of which bear a row of seeds, or peas. Each pea consists of an outer skin, inclosing two half globular seed lobes, connected together as in the bean, the description of which may be referred to as applicable to the various parts of the pea. Cultivation has

produced many varieties of this vegetable; some are remarkable for ripening earlier than others; some for their peculiar form, size, or color. The common field pea requires a rich, strong soil, but the garden varieties succeed better on dry, light lands.

Uses.—The garden pea is highly valued for the table, when gathered in its green state, and when ripe, dried, and separated from the skins, we obtain from them the well known split peas, and pea flour, so much used for making puddings and soup. In this form they furnish an exceedingly nutritious and wholesome, but, to some persons, not always an easily digested article of food.

The common pea is largely used in feeding pigs; it is grown as an agricultural crop, being sown either broadcast or in drills; in either case it spreads over the ground, and for the purpose of support a few beans are sometimes sown with it. The dry haulm or straw of the pea is very valuable as food for horses and cattle.

Fruits and Seeds.

LESSON XIX.

FOREIGN CURRANTS.

The foreign, or dried currants, are a species of small raisins or grapes, which chiefly grow in the Grecian Islands. They were formerly very abundant in the Isthmus of Corinth, and were called from thence Corinthians; this term has been corrupted into currants, probably from their resemblance to the English fruit of that name. These little grapes have no stones, and are of a reddish black color; they are extremely delicious when fresh gathered. The harvest commences in August, and as soon as the grapes are gathered they are spread to dry on a floor, prepared for the purpose by stamping the earth quite hard. This floor is formed with a gentle rising in the middle, that the rain, in case any should fall, may flow off and not injure the fruit. When sufficiently dry, the currants are cleaned, and laid up in magazines, where they are so closely pressed together that, when a supply is needed, it is dug out with an iron instrument.

They are packed in large casks for exportation, and trodden down by the natives.

LESSON XX.

THE COCOANUT.

The tree which produces this fruit is a kind of palm, which is found in Brazil, Ceylon, and throughout the East Indies; its trunk resembles a stately column, crowned at the summit with narrow leaves, fourteen or fifteen feet in length, and only three in breadth; amidst these, hangs the fruit. The external rind of the cocoanut is thin, brown, smooth, and approaches a triangular form. This covering encloses an extremely fibrous substance, of considerable thickness, which immediately surrounds the nut; the latter has a thick and hard shell, with three holes at the base, each closed by a black membrane. The kernel, which is about an inch in thickness, lines the shell and encloses a sweet, refreshing liquid. The cocoanut tree affords the Indians

food, clothing, and means of shelter. Before the kernel comes to maturity, it is soft and pulpy, may be scraped out with a spoon, and supplies the natives with an agreeable and nutritious food; when pressed in a mill, it yields an oil. By making incisions in the flower-buds at the top of the tree, the sap flows out, and is esteemed an agreeable and cooling drink; it is sold in the bazaars under the name of toddy. If allowed to stand a few hours it ferments, becomes extremely intoxicating, and is called palm wine. By soaking the fibrous trunk in water it is made soft, and can be manufactured into sail cloth, or twisted into cordage of any description, which surpasses in durability that formed of hemp. The woody shells are very hard, and susceptible of a high polish; they are used for cups, ladles, and other domestic utensils. The trunk of the tree furnishes either beams or rafters for habitations, or is made into boats. The leaves platted together form an excellent thatch; they are also used for umbrellas, mats, and various other useful articles.

LESSON XXI.

RAISINS.

Natural History.—Raisins, or dried grapes, are the produce of the vine—a plant which, although now cultivated in all the warm parts of the globe, was originally a native of the south of Asia, from whence it has been carried into Europe, Africa, and America. The early cultivation of this plant is mentioned in Genesis ix, 20; and the large size of the fruit produced in the genial climate of Palestine is as remarkable now as in the time of Moses.

In this country the fruit of the vine does not arrive at a sufficient degree of perfection to make wine, without the addition of sugar; nor is the warmth of the sun powerful enough to dry raisins; we are, therefore, dependent upon other countries for our supply.

In Valencia, from whence our great supply is obtained, the raisins are prepared by dipping the bunches of grapes into a hot lye made of wood ashes, oil, and lime; they are then exposed on frames of basket-work for fourteen or fifteen days, to be dried by the heat of the sun.

Muscatel raisins are dried on the vines without being dipped; hence the different appearance and flavor. The effect of the lye is to soften the skin of the fruit, rendering it less tough, but it somewhat injures the flavor. Valencia raisins are employed in pastry, the Muscatels for eating uncooked.

Sultana raisins are a smaller variety from Smyrna, without seeds. A peculiar mildew has attacked almost all the varieties of the grapevine during the last few years; the quantity of raisins has been lessened, and the price correspondingly increased.

LESSON XXII.

FIGS.

Natural History.—Figs are produced on a small tree, originally a native of the southwest of Asia, but now cultivated extensively in all the countries of the south of Europe; in height it seldom reaches above twenty feet, and bears large, deeply-lobed leaves, very rough on the upper

surface, and downy beneath; it is not furnished with any visible flowers, the fruit arising from the stem in the form of small pear-shaped buds, which are pierced at the larger end with a small hole; these buds enlarge in size until they become ripe, still retaining their original shape. Each one contains a cavity, lined with numerous small, scale-like bodies; these are the flowers enclosed within the fruit. The structure cannot be seen in the dried fig, the cavity having been closed up by pressure, and the internal flowers ripened into the seeds. In its unripe state, the fig abounds with a bitter milky juice—this, as it ripens, becomes changed into sugar.

One of the most remarkable circumstances connected with the fig is the fact of its bearing two, or even three, crops of fruit during the year; this peculiarity, and the extreme value of it as an article of food, are alluded to frequently in the Old Testament,—"I found Israel like grapes in the wilderness; I saw your fathers as the first-ripe in the fig tree at her first time."—(Hosea ix, 10).

The first crop is formed on the old wood, and is ripe in May and June; the second grows on wood of the same year, and is ripe in September; and in very warm climates, as Greece and Egypt, a third crop is produced, which ripens after the leaves are shed, thus supplying the inhabitants with fresh fruit during the greater part of the year.

Those intended for exportation are not gathered until perfectly ripe; they are dried on frames, which are placed in the sun by day, and under cover at night; in very wet seasons they are partially dried by stoves; when quite dry, they are packed in boxes and baskets for exportation. Most of the figs used in this country and Great Britain are imported from Turkey.

Uses.—Figs are a very nutritious and valuable article of diet; in many parts of the East they form, with a small portion of bread, the chief food of the inhabitants, and when abundant are even given in small quantities to animals, as corn is in this country. The sycamore of Scripture is a larger species of fig, the fruit of which is also occasionally eaten.

Vegetable Secretions.

LESSON XXIII.

CAMPHOR.

Natural History and Preparation.—Camphor exists in small quantities in many plants, but is chiefly obtained from a species of laurel tree, a native of China and Japan, which is now cultivated in most of the warm parts of the world; the great supply is obtained from the Island of Formosa, and carried in Chinese junks to Canton, whence foreign markets are supplied.

Camphor is obtained by heating in a still the leaves, branches, and wood of the tree cut up into small pieces; being volatile, it rises in vapor; this is collected in a solid form in a cold part of the apparatus. The camphor of commerce is in a dirty, granular state, and is purified by a second distillation. The art of refining it was long monoplized by the Venetians, and afterward by the Dutch. It is now, however, practised in the United States.

Properties.—Camphor is a solid, semi-transparent substance, so tough that it cannot be powdered without the addition of a few drops of spirit or oil; it possesses a strong aromatic and very peculiar odor; it is very sparingly soluble in water, to which, however, it imparts its peculiar odor and bitter taste; in spirit it dissolves readily, the camphor separating in the solid form when the solution is poured into water. Camphor is also soluble in oil. In large doses it acts as a poison, producing convulsions, stupor, and death.

It melts at a moderate heat, and at the same time passes off rapidly in vapor; if brought into actual contact with a flame, it takes fire readily, burning with a large flame and much smoke.

Uses.—The strong odor of camphor is obnoxious to insects and moths; it is, therefore, employed to protect cabinets of natural history and clothes; when taken as a medicine, its first effect is that of a stimulant, but its action afterward becomes depressing; its strong odor has given rise to the idea that it is capable of preventing infection, and it is frequently carried about the body with this view; it has not, however, the slightest power of destroying infection, and, from its depressing effects, its action is decidedly injurious.

Dissolved in spirit, it forms a valuable application to unbroken chilblains, and also to burns or scalds when the skin is not destroyed.

LESSON XXIV.

GUM ARABIC.

Natural History.—Gum arabic is the produce of several kinds of acacia trees, natives of the sandy deserts of Africa and the East Indies.

In the hottest seasons of the year the gum oozes out from the bark in a thick mucilage, which hardens on exposure to the air, in a similar manner to the gum produced by the plum and cherry trees of this climate, but to a much greater extent.

When pure, gum arabic is transparent and colorless, but the commoner kinds are generally yellow. It has a glassy lustre, is perfectly inodorous, and has an insipid taste. It dissolves readily in water, forming a thick adhesive solution, which becomes sour after having been made some time.

Uses.—Gum in the form of mucilage is much used as a cement for small articles, as for fastening labels to glass, &c.; it is also employed extensively in the arts, for stiffening crapes and other fabrics, and in the manufacture of ink. Paper which has been gummed on one side, and allowed to become dry, is readily attached to any object by moistening with the tongue or otherwise; in this manner gum is largely employed for postage stamps and envelopes, a portion of sugar being usually mixed with it, to enable the cement to be more rapidly softened by the moisture employed. The gum usually employed for this and other coarse purposes is termed British gum, or Dextrine, being made by baking starch in a moderate heat until it assumes a pale brown color, and becomes soluble in cold water.

LESSON XXV.

INDIAN RUBBER, OR CAOUTCHOUC.

Natural History.—Indian rubber is produced by several trees, natives of the warmer parts of South America and the East Indies; it is obtained, during the rainy season, by making deep incisions in the bark, when a thick, creamy juice, of a yellowish white color, flows out, capable of being mixed with water; this remains unchanged if kept in closely corked bottles, but dries slowly on exposure to the air.

In South America the natives spread the juice, as it is obtained from the tree, on moulds of clay, applying one layer as soon as that previously put on is dry; the drying is hastened by placing the moulds over a wood fire, the smoke of which colors the Indian rubber. These moulds are sometimes in the form of a shoe, and sometimes of a bottle.

When a sufficient number of coats have been applied, so as to produce the desired thickness, the clay moulds are broken and the pieces withdrawn, leaving the Indian rubber in the form of the mould; from the East Indies it is usually imported in the form of balls or irregular pieces.

Properties.—Indian rubber is a soft, pliable, and highly elastic substance, tough, and difficult to be cut; its elasticity varies, being much lessened by cold and increased by a moderate heat; when suddenly stretched it becomes warm—an experiment readily tried by extending a thin thong suddenly between the lips; if stretched, and placed in cold water for some time, it loses its contractile power, which, however, it regains immediately on being warmed.

Indian rubber is insoluble in cold or hot water, but is softened by long boiling, and becomes somewhat adhesive; it is also insoluble in spirits or weak acids, but dissolves readily, with the aid of heat, in pure ether, spirits of turpentine, and coal naphtha, remaining unchanged when the liquids evaporate; it is partly dissolved by oil, becoming clammy and glutinous.

Freshly cut, clean surfaces of Indian rubber, readily adhere, if pressed together, or they may be united by using that which has been dissolved in naphtha or turpentine; heated to a degree rather higher than boiling water, it melts, but it is altered in its properties, and does not become solid on cooling; if brought into contact with a flame, it immediately takes fire, burning with a white flame, and giving out a dense smoke and a very peculiar odor. In Guiana, where the trees abound, it is frequently used for torches.

Preparation.—Indian rubber is formed into blocks by being placed in an iron cylinder, lined with spikes, through which passes an iron shaft, also armed with spikes, and made to turn round rapidly; by this operation the Indian rubber is torn into small pieces, which, when firmly pressed together, unite into a uniform solid block, capable of being cut up into thin sheets or threads; this is accomplished by means of wet knives, moved by machinery; threads of

such a degree of fineness are produced, that 5,000 yards weigh only one pound.

Uses.—The elasticity, flexibility, and impervious nature of this substance render it of great use in the arts; the natives of the countries where it is produced make waterproof articles by spreading the fresh juice on cloth and other substances; in this country it is so used by being dissolved in naphtha or turpentine, and then spread upon cloth, or applied between two thin fabrics, which are pressed together by rollers. The dissolved Indian rubber is also used as a cement in binding books, and for other purposes.

When dissolved with shellac it forms a valuable cement, termed marine glue, used in ship-building.

Advantage is taken of the property of Indian rubber of becoming inelastic when cold, in weaving elastic bandages, &c. The threads employed for this purpose are stretched to seven or eight times their original length, and wound on rollers; they are then kept extended in the cold for two or three weeks, by which time they entirely lose their elasticity; in this state they are woven readily, and when passed over a hot roller the Indian rubber resumes its elasticity; these fabrics are employed for many purposes, as glove bands, brace ends, surgical bandages, &c., &c.

The use of Indian rubber in removing black lead pencil marks from paper is well known; its name is derived from its being so employed. It is also used, either alone or in combination, in the manufacture of boots, shoes, travelling bags, life preservers, &c.

Vulcanized Indian rubber is usually prepared by adding a small quantity of sulphur to the rubber as it is prepared in the mill; when the article required is finished, it is heated; the sulphur and heat effect a very important change; the Indian rubber becomes much more elastic than before, and possesses the great advantage of not being stiffened by cold, nor softened by the heat of boiling water; it loses also its adhesiveness to so great a degree that it cannot be made to unite, and the waste pieces are comparatively valueless. The red vulcanized Indian rubber is prepared in a similar manner, a compound of sulphur and antimony being employed. The permanently flexible and elastic character of vulcanized Indian rubber has led to its extensive use for gas tubes, elastic bands, springs, toys, &c., &c., &c. By the addition of magnesia to vulcanized rubber it acquires that degree of hardness which adapts it to the manufacture of knife handles, combs, canes, buttons, fancy boxes, and many other articles.

LESSON XXVI.

GUTTA PERCHA.

Natural History and Preparation.—Gutta percha is the product of a tall tree, a native of the Malayan Peninsula, and the adjacent islands, which, when wounded, exudes a milky juice, hardening on exposure to the air. It was formerly procured by the natives in a most wasteful mode, by cutting down the trees and collecting the thickened sap from between the bark and the wood; but tapping has lately been introduced. This sap, as it hardens, is kneaded into shapeless masses; these, when imported into this country, are prepared for use by being cut into shreds, cleaned by washing, and caused to unite by warmth and pressure. Each tree yields from twenty to thirty pounds.

Properties.—In its prepared state, gutta percha is a tough, strong, flexible substance, somewhat resembling leather; it is lighter than water, of a brown color, tasteless, and having a peculiar odor; it is quite insoluble in water, spirit, and weak acids, but is dissolved by ether, spirits of turpentine, and coal naphtha. It is softened by a degree of warmth much less than that of boiling water, but greater than that of the human body; it then becomes a plastic mass, capable of being readily moulded into any required shape; it is inflammable, burning with a white flame and much smoke; it is quite impervious to water, even in thin layers, and is not a conductor of heat or electricity.

Uses.—The uses to which this substance has been applied depend chiefly on its toughness, insolubility, and the ease with which it may be made to assume any form. By pressure in moulds it is made into trays, cups, bottles, picture frames, inkstands, &c., &c.; flattened between rollers, it forms bands, traces, shoe soles, thin waterproof sheeting, &c.; and it is also formed into pipes for conveying water, which, from their toughness, resist great pressure; and for speaking tubes, for which purpose it is peculiarly adapted, as it possesses in this form an extraordinary power of conducting sound. From its extreme strength it is also well fitted for forming substances submitted to rough usage; it possesses, however, the disadvantage of being readily altered in shape by a degree of heat less than that of boiling water.

One of its most useful applications depends upon its being a non-conductor of electricity; hence it is employed to cover the wires of the submarine electric telegraph.

LESSON XXVII.

OILS.

Fixed or greasy oils are abundantly formed by various vegetables, and are of extreme value to man, as food, for lighting, soap and candle making, and many other purposes.

Oils are seldom, if ever, stored up in the leaves or bark, but are usually found in the seed-vessel or seeds; in the latter, oils answer the twofold purpose of nourishing the young plant during its early growth, and of affording a supply of food to man and animals.

The quantity of oil in various seeds is very great. The kernel of the hazel nut contains 60 per cent.; walnut 50; almond, 46; poppy seed, 50; rape, 39; hemp, 25; flax, 22. Many of these seeds when dry, as the almond, take fire and burn readily when placed in the flame of a candle.

The most commonly used vegetable oils are olive, linseed, palm, and castor oils.

Olive Oil. Natural History.—The olive is a small evergreen tree, common in the south of Europe, Barbary, and the Levant; it has lance-shaped grayish-green leaves, and white flowers; the latter are followed by a fruit the size and shape of a damson, of a purple color, with a nauseous, bitter, oily flesh, which encloses a sharp-pointed stone.

The oil is obtained from the fruit by crushing it under rollers into a paste, which is then enclosed in bags and subjected to the action of a screw press. That which flows first is regarded as the best; after that has been removed, hot water is added to the mass, and an additional quantity obtained.

Properties and Uses.—Olive oil is an insipid, inodorous, pale, yellow, oily liquid, not liable to turn rancid, and very inflammable; at a temperature several degrees above the freezing point of water it becomes solid.

In the south of Europe and Syria, of which countries the olive is a native, the oil has been in use from the earliest periods of which we have any record, both for food (1 Kings, xvii, 12) and burning in lamps (Exod. xxvii, 20); at the present time it may be regarded as the cream and butter of Spain and Italy, and so much is it valued, that the tree is chosen as the emblem of peace and plenty.

In our own country olive oil is used in the preparation of food, though to a much more limited extent than in Europe; the common kinds are largely employed in the woollen manufacture, and some kinds of soap.

Linseed Oil. Natural History.—The description of the plant yielding flax and linseed will be found under the head of Textile Fabrics; the seeds, when separated, are crushed and pressed in mills, when they yield nearly one fourth of their weight of oil; this, of all vegetable oils, is one of the cheapest and most useful. It possesses the property of drying when exposed in thin layers to the action of the air; hence its use in the preparation of paint and varnish, for which purpose the employment of a fatty, non-drying oil, as that of the olive, would not answer. It is also employed in large quantities for making putty, and for various purposes in the arts; it is not unwholesome, but it has a nauseous and unpleasant taste, which renders it unfit for the food of man.

The crushed mass that remains after the extraction of the oil is termed oilcake, and is much used for fattening cattle. The skins of the seeds contain a large quantity of mucilaginous or gummy matter; this is dissolved when boiling water is poured upon the seeds, and forms the solution termed linseed tea; ground into powder the seeds furnish linseed meal, a substance used medicinally for poultices, &c.

The manufacture of this oil has become a very important branch of industry in this country; the seed for this purpose being largely imported from the British East Indies.

Palm Oil.—This substance, which is in a solid form in temperate climates, is obtained from the fruit of a species of palm, found upon the western coast of Africa, in the West Indies, and some parts of South America. It is exported mostly to England, where it is bleached and manufactured into candles and fine soaps.

Castor Oil.—Is expressed from the seeds of the castor oil plant, and is chiefly used medicinally. It is also much used for burning in France, Italy, and some other countries.

Volatile oils are very distinct in their character from

those that are fixed and greasy. They are usually found in the flowers, but also in the other parts of certain vegetables. By boiling the substances containing them with water, the oil is volatilized, and, passing over with the steam, may be collected and preserved for use. By this process of distillation, most of the volatile oils are collected; some, however, as the volatile oil of lemon peel, are obtained by pressure. Many volatile oils are used as flavoring ingredients, as the oil of lemon; or as perfumes, as those of bergamot, lavender, rosemary, &c., &c. The most valuable volatile oil is that obtained from turpentine. The substance known as turpentine is a soft solid, composed of a mixture of resin and volatile oil, obtained by wounding different trees of the fir tribe, when it exudes and is collected.

The oil, or spirits of turpentine, is obtained by distilling it in an ordinary copper still, when the oil distils over, and the resin remains behind. The distilled fluid is colorless, very limpid, and possesses a peculiar and powerful smell. It is much lighter than water, its specific gravity being about 875. From its volatile character, it is largely employed in common paint, as it flies off in vapor when exposed to the air, leaving the drying linseed oil and white lead, of which the substance of the paint is chiefly composed.

It is very inflammable, burning with a large flame and much smoke; purified by a second distillation, it is known as camphene, and was formerly much used in lamps of a peculiar construction, but latterly its use has been entirely superseded by the mineral oil known as kerosene.

LESSON XXVIII.

SUGAR.

Natural History.—Sugar is the produce of a plant called the sugar cane, which has been cultivated from very remote times by the Chinese. It is now extensively grown in both the East and West Indies, Brazil, the United States, &c. The root of the sugar cane is jointed, solid, and perennial; sending up several smooth, jointed, unbranched stems, which rise to a height of from six to twelve feet, and which are filled with a pithy substance, containing a very sweet juice. The leaves, which are about three inches broad, and from three to four feet in length, spring singly from the joints, sheathing or wrapping round the stem for some distance, like the leaves of grasses. The top of the stem is furnished with a loose bundle of small downy flowers, of a pale lilac color, giving to the plant an exceedingly elegant appearance; these blossoms are, however, rarely seen in the West Indies, as the canes are cut down before the time of flowering.

The sugar cane is cultivated by planting the top joints when the cane is cut, each cutting producing several stems. The planting does not require to be renewed annually, as fresh canes spring from the roots for some years in succession. During growth, the canes are sometimes destroyed by numerous small insects that live on the juice; they are also subject to the depredations of monkeys, rats, &c.

When the canes are ripe, which is usually in March, they are cut, divided into convenient lengths, and carried to the mill, where they are crushed, and the juice expressed by passing them between large iron rollers. The juice is immediately boiled, with the addition of a small quantity of lime, to promote the separation of the impurities, which rise to the surface in the form of a scum, and are skimmed off. The clear liquor is then rapidly boiled, until it becomes sufficiently thick to form solid grains on cooling. The sugar in this state is termed raw or moist sugar, and is packed in casks for exportation; these casks are pierced with holes, through which the molasses, or uncrystallized portions of the sugar drain away.

It is estimated that about one hundred canes yield five gallons of the best juice, and that these produce about five pounds of sugar. The fuel generally used in boiling is the crushed cane itself, previously dried by exposure to the sun.

Sugar is also obtained from other plants: in some portions of the United States it is obtained from the sweet maple, and in France large quantities are prepared from beet root.

Raw sugar is converted into loaf or lump sugar by a process termed refining. The raw sugar is dissolved in warm water, with the addition of a little lime, and the liquor filtered through thick folds of cloth; by this means it is freed from many impurities, and rendered transparent, although it remains colored. The next stage is the discoloration of the syrup, which is effected by filtering it through layers of animal charcoal, or bone black, formed by heating bones to redness, in close iron vessels. The colorless syrup is pumped into covered boilers, or, as they are called, vacuum pans; here it is heated by steam pipes; and the air and vapor rising from it are pumped away by an air pump, the effect of which is, that the syrup boils at a very moderate heat, and is not discolored by burning When sufficiently concentrated by heat, the syrup is placed in moulds, where it forms, on cooling, a solid mass of granular sugar; this is purified by pouring a small quantity of clear syrup on the top, which, flowing through, carries with it any portions of sugar that have not crystallized. The substance known as treacle consists of the uncrystallizable portions of sugar which are left in the different processes of manufacture.

Loaf sugar is a granular white solid, formed of a number of small, hard, transparent crystals, slightly adhering together. When pure, it is free from smell, and has a sweet taste. It is soluble in water, forming a syrup of greater or less degree of thickness, according to the quantity of sugar dissolved. Weak solutions of sugar, especially if any other vegetable substances are present, are apt to ferment, when the sugar is converted into spirit. The spirit of fermented liquors, it may be observed, in all cases, depends on the quantity of sugar contained in the substances of which they are formed.

Loaf sugar is readily melted by a moderate heat, becoming reddish brown; if the heat is increased, a dark brown, soluble, slightly bitter substance is produced, much used for coloring soups, spirits, &c., under the name of caramel, or browning. Refined sugar furnishes a good example of a phosphorescent substance, two pieces rubbed against each other in the dark giving out a beautiful pale light.

Uses.—Sugar forms an exceedingly wholesome article of food. It is remarked that during the harvest time the negroes engaged in the work, and even the horses and cattle feeding on the refuse become in good condition, although their labor is at that period much increased. It is the basis of all our confectionery, and an important element in many table delicacies. It is also much used in preserving fruits, meats (particularly hams), and fish.

The quantity of raw sugar imported into England is above 9,000,000 cwt. yearly; about 300,000 cwt. of refined sugar is also imported. This amount shows a consumption of upward of thirty pounds per head to each person in Great Britain annually, a consumption greater than that of any country in the world, except the United States. In France the annual consumption is only four pounds per head; in Russia and Germany still less.

LESSON XXIX.

COFFEE.

Coffee is the seed of a plant growing principally in Arabia and the West Indies; it reaches the height of 16 or 18 feet; the flower resembles jessamine, and the leaves are evergreen; the fruit when ripe is like the cherry; it contains two cells, and each cell has a single hemispherical seed. When ripe, it is either gathered by the hand, or shaken from the trees, and placed on mats for the sun to dry the pulpy substance which surrounds the seed. The husk is broken by heavy rollers, and afterward removed by winnowing. In order to prepare the coffee for a beverage, it must be roasted till it becomes of a dark brown color, and extremely odorous; after which it is ground, and either infused or boiled in water. It is remarkable for its very stimulating property, and is used not only as a beverage, but as a medicine. Its discovery is said to have been occasioned by the following circumstance. Some goats, who browsed upon this plant, were observed by the goat herd to be exceedingly wakeful, and often to caper about in the night; the prior of a neighboring monastery, wishing to keep his monks awake at their matins, tried if the coffee would produce the same effect upon them as it was observed to do upon the goats; the success of his experiment led to the appreciation of its value.

LESSON XXX.

TEA.

Natural History, &c.—Tea is the produce of a small evergreen shrub, a native of China, Japan, and some parts of India. The leaves are lance shaped, toothed like a saw, or serrated at the edges, of a bright deep-green color when fresh, their length varying from two to five inches. The flowers, which are white, with numerous yellow stamens, closely resemble those of the camellia japonica—a plant to which the tea shrub itself has a very considerable resemblance. Each flower is succeeded by dry fruit, containing three seeds.

The first crop of tea is not collected until the plants,

which are raised from seeds, are three years old; after this age the leaves are gathered several times during the course of the year, the young ones alone being plucked; as soon as collected they are put into shallow baskets, partly dried by the sun and air, and afterward over a charcoal stove; during the process they are rubbed between the hands, so as to roll them up, and are constantly stirred, to prevent scorching.

There are two kinds of tea imported into this country —black and green. The black tea is prepared by placing the leaves in a heap after they are gathered, which produces a slight degree of heat, sufficient to darken the leaves; whereas the green tea is dried and rolled immediately after having been gathered. The inferior kinds are prepared by coloring the leaves with Prussian blue. The Chinese tea-makers employed by the East India Company in Assam make both green and black tea indiscriminately from the same trees.

The transportation of tea from the tea districts to the shipping ports, is much of it performed by men, who carry the chests, slung one at each end of a bamboo, which rests across the shoulder.

The consumption of tea in Great Britain is about 65 millions of pounds annually, being about two pounds for each person; in the United States the quantity consumed is at the rate of about one pound for each person annually; on the continent of Europe coffee is employed to a much greater extent than tea; and in the German States the annual consumption is only half an ounce per head annually.

Uses.—The mode in which tea is used as a beverage requires no explanation. Its precise action on the system is not thoroughly understood; it is slightly astringent, and contains a volatile oil, which has a peculiar effect on the nervous system, occasioning, when taken in large quantities, watchfulness and sleeplessness; on the other hand, when taken in moderation, it has a soothing effect on the circulation; tea also contains a peculiar substance, termed *thein*, which is supposed to assist considerably in the nutrition of the system.

LESSON XXXI.

HOPS.

Natural History.—The plant producing hops is found wild in the Eastern States, on the banks of the Mississippi and Missouri, and in the temperate parts of Europe. It is cultivated extensively in New England, New York, and Ohio. The English have carried its cultivation to great perfection; in the county of Kent alone from 25,000 to 30,000 acres are occupied by hop plantations. It has a perennial root, and a coarse, harsh, twining, annual stem, which grows to a great length, bearing large, opposite, heart-shaped, or lobed leaves, toothed like a saw at the margin, and extremely rough. The barren flowers are small, greenish, and very numerous. The fertile flowers grow on distinct plants, and consist of green scales, arranged in cone-shaped heads, each scale enclosing a small seed vessel with a single seed, and several grains of a yellow powder, in which the bitter flavor of the hop chiefly resides.

In the hop grounds poles are placed for the plants to twine around; these are taken down and laid across large baskets or boxes, when the hops are picked. The fertile flowers only are valuable, and the plants bearing the barren ones are seldom allowed to grow. After being picked, the hops are dried in kilns, termed oast houses, and packed in large bags for the convenience of carriage. This packing is frequently done by machinery, and the parcels are made so compact that they may be cut into blocks with a knife, and kept for years in a dry situation. The expense of cultivation is very great, and the crop is exceedingly uncertain both in quality and quantity, the latter varying from two to twenty hundred-weight an acre; from ten to fourteen is regarded a favorable return; warm seasons, with little rain, are most productive.

Uses.—Hops possess a peculiar, bitter taste, and a strong odor; they are valuable from their strengthening properties, and are also cultivated for their use in making beer and yeast, to which they impart their aromatic flavor, enabling them also to be kept a considerable time without turning sour. They are used in medicine, both in decoctions and in poultices. The fibres of the vine are strong and flexible, and are sometimes woven into coarse cloth, which serves for sacks in which to carry the hops to market.

LESSON XXXII.

SAGO.

Sago is the pith of the sago palm, a tree indigenous to Japan, and the dry rocky mountains of Malabar.

It is hardly possible to imagine a plant more graceful in its foliage, or more beautiful when in fruit, than this species of palm. The foliation, which slightly resembles that of the fern, is placed on the stem in the manner of the feathers of a shuttlecock, forming a gigantic basket of the most graceful appearance; at the bottom of this is the salmon-colored flower, resembling, both in shape and texture, the blossom of the cockscomb, but of a pale buff color, inclining to brown. The fruit is a drupe, that is, a nut surrounded by a pulpy substance, as a plum. The growth of this plant at first is slow; it appears for some time a shrub thickly set with prickles; as it increases in height, it loses its thorns. When the tree has reached its maturity, a whitish powder transpires through the pores of the leaves, and adheres to their extremities. On this intimation of the trees being filled with pith, the Malays cut them down near their roots, and divide them into several sections, which are split into quarters. The bark is woody, and about an inch in thickness; in the centre of the stem is a fat or gummy pith, which forms the sago. This pithy substance, being scooped out, is diluted in pure water, and strained through a bag of fine cloth, which separates the glutinous from the farinaceous matter. This latter having lost part of its moisture by evaporation, is passed through sieves, by which process it become granulated, and being received into earthen vessels, it dries and hardens into little globules. Sago is extremely nutritious and wholesome, and forms an excellent light diet for invalids.

LESSON XXXIII.

STARCH.

History and Properties.—Starch is a vegetable product, formed in very large quantity by many plants, and stored in various parts of their structure; constituting a reservoir of food to be used in the future growth of the plant. It is found abundantly in seeds, as in wheat, rice, chestnuts, &c., &c.; in stems, as in the sago palm; in underground tubers and roots, as the potato, arrowroot, &c., &c.

Starch is insoluble in cold water, and remains unchanged until it is required for the growth of the plant for whose use it was stored up; it then alters its character, becoming converted into sugar, which being soluble, is available for the nourishment of the growing plant. The results of this change are familiar in the conversion of barley into malt, and in the sweetness of a potato that has begun to grow.

Starch is prepared in England chiefly from wheat and rice flour; in America, from Indian corn and potatoes; and in France from horse chestnuts. Its preparation on a small scale may be shown by tying a small quantity of flour in a piece of muslin, and working it with the fingers in a vessel of water until all the starch has passed through, leaving the gluten of the flour; on allowing the water to remain at rest, the starch so obtained settles at the bottom of the vessel.

As thus obtained, starch is a granular powder, of a brilliant white appearance, perfectly insoluble in cold water, but soluble in boiling water, forming a thick gummy solution, which is much used by laundresses, and in the manufacture of many textile fabrics, for the purpose of stiffening.

Starch may also be rendered soluble by a dry heat; the substance called dextrine, or British gum (which is used in the glazed print works), is made by exposing starch in ovens to a degree of heat rather above that of the boiling point of water.

In addition to these uses, starch is an important ingredient in almost all our vegetable food, and in a nearly pure state is used in the form of arrowroot, potato starch, corn starch, sago, and tapioca.

Miscellaneous Substances not used as food.

LESSON XXXIV.

WAFERS.

Manufacture.—Wafers are made from wheaten flour, which is mixed with water so as to form a thin smooth paste; this paste is pressed by the workmen between two thin polished iron plates, so joined together as to form, when closed, a pair of "wafer tongs;" the plates do not quite touch each other, but are separated by a space as thick as the wafers are required; when used they are slightly warmed and greased, filled with the flour paste, closed, and held for a few moments over a charcoal fire; the heat sets the paste, and on separating the tongs, a thin sheet of polished dry brittle wafer falls out. Several of these are piled up, and by means of a punch are cut into small circular wafers of the size required. Made with flour only, the wafers are white, but they are frequently colored by mixing various substances with the paste, as lamp black, gamboge, indigo, vermilion, and red lead; most of these substances are poisonous, especially the last two, and injurious effects have in consequence often followed their use in large numbers. Transparent wafers are made of fine glue or isinglass, and some fancy wafers are cut from gilt or silvered paper, gummed on the lower surface, and generally embossed.

Uses.—The use of wafers for fastening papers and letters depends on their becoming soft and adhesive when moistened; if in this state they are placed between two pieces of paper, and the latter pressed together, the wafer adheres to both, and when dry unites them firmly.

LESSON XXXV.

SEALING WAX.

Manufacture.—Sealing wax is prepared by melting together a resinous substance termed shellac (which is found encrusting certain trees in the East Indies), and about one quarter of its weight of Venice turpentine, a thick clammy substance, obtained by wounding the larch tree; to these ingredients are added, for red wax, the pigment vermilion, and, for black, lamp black; these substances are well mixed, and rolled into cylindrical rods on a hot smooth marble slab; these rods are cut into sticks of the proper length; polished by exposure for a few moments to a charcoal fire; and marked by a stamp with the maker's name; oval sticks are formed by casting the wax into moulds of the desired shape.

Inferior kinds of wax, such as that used for covering the corks of bottles, are made from common resin and red lead, or other coarse coloring material.

Properties and Uses.—Sealing wax is a hard, easily fusible substance, capable of catching fire when placed in the flame of a candle, and of burning steadily; the heat given out by the blazing portion melts another part, which falls down in drops in a fused and adhesive state, capable of adhering very firmly to paper, or any other porous substances; it will not, however, unite to the polished face of a metal or stone seal. In its melted state, sealing wax is sufficiently plastic to receive any impression stamped upon it; this it retains as it becomes solid. It is therefore much used by seal engravers in obtaining fine proof impressions.

The ordinary resins do not answer for sealing wax, because they are so fusible as to melt in the flame before they are sufficiently heated to take fire.

LESSON XXXVI.

PAPER.

Paper is made from a great variety of materials, as linen, cotton, worn out India bagging, wood, bark, straw, hay, and thistles, according to the kind required. The Chinese are supposed to have been the first manufacturers of *linen* paper. It was not, however, till the 13th or 14th

century that the art became known to European nations. It is made of linen rags, first carefully picked and sorted according to their quality; they are then reduced to a pulp by a machine which consists of a solid cylindrical piece of wood, into which are fastened plates of steel ground very sharp; this is fixed in a trough, into which the rags are put with a sufficient quantity of water. At the bottom of the trough is a plate with steel bars, also ground sharp. The engine being turned round with considerable velocity, and the rags passing through the two sets of iron plates, are torn to pieces, and in the course of four hours are reduced to a pulp. The motion of the engine causes the water in the trough to circulate, and by that means constantly returns the stuff to the engine. The trough is fed with clear water at one end, while the dirty water is carried off at the other through a hole defended with wire grating to prevent the escape of the pulp. From this, which is called the *washing engine*, the pulp passes in a state of purity and whiteness to another engine, similarly constructed, and called the *beating engine.* The only difference between this operation and the former is, that the velocity is increased, and that it is no longer necessary to introduce fresh water, the pulp having been already cleansed from its impurities. From hence it passes into a large vat connected with boilers, and the heat they produce gives the pulp a degree of consistency; it is afterward conveyed into smaller vessels, in each of which is a wheel called an agitator, which prevents it from sinking to the bottom. Into these vessels a workman dips a mould, a kind of sieve, the size of the paper to be made, and about an inch deep; the bottom is formed of fine brass wires, through which the superfluous water passes. The skill of the workman consists in taking up just so much pulp as is necessary to form the paper of a proper thickness. Another workman is stationed to receive from the first the mould, out of which he turns the sheet upon a felt or woollen cloth; another woollen cloth is placed upon it, ready to receive the next sheet. Thus they proceed, placing alternately paper and felt, till they have made six quires of paper. This is then wheeled to the press, where great force is applied, and the water is squeezed from it. After this the paper is separated from the felt; one sheet is laid upon another, and it undergoes a second pressure. This operation is repeated five or six times, and the sheets are separated from one another between each application of the screw-press. They are afterward hung up to dry in rooms where there is a current of fresh air. In this state the paper is absorbent, like blotting paper; to fit it for writing it is sized. Size is made of vellum* shavings, boiled in water, with sulphate of zinc and alum finely pounded. After the paper is sized, it is again pressed four or five times, and hung up to dry as before. It is then *told* into quires, and sent to the *stationer*, who prepares it for sale.

The most ancient kind of paper was made from the papyrus, a species of reed growing on the banks of the Nile, from whence our name *paper*. Leaves also were employed at a very early period for the purpose of preserving and transmitting the opinions and experience of mankind;

* Vellum is the prepared skin of young calves.

hence originated the word *folio* (folium being the Latin for leaf), and also the meaning of leaf as applied to a book. The use of bark succeeded that of leaves, generally the inner bark of the lime tree; it was called by the Romans *liber*, and they gave the name of *liber* to a book, and we have adopted the term *library* for a collection of books. For the convenience of carrying, this substance was rolled up, and in this form was denominated *volumen*, from which is clearly derived our *volume*. Our Saxon ancestors employed the bark of the beech, and called it *boc*, a name which we have transferred to our *book*. It is probable that the skins of animals were the first substances upon which characters were written.

LESSON XXXVII.

NUTGALLS.

Natural History.—Nutgalls are obtained from a small, shrubby oak, that grows abundantly in all the countries of Asia Minor. The plant seldom attains a greater height than six feet. It bears leaves, flowers, and acorns, which do not differ in any very great degree from those of our native oaks. The nutgalls are caused by a small fly, which pierces the bark of the young shoots to deposit its egg; around this a swelling takes place, forming the gall; when the egg is hatched, the grub feeds on the substance of the gall that surrounds it; after a time it is changed into a perfect insect, and, by gnawing a hole through the side of the nutgall, makes its escape.

Nutgalls are gathered by hand. They are most valuable when arrived at their full size, and before they are pierced by the fly; in this state they are termed blue galls; as obtained in commerce, they are nearly spherical, varying in size from a large pea to a large nut; the best are of a deep olive color, and are covered with tubercular projections, heavy, brittle, with an almost flinty fracture; when broken, they exhibit the remains of the grub, and not unfrequently the perfect insect is found enclosed. Those from which the insects have escaped are lighter in color, not so heavy, and, as before observed, of less value. They are known in commerce as white galls.

Properties and Uses.—Nutgalls are inodorous, and of an extremely nauseous, astringent, bitter taste. They are much used in the manufacture of writing ink, as they produce a black color when mixed with preparations of iron; they are also largely employed in dyeing silk, cloth, and other substances, of a black color; occasionally they are used in medicine.

THE ANIMAL KINGDOM.

INSECTS.

General Observations on Insects.

The animals which belong to this large and important class receive their name from the Latin word *insectus, cut into;* as they have in general the appearance of being cut into three parts—the head, the chest, and the abdomen. They are also distinguished by passing through a very remarkable series of changes before they arrive at their perfect state. The bodies of insects, in every stage, are destitute of any internal framework of bones, being supported by the skin, which is frequently sufficiently firm to be capable of giving a fixed shape to the body, and of forming the joints to the limbs.

In their perfect or mature state the head is covered with several distinct pieces of horny skin, and usually furnished with two movable organs, termed from their use *feelers;* below these is the mouth, which opens perpendicularly. The eyes of insects generally are *compound,* each eye, though apparently single, consisting of a large number of eyes united together; in some species, however, the eyes are simple, and few in number.

The chest supports the wings, which are either two in number, as in the house fly; or four, as in the butterfly. In some classes the upper wings are not used for flight, but form a horny covering for the protection of the two lower wings, which are thin and delicate; this occurs in the lady bird, the cockchafer, &c. The difference in the construction of the wings is very considerable, and furnishes the means whereby this large class of animals (of which naturalists have reckoned more than 100,000 distinct kinds) can be arranged into several smaller divisions or orders; to the chest also are attached the legs, which in all true insects are six in number. Insects do not breathe through their mouths, or by means of lungs, but the air passes through pores in their sides, and is then conveyed by very small tubes over the whole body.

The changes through which insects pass are very singular; they are hatched from eggs, which are usually laid in great numbers, and deposited with remarkable instinct in the immediate neighborhood of such food as will be suitable to the young. From these eggs proceed *larvæ*, or, as they are more commonly called, grubs, maggots, or caterpillars, which are at birth very small in size; they, however, usually grow with great rapidity, eating voraciously; a silkworm, for example, attains in thirty days many thousand times its original weight.

During their continuance in this state, their rapid growth renders it necessary that the skin should be several times cast off, to permit the great increase of size that takes place.

Arrived at its full size, the larva changes into a *pupa*, or chrysalis, in which state it is enclosed in a horny skin, is destitute of limbs, and without the power of moving. After remaining in this state for some time, the animal bursts its enclosure and appears as the perfect insect; in

this stage its life is usually short; it lays eggs for the production of another generation, and dies. In some insects the whole of the stages described are not passed through, or are not distinctly marked. This is the case with the common cockroach, or house beetle, and many others.

Though individually of small size and comparative insignificance, yet insects, from their vast numbers and great voracity, are of the utmost importance in the economy of nature. In numerous cases they act as natural scavengers, removing with great rapidity all kinds of decaying animal and vegetable matters; and many are useful directly to man, furnishing him with food, medicine, dyes, &c.

INSECTS, AND SUBSTANCES DERIVED FROM THEM.

LESSON XXXVIII.

BEESWAX.

Preparation and Uses.—Beeswax, the formation of which has been already described, is prepared for use by melting the comb in boiling water, the honey having been previously extracted; in this state it is yellow, and has a peculiar smell. Yellow wax is freed from impurities by melting, when the heavier particles sink to the bottom, and the lighter rise to the top, and are removed by skimming. When purified, it is used for making ointments, cements, &c.; it melts quickly under the heat of boiling water, and becomes soft at the temperature of the human body. When warm, it is sufficiently soft to take the impression of any object, which it retains when cold and hard; for this purpose wax is much used by dentists, &c. Beeswax is whitened by the process of bleaching; it is first formed into thin ribands or shavings, which are laid upon canvas in a bleaching ground, where, by the action of the sun, they become colorless, and are cast into small flat cakes. In this state wax is used for making artificial flowers and fruit, for waxing sewing thread, and for making candles. The manufacture of wax candles differs from the mode adopted in making any other kind. Common candles are made by repeatedly dipping the wicks into the melted tallow until they are of sufficient size for use; and the name of dips is given them from the manner in which they are made. The candles called moulds are made by pouring the melted tallow into pewter moulds in which the wick has been previously stretched. If wax were to be treated in this way, it would not come out readily from the mould; therefore, in forming candles of this substance, the wicks are hung on a hoop suspended over a pan of melted wax; the workman pours over each wick a quantity of wax, which adheres to it; but as the candle would be larger at the bottom from the running down of the melted wax, the wick is unhooked and hung up again bottom upward, when wax is again poured over it, and it becomes of a more uniform shape. It is then taken from the hoop, laid on a moist slab, and rolled with a smooth board until it is of the proper shape; the required length is given it by cutting off the rough end.

LESSON XXXIX.

GRASSHOPPER.

Natural History.—Grasshoppers are well known insects, remarkable for possessing in an almost equal degree the powers of flying and leaping. The body is thin, long, and flattened at the sides; the legs are six in number, the hinder ones being much larger than the others, and longer than the body. Each hind leg consists of three distinct parts—the thigh, the shank, and the foot; these legs are not used in walking, but are only employed in leaping. When the animal wishes to leap, it draws the feet of the hind legs close to that part of the thigh that joins the body, the joint uniting the thigh and shank being bent to a very sharp angle, high above the back of the insect; the various joints of the leg are then suddenly and powerfully straightened, and the foot forcibly striking the ground, the animal is propelled high into the air.

The wings of the perfect insect are thin and membranous; when at rest they are not observed, as they are folded up in a fan-like form under narrow wing-cases.

The chirping noise made by the insect is caused by the rubbing of the thighs of the hind legs against the horny wing covers. The appetite of these insects is voracious; they feed entirely on vegetable substances.

The eggs of the female are deposited in the ground, and the young hatched from them resemble the old ones in appearance; but they are not furnished with either wings or wing-covers, consequently they are unable to fly or chirp. After some time these parts grow, and the young one is changed into the perfect insect.

SHELLS.

General Observations on Shells.

The substances known as shells are the natural coverings of certain animals, which are distinguished by the absence of any internal framework or skeleton; by having cold and colorless blood; by their senses being usually but slightly developed; and by their being soft, fleshy, and cold to the touch; animals of this kind are termed molluscous, from two Latin words signifying soft flesh; some of them, as the common slug, are destitute of any shelly covering.

The number of distinct shells which have been described is upward of fifteen thousand.

Shells consist chiefly of chalk or carbonate of lime, which is cemented into a mass by animal matter; the inner surface of each is lined by a part of the skin of the animal, which has the power of secreting or forming the substance of the shell; and, as the animal grows, is constantly enlarging it, by adding new shell at the edges, or around the mouth of the opening; this skin has also the power of repairing any injury that may have occurred, by forming new shell at the injured part.

Shells are interesting to us, not only on account of their beauty and durability, but also from the evident instances of design they afford, and from the creative wisdom displayed in their formation; those which are exposed to

the dashing of the waves on the shore, or to the torrents of rapid rivers, are often of almost impenetrable hardness, as in the periwinkle; others, like the common snail, not exposed to violence, are thin and light, so that they may be readily borne by the inhabitant; every shell offer striking proofs of design and fitness in its adaptation to the animal's station and habits.

Shells, and their inhabitants, are of direct use to man in numerous instances; the animals in many cases furnish very nutritious articles of food. Shells are often burned for the sake of the lime they yield; others are employed in an unburned state as valuable manure; and some kinds are used as a substitute for gravel in garden and park walks. To the natives of savage countries they are especially valuable; the sharp edges of broken pieces being used as substitutes for knives, and for forming arrow and spear heads; they are also formed into fish hooks, and used as vessels for holding liquids. Over a large extent of Africa a small shell, the money cowry, passes instead of money, being taken in exchange for goods and labor in the same manner as coins are in civilized countries; the value, however, of each shell is very small, a string of forty being not worth more than from one cent to four cents. About 1,000 tons of money cowries are annually imported into England from India, being employed by English traders in the purchase of goods from the natives on the west coast of Africa.

In China, a thin, semi-transparent shell is used as a substitute for glass in glazing windows in the junks, and for lanterns.

Vast numbers of several distinct species of foreign shells are used in the manufacture of cameos for brooches and other ornaments. These are formed from univalve shells, which consist of several layers of different colors. The engraver cuts away the outer layers, so producing the pattern or design required. Cameos are chiefly made in Paris, where upward of 100,000 shells are used annually. A large proportion of the cameos made in France are sent to England, and are mounted as brooches at Birmingham, and then exported to America and the colonies. In 1856 there were imported into England unmounted cameos of the declared value of 6,683*l*.

Shells, for the convenience of arrangement, are arranged into three groups—those formed of one piece, or valve, are termed univalves, as the snail, whelk, &c.; those formed of two valves, united by a hinge, are termed bivalves, as the oyster, mussel, &c.; and those formed of several pieces are termed multivalves; the latter, however, are not so abundant as the first two divisions.

UNIVALVE SHELLS.—A univalve shell is usually formed of several hollow *whorls*, which are coiled round so as to form the *spire*, the largest and last formed being termed the *body whorl;* the entrance into the shell is termed the *mouth*, its two sides the *lips;* where the spire ends is termed the *point*, or top of the shell; its opposite extremity the *base;* many shells, as that of the whelk, have a projection at the bottom of the mouth; this is called a *beak;* it frequently contains a *canal*, into which the trunk of the living animal is received. When an animal inhabiting a univalve shell is full grown, the body whorl and mouth are often much altered in form, and frequently so much enlarged as entirely to overspread and conceal the spire and other parts,—this happens in the cowries, the spotted and striped varieties of which are frequently seen ornamenting our sitting rooms.

The animals inhabiting univalve shells are much more complicated in their formation than those of the bivalves; they have a distinct head, which is generally furnished with organs termed feelers; they also possess the sense of sight, and are furnished with a broad fleshy foot on which they crawl.

LESSON XL.

SNAIL.

Natural History.—Snails, of which many distinct kinds are found in this and other countries, are univalves, of a conical form, with a large swelling body whorl, a smooth surface destitute of spires or projections, and a roundish mouth without a beak; the shell is thin and light; at the same time it is possessed of considerable strength; the animals are furnished with four feelers, the two upper are the longer, and carry at their ends two eyes, which appear like dark spots; the means by which these feelers are protruded and drawn in at the will of the animal are particularly interesting; each feeler may be compared to the finger of a glove, the inside of which has a string sewn to the tip; the effect of pulling the string would be to turn in the finger of the glove, beginning at the extremity; precisely this contrivance exists in the feeler of the snail, which, however, possesses what does not exist in the glove,—a series of circular rings like fibres surrounding it at every part, by the contraction of which, in their proper order, the feeler is again turned out or protruded. The eggs of the snail are large for the size of the animal; they are white, and resemble berries in appearance; they are deposited in June.

Its food consists entirely of vegetable substances; during winter, or the extreme drought of summer, or at any time when their natural food is not to be obtained, they close the mouth or opening of the shell with a thin lid of hardened slime, and become torpid; if put into a box they will fix themselves to the sides and remain in a dormant state for years, reviving, however, immediately if moistened. By this beneficent contrivance these animals are not only enabled to abstain from food during winter, but when extreme dryness in summer has parched up the vegetables on which they live, they have the power of becoming dormant, whilst the same refreshing shower that restores the green herbage, calls back to life those animals whose food it forms.

Various kinds of snails have been used as food; a large species, with a shell of a whitish color, with brown bands, was eaten by the Romans, and is now used for food in many parts of Europe. The common garden snail has been used sometimes in soup prepared for consumptives. Snails form the favorite food of many birds, especially those of the thrush kind, and they are also eaten by other animals.

LESSON XLI.

LIMPET.

Natural History.—The shell of the limpet is remarkable for its form, being conical without and concave within, and destitute of the spirally twisted whorls that are usually found in univalve shells. The animal is furnished with a pair of feelers, with eyes, and a hard, firm mouth, having a long tongue covered with minute hooks for rasping down the sea-weeds on which it feeds; it has a broad fleshy foot, with which it fixes itself immovably to rocks and stones when left uncovered by the tide; this it effects by drawing up the foot in such a manner as to form a vacuum in the interior, when the weight of the air and water firmly presses down the shell, on the same principle that one may attach a key to his tongue. This simple contrivance, and the conical form of the shell, enable it to withstand the violence of the waves that dash against the rocks; and thus this little animal from within its stony castle bids defiance to the storm, and magnifies the goodness of Him who made it.

In Scotland the limpet is frequently used for food, and the liquid obtained by boiling it is, when mixed with oatmeal, much esteemed.

LESSON XLII.

PERIWINKLE.

Natural History.—The shell of the periwinkle, although apparently resembling that of the snail, differs in several important particulars, as might be expected from the fact that one animal inhabits the land, while the other is exposed to the violence of the waves on the sea-shore; the shell of the snail is thin, light, and delicate; that of the periwinkle exceedingly thick and of uncommon strength, so that it will frequently support the weight of a person standing on it without being crushed; in form the shell is more pointed than that of the common garden snail,—it consists of five or six rounded whorls, the body whorl being larger than all the others; attached to the animal is a horny lid, with which it is able to close the opening of the shell when it retreats within it. The animals inhabiting these shells differ also very considerably,—one breathing air by means of lungs, while the respiration of the other resembles that carried on by the gills of a fish.

The periwinkle is very extensively used for food by the poorer classes of London, being eaten after having been boiled; it is collected in enormous quantities from the rocks and stones, when they are left bare by the ebbing of the tide.

LESSON XLIII.

WHELK.

Natural History.—The shell of this animal is formed of seven or eight rounded whorls marked with raised stripes, and is of a dingy white or brownish color; the mouth of the shell is oval, with a short beak and a canal at

the base; the spire is much more elongated than in the snail or periwinkle.

The animal is not a vegetable feeder, but subsists on the inhabitants of other shells, especially on muscles; it is enabled to obtain its food by means of a short trunk or proboscis, furnished at the extremity with a number of very small teeth,—with these it bores through the shells of its prey, and extracts the softer parts. The destructive powers of a kind of whelk proved very annoying to the builders and light-house keepers of the Bell Rock light-house, on the coast of Scotland; they had obtained a number of a large kind of muscle, and endeavored to plant a colony of them on the rock, for use as food and for bait; the muscles were soon observed to open their shells and die in great numbers; and it was ascertained that the rock whelk, with its proboscis, bored small holes in the shells, and sucked out the finer parts of the body of the muscle, which, of course, perished; it was remarked that the whelk always bored the thinnest part of the muscle shell, and that the hole was beautifully smooth and circular. As the muscles were of great importance to the men, they endeavored to destroy their enemies; but these were so numerous that all their efforts were in vain, and in three years the muscles were all extirpated.

Whelks furnish but indifferent food for man, as they are hard and indigestible; they are, however, liked by some persons, and are constantly sold in the streets of London and other places; by fishermen they are largely employed as bait.

LESSON XLIV.

SHELLS OF TWO PIECES, OR BIVALVES.

The two pieces, or valves, of which these shells are formed, are united, at the part called the hinge, by an elastic ligament, which keeps the shell open; but the animal, by means of one or more strong muscles, or white fibrous contractile bands, which are attached inside the valves, and pass from one to the other, can close them at pleasure. At the hinge are often small prominences; these are called teeth, and the points of the valves over the hinge are called beaks.

The animals inhabiting these shells differ much from those of the univalves; they have no distinct head, and consequently do not possess either eyes or feelers; their mouth is merely a small aperture, destitute of teeth; they breathe by means of gills; these gills in the oyster are the parts familiarly known as the beard,—when examined by a microscope, they are found to be covered with minute bodies called cilia, in shape like hairs, which, by their constant motion, cause currents in the water that carry food to the mouth of the animal.

Some of these animals are furnished with feet, by which they crawl; others, like the muscle, anchor themselves by a cable of small fibres, while a third set, as the oyster, cement themselves to rocks, and are incapable of moving from place to place.

LESSON XLV.

MUSCLE.

Natural History.—The shell of the muscle consists of two valves of equal size, and similar oval shape, pointed at the beaks; their color is brown externally, but when freed from the outer layer, and polished, of a beautiful deep blue, the inside pearly white, but bluish towards the edges. The animals have the power of moving from place to place by means of a tongue-shaped foot, which they push out of the shell to some distance, and withdraw again; when they wish to move, they place the shell erect on its edge, and stretch out the foot,—this, being sticky, adheres to the ground, and, when shortened, pulls the shell forward; in this way the muscle moves along until it finds a convenient place of residence, when it forms a bundle of fine silky threads, one end of which it fastens to the rock, while the other is attached to the animal; thus it remains securely anchored.

Muscles are found on the coast of England in immense numbers, in beds which are uncovered at low water; women and children tear them away with iron hooks from the rocks and stones to which they are attached, and sell them as they are thus collected; but in France they are fattened as oysters are in this country.

The muscle is largely used for food, being eaten either plainly boiled or pickled; it is a rich, and, when in season, not an unwholesome food; in the summer, however, it is apt to disagree with many persons; this was long thought to be owing to a small crab, which is often found in the shell with the muscle, but there seems no good reason for this supposition; the muscle is much used by fishermen as a bait for cod, haddock, &c. The shells are also much employed for holding the gold paint used by artists.

LESSON XLVI.

MOTHER-OF-PEARL.

Description.—Mother-of-pearl is the hard, semi-transparent, brilliant, iridescent substance which forms the internal layer of several kinds of shells; the interior of the common oyster shell is of this character, but the mother-of-pearl used in the arts is much more variegated with a play of color, and the larger shells of the tropical seas alone have this substance of sufficient thickness to be useful; the chief supply of the mother-of-pearl oyster shell comes from the coasts of Ceylon, the Persian Gulf, and parts of Australia.

The play of colors in mother-of-pearl depends on its peculiar structure; it is so formed that it possesses, even when polished, a series of fine grooves running over the surface; these reflect the light in such a manner as to produce the various hues seen on the surface; the furrows are too small to be distinguished by the naked eye, but may be seen with the aid of a microscope; an impression of them may be taken with very fine black sealing wax, which will then possess, to a considerable extent, a similar appearance.

Uses to Man.—Immense quantities of mother-of-pearl are used in the manufacture of small articles, such as buttons, knife handles, salt spoons, &c., &c., and it is much employed in inlaying dark woods, with which its varied surface forms a beautiful and striking contrast.

Recently, the dark varieties of the shell have come into demand; these were formerly regarded as valueless, and were rejected. It is stated that whole wagon loads lie buried under some of the streets of Birmingham, where it was thrown as waste, while it is now worth from 15*l.* to 20*l.* per ton.

Some idea may be formed of the extensive use of this material from the fact that England imported in 1857 nearly 35,000 cwt., the estimated value being 57,819*l.* Of this quantity, about one-fourth was re-exported to other countries, the remainder being retained for home consumption.

MISCELLANEOUS OBJECTS.

LESSON XLVII.

BONES.

Natural History.—The bodies of all the higher classes of animals are supported by an internal framework of bones, termed the skeleton; these bones, to resist without injury the various forces to which they are exposed in the living body, must be able to bear compression, extension, and twisting, without either bending or breaking; for that purpose they are formed of two materials—one an earthy substance, which is chiefly phosphate of lime, to give solidity and hardness; the other an animal substance, resembling glue or gelatine, to impart toughness; if a bone is slightly burnt in the fire, the gelatine is charred, and it becomes black; when exposed to a red heat in the open air for a longer time, the animal matter is entirely burnt away, and the white earthy phosphate of lime alone remains; this retains the form of the bone, but is exceedingly brittle, from the destruction of the gelatine; by soaking a bone in diluted acid for a considerable time, the earthy matter may be removed, leaving the gelatine in the form of a flexible gristle. The composition of bone may be stated generally as—

Organic matter, chiefly gelatine,	40 parts.
Phosphate of lime,	50 "
Carbonate of lime (chalk),	8 "
Other mineral materials,	2 "
	100

The uses of the framework of bones to the animal may be arranged under three divisions:—1st, by their hardness and firmness they give support and a fixed shape to the body. 2d, they enclose and protect delicate and important organs from external injury,—thus, the bones of the skull protect the brain, those of the chest the heart and lungs. 3d, they give firmness to the limbs, and at the joints, where they are connected together, admit of motion; those parts of the bones that rub over each other during the movements of the limbs, are covered with a very smooth gristle or cartilage, and are moistened by an unctuous fluid.

As the same quantity of material makes a stronger column when arranged in the form of a hollow tube than

as a solid cylinder, the long bones of the limbs are formed into hollow tubes, the cavity being, in terrestrial animals, filled with an oily fluid, which hardens, when cold, into marrow,—and in birds, with air; this, when heated by the warmth of the animal, has a tendency to render it lighter.

Uses to Man.—Bones are a very important article of commerce. After having been boiled to extract the grease, which is used in soap and candle making, the larger kinds, termed shank bones, of which 2,000,000 are used annually at Sheffield, are employed for knife handles, tooth and nail brushes, combs, paper knives, spoons; the smaller for buttons, and a variety of small articles; the shavings and sawdust formed in making these articles are used either as manure or for size-making. Heated in closed iron vessels, bones turn black; in this state they are termed animal charcoal, or bone black, an article much used in clarifying sugar.

One great use of bones, is as manure, especially in England; for this purpose they are collected from every part of the island, and even from the Continent, and crushed, either coarsely, or into a fine powder; in either state the farmer scatters them over his land, or sows a quantity with his seed. When acted upon by oil of vitriol, or sulphuric acid, they furnish a valuable manure, known under the name of superphosphate of lime.

The earthy matter of bones contains a large portion of phosphorus, which, when extracted by chemical processes, is used extensively for the manufacture of matches.

About 70,000 tons of bone are annually imported into

England; about one third of this large quantity comes from the cattle feeding plains of South America, and about one fifth from Russia.

LESSON XLVIII.

FEATHERS.

Natural History.—Feathers are the substances that form the clothing or natural covering of birds. The habits and movements of these animals are so peculiar as to require in their clothing a very unusual combination of qualities; it must be a bad conductor of heat, so as to prevent the escape of the natural warmth of the animal, under all circumstances, whether in the water or in the cold upper regions of the air, or in winter. It is necessary also that it should be exceedingly light, for, if heavy, it would render flight impracticable; a striking example of the extreme lightness of a bird's plumage is afforded by the fact, that all the feathers of the common owl (a bird very abundantly clothed) weigh only one ounce and a half; this lightness must, nevertheless, in the feathers of the wings, be combined with great strength, as these parts are forcibly struck against the air, in the act of flying. The whole covering must be flexible, to permit the varied movements of the animal, and sufficiently smooth to offer the least possible resistance to the rapid passage of the bird through the air; and, lastly, the entire covering must, in many instances, be waterproof.

On examination we shall find that these apparently

opposite qualities of warmth, lightness, strength, flexibility, smoothness, and the power of resisting the entrance of water, are combined in the covering of birds in a manner which most strongly proclaims the wisdom and beneficence of the Creator, who has declared that without Him "not even a sparrow falleth to the ground." A feather consists of three parts—a quill or barrel, a shaft, and a vane or beard; the quill is that part of the feather by which it is attached to the body of the bird; it is formed of a horny substance, of a hard and elastic nature, remarkably strong and light; this lightness is given by its being formed in the shape of a hollow cylinder, which is filled with air; it is hollow for the same reason that the bones are hollow, that is, to ensure strength with the least possible weight. That the quill may also possess strength in every direction, it is formed of two sets of fibres, (though, from their being transparent, this is not readily seen); one set runs in the direction of the length of the quill; it is this set that is torn apart (not across) when a quill is split to make a pen; the other fibres are circular, and run round the former, binding them together; if this circular set is not scraped off before making a pen, the slit is jagged, in consequence of their being torn across.

The membranous substance found within the quill is the dried remains of the blood vessels by which the feather was nourished during its growth.

The shaft of the feather is four sided; it is largest near the quill, and gradually lessens in size to the end; it is slightly bent, to adapt it to the shape of the bird, covered with a horny substance like that of the quill, but not so thick, and filled with a light elastic substance resembling pith.

The vane or beard of the feather is composed of a number of flat barbs or pieces, which grow from the sides of the shaft; these are placed with their flat sides toward each other, their edges being turned upward and downward; this method of placing them is the strongest that could be adopted, as it is these edges that strike the air during flight.

In an unruffled feather the barbs or pieces of the vane are united together, and cannot easily be parted; it is evident, however, that they do not adhere by any adhesive matter, or the feather would feel clammy; if these barbs are ruffled, they reunite when the feather is smoothed from the quill toward the end. This reunion is effected by the following beautiful contrivance:—Every barb has a row of very minute hooks on each side; those on the side nearest the quill turn their points upward, those on the other side downward; these all hook in one another, and hold the barbs together; when the feather is ruffled by any force, these elastic hooks are stretched apart without being broken, and so exquisitely perfect is their adaptation to each other, that on being brought together, either by smoothing the feather upward between the thumb and finger, or by the bird preening them with its bill, they reunite; this exquisite contrivance enables the bird to keep the vanes of the feathers, particularly those of the wings and tail, in the best possible condition for resisting the air in flight. That part of the vane nearest the quill is often formed of softer barbs without hooks; this downy portion, when the feather

is in its natural situation, is next the skin of the bird, and serves to keep the body warm. Many birds are, in addition, furnished with down growing from the skin, so as to form a warm under clothing, the delicate and elastic filaments of which are not hooked together like the barbs of feathers, but remain separate. Down is most abundant under the feathers of swimming birds, where it is requisite to prevent the water from abstracting the heat of their bodies; and it is much more abundant on the under surface of the body than elsewhere. The down of these birds is never wet, the close oily layer of feathers protecting it from the water. Some water birds, as the goose, pluck the down from their breasts to line their nests.

Feathers are often modified so as to suit the wants of the particular species of bird. Thus birds of prey, as hawks and eagles, have hard, firm feathers, extremely strong and elastic. Owls have soft, downy feathers, so that they fly silently at night, and surprise their prey. In the ostrich, and other birds that do not fly, the barbs are not joined by hooks, but are loose and flowing. Swimming birds have their feathers close and oily, to prevent the entrance of water.

Uses to Man.—The coverings of birds are of great use to man, and form articles of commerce, under the names of quills, feathers, and down.

Quills are chiefly used for the manufacture of writing pens, and are generally obtained from wings of geese, which, at stated times, are partially deprived of their quills and feathers. The quills, when pulled from the animals, are sorted according to their size and quality; the smallest are sold under the name of pinions. Before they are sold for use, quills are sometimes stained yellow. In 1855, nearly twenty-seven millions of foreign swan and goose quills were imported into England, valued at about 30,000*l.*

Feathers are used in this country for stuffing beds, bolsters, and pillows, &c. The most valued are obtained from geese, the inferior kinds from ducks, fowls, and other poultry. Ornamental and colored feathers, as those of the ostrich, bird of paradise tails, the domestic cock, &c., &c., are much employed in personal decoration.

Down is used in two states, either removed from the skin of the animal for stuffing pillows, quilts, and other substances, or attached to the skin for making tippets, &c., in the same manner as fur.

LESSON XLIX.

GLUE.

Manufacture ana Uses.—Glue is an impure variety of the animal substance known as gelatine. It is much used by carpenters, and in the various arts, as a strong cement. The best is obtained from the skins of animals, the small cuttings rejected by the currier being generally employed; an inferior kind is made from the sinews and hoofs of horses and other animals.

These materials are first well steeped in lime water, which assists in removing any grease; they are then boiled in water until all the soluble parts are dissolved; the impurities that rise to the surface are skimmed off; the liquor

is then strained, to separate the undissolved pieces of skin, and again boiled down until it becomes on cooling a very firm, hard jelly. This jelly is cut into thin, flat, square pieces, which are dried upon coarse netting. The depressions left by the network are visible on the dried glue.

When of a good quality, glue is of a rich brown color, semi-transparent, and without spots or clouds in its interior; it should be perfectly soluble in hot water, not leaving any sediment. The solution of glue in water is, when cold, a jelly-like mass, which varies in firmness according to the quantity of glue dissolved; even when made very firm it readily melts with heat, and in this state is used as a cement, being applied while hot to the substances which it is wished to unite; they are pressed together, and as the glue becomes firm on cooling, remain cemented, although it is not till after some days (when the glue has become perfectly dry) that the joint is very firm.

The use of glue depends on its being readily soluble in hot water, its adhesiveness when dissolved, and upon its becoming hard as it cools and dries. Its tenacity when used as a cement is very great; frequently the wood work joined by it will break at some other place, and not at that at which it is cemented. From its solubility in water, glue is useless in damp situations.

To prevent the glue from being burnt in heating, it is dissolved in a glue-pot, consisting of two vessels, one placed within the other. The outer one, which is much the larger, is partly filled with water, while in the inner one the glue to be dissolved is placed. By this arrangement the glue cannot be overheated as long as any water remains in the outer vessel.

The workmen using glue are chiefly joiners and cabinet makers; a weak solution, termed size, which is usually obtained by boiling down the clippings of parchment, glove leather, &c., is mixed with whitewash, to prevent its being readily rubbed off when dry.

Isinglass, so much used for making jellies, &c., &c., is a purer kind of glue obtained from the air-bladders or sounds of the sturgeon, and several kinds of fish; a variety of glue obtained from the skins of animals is sold under the name of *gelatine*, and used for the same purpose.

LESSON L.

HORN.

Description.—The substance known as horn is obtained from many ruminating animals, as the ox, the goat, the sheep, and the antelope; the term horn is often applied to the antlers of animals of the stag or deer tribe, but erroneously, as they consist, not of horn, but of solid bone, are generally branched, and are shed annually, while true horns are permanent. The horns of the ox, &c., are of a conical form, and generally somewhat curved; they have a bony core in the centre, which takes its rise from the bone of the forehead; this core is supplied with nerves, and also with vessels, by which nourishment is conveyed to the horny portion that surrounds it like a sheath.

The outside horn, like the nails of the fingers, is quite insensible; the tip may be cut off without giving pain; if,

however, the bony core is injured, it bleeds freely, and the animal suffers pain. The chief difference between horn and bone arises from the former being destitute of earthy matter; hence its semi-transparency.

The horns used in the arts are obtained from various animals of the ox tribe, and are imported in large numbers from Russia, the Cape of Good Hope, South America, &c.

Preparation and Uses.—Horns are prepared by first soaking them in water for five or six weeks; this loosens the core and permits its removal; the solid part of the horn, near the tip, is then cut off, and used in making knife handles, buttons, &c.; the remainder is softened by boiling water and exposure to heat; in this state it is prepared for use by being split up with a knife, and pressed flat between hot iron plates. If required in thin sheets, it is split into layers, smoothed by scraping, and afterward polished.

When prepared for combs, the horn is pressed, and made into the required shape by a saw and rasps. If a very large piece of horn is required for a comb, or any other article, two pieces are joined together by heating the edges until they are quite soft, and keeping them pressed together firmly until cold.

Drinking cups are formed by moulding the hollow part of the horn (softened by heat) into a regular shape—it is then polished. A deep groove is afterward cut or turned near the bottom; the cup is again softened by heat, and a flat piece of horn, of the proper size, forced into the groove. The horn contracts as it cools, and the joint is perfectly water-tight.

Horns were anciently used in making the musical instruments so called, and the name still remains; hence we have the bugle horn, &c., though they are now made of brass and other materials.

The waste from buffalo and ox horns is of some value, being either used as manure, or in the manufacture of Prussian blue.

The hoofs of the ox consist of a material similar to that forming the horn, and they are extensively employed for making buttons and ladies' side combs. At one comb manufactory near Aberdeen, in Scotland, eighty tons of hoofs are stated to be used for the latter purpose.

LESSON LI.

HORSE HAIR.

Description.—The horse hair used in the arts is in general obtained from the tail and mane of horses.

The long hair of the tail is woven into a kind of coarse cloth for sieves, also into a fabric for covering chairs, sofas, &c.; in the latter case the horse hair runs in one direction only, and threads of flax or hemp in the other, sufficiently firm and strong to give great strength to the whole. The long hairs are also used to form fishing lines, violin bows, &c.

The shorter hair is usually curly; it is generally sold in commerce twisted into cords, which are afterward picked open, and the hair used for stuffing mattresses, chairs, sofas, &c. To fit it for this purpose it is baked

with a gentle heat, by which its elasticity is much increased. The short hair of the mane is also used for stuffing horse collars, and other inferior work. Much of the hair used in manufactures is imported from South America.

LESSON LII.

IVORY.

Natural History.—Ivory is the hard, bony substance forming the tusks of several animals, as the elephant, hippopotamus, walrus, and spermaceti whale. The chief and best supply of elephant ivory comes from Africa. Large quantities are obtained also from immense collections of bones and tusks of extinct species of mammoths and elephants, which are found in the banks of the northern rivers of Siberia. Some of these tusks were ten feet long, and weighed 186 lbs. each. The tusks found in Africa occasionally weigh from fifty to seventy pounds, but do not average quite twenty pounds each. At the low estimate of 30*l.* per cwt., the total value of the ivory imported into England, is nearly 300,000*l.* yearly, and above 20,000 elephants are annually slaughtered to yield this supply. Elephant ivory is a white, translucent substance, mainly composed of the same materials as bone, possessing a very fine, close texture, in which may be observed a diamond-shaped network, caused by curved lines interlacing each other with great regularity and beauty, and giving rise to a pattern resembling the engine turning of a watch, extremely hard, yet slightly compressible by great force, and elastic. Cut into thin layers it has a greater degree of transparency than paper of the same thickness.

Uses to Man.—The semi-transparency and whiteness of ivory, together with its fine, even surface, render it the best known substance for the groundwork of small delicate paintings, such as miniatures; it is also employed by the turner for various articles, as well on account of its beauty and hardness, as from its being less liable to crack than bone. The keys of pianofortes, knife handles, chess men, surgical and mathematical instruments, and toys are made from it. The ancients esteemed it highly as a material for sculpture, and it is still used by the carver for small figures and ornamental devices.

LESSON LIII.

LEATHER.

Manufacture and Uses.—Leather is a substance universally used among civilized, and very generally among barbarous nations; it is made from the skins of animals, which are tanned or prepared with some substance having the power of converting the perishable skin, that decays readily when wet or moist, into a lasting and comparatively imperishable leather. Several tanning substances are employed, according to the kind of leather required; that for the soles and upper leathers of shoes, for harness, and similar purposes, is tanned with the aid of oak bark. The hides or skins, either fresh, as received from the butcher, or salted, as they are brought from abroad, are first scraped to remove any pieces of flesh or fat that may remain attached to the inside, and are then soaked in a mixture of lime and water, by which means the hair is loosened, and can be readily scraped off. Thus cleansed from the hair and flesh, they are again soaked for some days in an acid liquid, made by putting barley or rye flour into water and letting it remain till it becomes sour, or by adding a small quantity of oil of vitriol; this acid solution has the effect of opening the pores of the skin, so that the tan can afterward penetrate more readily. The hide is then placed in the tan-pit with oak bark and water; first in a weak, and afterward in a strong solution. The process of manufacturing skin into leather is a very slow one; to make strong and well-tanned leather the hides should remain in the pits from six to twelve, or even eighteen months; if taken out too soon, the middle of the skin is not well tanned. The hides when removed are dried, and finally passed between rollers, to give them a smooth surface and render them firm.

By these processes the skin is much altered in its properties; when taken from the animal it is soft and moist, and, when dry, brittle, and liable to crack; it is also very perishable, and putrefies rapidly if kept wet; these qualities render untanned skins of little use. Leather, on the contrary, is flexible and soft, whether wet or dry; it is also, if properly prepared, waterproof and lasting; at the same time it is light, and sufficiently strong to withstand much wear when made into shoes, harness, &c.

There is a mode of tanning by steam, called the "hot process," by which the leather is produced more rapidly and cheaply, but it is of very inferior quality.

The leather required for the upper parts of boots and shoes is prepared by the currier, who, by paring and rubbing, renders it thinner, more flexible, softer, and capable of taking a polish; at the same time he blackens it with lampblack, and oil or tallow. The skins used for upper leathers are calf, and the thinner skins of cows and horses; while the thicker skins, and those of oxen, &c., are used for the soles. These skins are imported mostly from South America and Calcutta.

The numerous kinds of leather, required for different purposes, are made by slight variations in the process.

Morocco leather, for example, is prepared from goat skins, which are mainly imported from Switzerland and Mexico. The flesh and hair are scraped off as before described; each skin is then sewed up in the form of a bag, which is filled with water and a vegetable substance termed sumach; this substance, like the oak bark, is astringent, and has the effect of tanning these skins in a few hours; they are then dyed, and rubbed with a grooved ball, in order to give them the ribbed appearance which distinguishes morocco leather; imitation, or inferior morocco, is manufactured from sheep skins. Morocco leather is soft and very flexible, while its grooved appearance renders it ornamental. It is frequently used for covering books and chairs, lining carriages, &c.

A very strong leather is made from seal skins, and is used for the tops of riding and hunting boots. In Louisiana the manufacture of leather from alligator skins was commenced some years since, and more recently a new source of leather has been found in the skin of the white

whale, which is found in the rivers emptying into Hudson's Bay.

The leather which, from its softness and power of stretching, is usually selected for gloves and ladies' shoes, though called kid, is mainly prepared from the skins of lambs. It is tanned with alum, and, to render it as soft and yielding as possible, eggs and flour are used during the process.

Wash, or chamois leather, is prepared by cleansing the skins with lime; they are then dried; afterward, they are beaten with heavy hammers, while kept wet with oil; again hung up to dry, and again beaten with the addition of fresh oil; this operation is many times repeated; lastly, the surplus oil is removed by soaking the skin in water containing pearlash; it is ultimately dried, and it is then fit for use. Being very soft, wash leather is much employed for polishing metal articles; and from its warmth and softness, it is made into under waistcoats, &c.; it does not resist the wet, and is, therefore, unfit for outer clothing.

Sheep skins are split by a machine so as to form a cheap kind of leather termed skiver, which is largely used for pocketbooks, hat linings, common bookbinding, and similar purposes. At the present time the skins of the larger animals are split; the outer side being employed as a substitute for morocco leather, and the inner for inferior purposes.

LESSON LIV.

SOAP.

Manufacture.—All the various hard soaps are prepared from different kinds of fat or oil, and the alkali, soda. It is necessary, however, that the common soda should be rendered much more caustic than it is in its usual state; this is done by boiling it with fresh burnt lime, which, acting chemically on the soda, greatly increases its caustic powers. The soda thus prepared and dissolved in water forms what is termed the lye or ley of the soap boiler.

White hard soap is manufactured in the following manner:—Into an iron vessel, heated by steam, a large quantity of fatty material is placed; into this a quantity of the ley is poured. The mixture is boiled for some time, and frequently stirred, during which time the tallow unites with the soda of the ley, and forms a viscid liquid; a strong solution of salt is then added, which causes the immediate separation of the water and the ley; this is pumped away, and a stronger ley being added, the operations are repeated until the whole of the grease is converted into soap. It is now submitted to another process called "fitting," which consists in boiling it in weak ley or water until the impurities settle to the bottom. The contents of the boiler are then left to cool and settle for two or three days. In order to harden the soap it is removed from the boiler and poured into large pans; when cold it becomes a solid mass, which is cut up by wires into bars.

When scented and cast in small cakes, it is sold as Windsor soap.

Yellow soap is made in the same way, with the addition of a portion of resin, which gives the peculiar smell and bitter taste by which it is distinguished, but it adds to its solubility, and to its power of forming a lather in water.

Fancy or toilet soaps are prepared from a great variety of materials, as palm, olive, castor, and spermaceti oils, mutton tallow, and lard. The well known Castile soap is made with olive oil and soda, while the Windsor soap requires mutton tallow.

Soaps are colored by mixing mineral paints into the melted mass, as vermilion for pink, ochres for the brown, &c.

In marbling fancy soaps, the paint is mixed with olive oil or soap, and a small portion, taken up on a palette knife, is moved about in the melted mass.

All the various soaps are soluble in water, forming semi-transparent solutions; when moist or dissolved, soap has a peculiar feeling, distinguished by the term soapy. The great use of soap depends upon its solubility, and upon its power of rendering grease and dirt soluble in water, without exerting any corrosive action; a weak solution of caustic alkali would act more powerfully in cleansing, but at the same time it would, like the washing powders in general use, destroy or materially injure the linen and other fabrics with which it might be brought in contact.

Soap is sometimes found as a natural product. In California a small shrub grows abundantly which is generally used for soap, and is even preferred to the artificial variety. The bulbous root of this plant is dug up, stripped of its husks, and rubbed upon the clothes in the water. Several other plants have been found in various parts of the world which serve the same purpose.

LESSON LV.

SPONGE.

Natural History.—Sponges are animal substances, which are found in marine and fresh waters in various parts of the world. The two principal varieties met with in commerce are known as Turkey and West Indian, the former coming from the Mediterranean, the latter, which is much coarser, from the Bahamas Banks and coast of Florida. The inhabitants of the Greek Islands, from whence the best sponges are obtained, are trained to dive for sponge from their childhood;—to quicken their descent they use a large heavy stone, which is attached to the boat by a rope; they seldom remain under water so long as two minutes at one time. Some of the coarser kinds of sponge are obtained by dredging the bottom of the ocean. Sponge is a very light, soft, compressible, highly elastic material; on examination with a microscope it is found to consist almost entirely of horny elastic fibres, which are so arranged as to form an infinite number of small tubes that open on the outer surface of the sponge, and communicate internally with larger tubes formed in the same manner.

During the life of the animal these tubes are lined with

a soft gelatinous flesh. The animal has the power of causing strong currents of water to flow out of the larger apertures, its place being supplied by what passes in through the smaller pores; this action is always going on, and while the water is so passing, the requisite food is withdrawn for the support of the animal. When removed from the water this soft flesh drains away, the elastic fibrous framework or sponge remaining. In some varieties the fibres of the sponge are flinty in their texture; such are, of course, useless in an economical point of view.

Uses.—The use of sponge as a material for washing, &c., depends on its porosity and elasticity; the first quality enables it to absorb water with great rapidity. This is readily forced out by pressure, and on being removed, the elasticity of the fibres causes the sponge to resume its former size, the tubes being again ready to receive an liquid with which they may be placed in contact.

LESSON LVI.

TORTOISE SHELL.

Natural History.—The tortoise shell of commerce is chiefly obtained from the back shell of two species of sea tortoises or turtles, a native of the seas of the torrid zone, the best being furnished by the hawksbill turtle. As in the other animals of the order to which they belong, these turtles are enclosed in a bony case formed underneath by the expanded breastbone, and on the back by the flattened ribs and spine; on the latter bony arch grow the scales of tortoise shell. Five large scales, or "plates," as they are termed, are taken from the centre of each shell, and four from each side; there are also twenty-five small ones at the edge. These plates are thick in proportion to the size and age of the animal, and overlap one another to a great extent.

The scales are removed from the bony arch by heating it over a fire; this process loosens them, and they are easily separated by a knife. The value of the rough shell is very considerable, the best being worth about three guineas a pound. It is frequently injured by barnacles and other shell fish, which fix themselves to the turtle while alive.

Manufacture and Uses.—Tortoise shell is manufactured in a similar manner to horn, a substance which it closely resembles. It is first softened by boiling in salt and water, and then pressed flat until co , it is rendered smooth and of uniform thickness by scraping and filing; and if larger pieces are required than can be obtained from single plates, two or more are united together. The pieces to be joined are sloped off to the distance of about a quarter of an inch from the edge. The margins are so placed as to overlap one another, and, after being pressed together by an iron clamp, the whole is placed for some time in boiling water; by this means the two pieces become so perfectly united that the joint cannot be seen. The filings and powder of the various processes are not lost; they are collected and placed in metal moulds, and by warmth and pressure are formed into any shape that may be desired. As heat darkens the tortoise shell, and greatly lessens its

beauty, it is usually cut into the required patterns by drills and saws, and not moulded like horn.

In making combs, in order to economize the shell, two are often formed out of one piece; the teeth of one being cut out of the spaces between those of the other. Besides its use for combs, boxes, &c., tortoise shell is used for inlaying and ornamenting tables, cabinets, &c.: for this purpose it is cut into thin sheets, and a bright metal is placed beneath, which, shining through the semi-transparent shell, gives the article a very ornamental appearance.

LESSON LVII.

WHALEBONE.

Natural History.—The substance termed whalebone is not, as its name might m to imply, obtained from the bones of the animal, but it forms a substitute for teeth in the Greenland whale, and some other species that nearly resemble it.

The plates, or blades of whalebone, which are usually about three hundred in number in each side, are arranged along the sides of the upper jaw, occupying the usual situation of the teeth in other animals. Each plate is flat, and they are ranged with these flat sides parallel to each other across the jaw. The edges are formed of coarse, loose fibres, and are turned toward the inside of the mouth, so that the whole together form a sort of strainer, the lower part of which is received into the hollow of the large and spoon-shaped lower jaw.

This apparatus is the only means which the whale possesses of securing its food; for although this creature attains the immense length of from fifty-five to sixty-five feet, and a girth of thirty or forty feet, with a weight equalling that of two hundred oxen, it feeds entirely on the small pulpy animals that float in countless multitudes in the water of the Arctic seas. In order to secure these, it swims with considerable rapidity, its mouth being open; the water rushes in at the fore part, where there are no plates of whalebone, and passes out at the sides, after having been strained through the fringe or filter of whalebone, which allows the water to escape, but retains the food.

The length of the blades varies considerably with the size of the animals, and the part of the jaw from which they are taken; the longest are usually about ten or eleven feet, and the quantity obtained from a full-sized whale is about one ton.

The surfaces of the blades are formed of a firm, compact, fibrous substance, which can be readily split in the direction of its length; this substance is tough, strong, very elastic, and capable of receiving a high polish; the color varies from black to a dusky gray or white. Between the two surfaces or sides of these blades there is a layer of coarse, fibrous material, and, as before stated, the inside edge and lower end of each blade form a coarse, fibrous fringe.

Uses.—Whalebone is prepared by boiling it for some hours in water; this renders it soft, and more readily cut; on cooling, it becomes harder and darker than before. Its uses greatly depend on its extreme elasticity; split into

fibres, it is employed in the place of bristles for making coarse brooms and brushes; it is also used in large quantities for the stretchers of umbrellas and parasols; the whiter pieces, cut into thin strips, are sometimes platted into bonnets, and, after having been dyed, into artificial flowers; it is also employed for stays, brushes, whip handles, canes, and the manufacture of hair cloth. The waste shavings are employed as a stuffing material for upholsterers, the refuse going to the farmers for manure.

A large quantity of artificial whalebone is now used for umbrellas and parasols. It is made from the inner portion of the common cane, which is steamed, and then impregnated with a fluid containing shellac; this renders it as elastic as whalebone.

LESSON LVIII.

CORAL.

Corals are the secretions made by one of the lowest class of animals, called polypi, inhabiting the deep; they sometimes assume the forms of branches of the most beautiful appearance; sometimes they resemble beads strung in a necklace, while others present a more consolidated mass; but all are perforated with pores more or less minute, which are the habitations of the little architects.

Among the various phenomena of the natural world, there are perhaps none more calculated to excite astonishment and admiration than the vast coral reefs that rise up from the deep, and at times even constitute islands. They are produced from a calcareous matter which exudes from the coral polyp, and hardening, forms at once its habitation and its mausoleum. This creature is of the class of zoophytes, the lowest grade of animal life, the link between the animal and the vegetable kingdom. They work only under water, so that the coral reefs never rise above the level of the sea; and when the tide retires, the rock appears dry, compact, rugged, and perforated; but when the returning waters wash its sides, a most interesting spectacle of active life is presented, countless myriads of various shapes and colors protrude themselves from the orifices, and the whole edifice seems teeming with life and animation.

The coral ceases to grow in height when the polyp is no longer exposed to the washing of the sea; the work is then commenced at the sides, and other parts rise in succession, till they reach the same height, and form a level surface at the top, with steep precipitous sides. In this manner, and by such insignificant agents, atom deposited upon atom, the solid rock is at length produced; upon this the sea deposits sand, mud, and decayed seaweed; these prepare for mosses and lichens, which in their turn produce a soil for more perfect vegetation; till at last the island thus formed becomes a fit residence for man.

As these rocks are constructed beneath the surface of the sea, they present no beacon to warn the mariner of their existence, and thus render navigation in those seas in which they abound exceedingly dangerous.

LESSON LIX.

WAX CANDLES.

Wax candles are manufactured from two kinds of wax —animal and vegetable. Beeswax is a substance secreted by bees in their bodies, and of which they construct their cells. For the methods of obtaining the wax, see the lesson on "Beeswax."

The insect wax of China is the product of a small white insect, which deposits it upon the trees on which it feeds.

Of the vegetable waxes, the Japanese, the palm wax of New Granada, and the myrtle wax of the United States, are the principal. Of these the myrtle or barberry wax is used most extensively, and is becoming an important article of commerce.

The Japanese and myrtle wax are obtained from berries, and the palm wax from bark.

Wax candles are generally made by pouring the melted wax over the wicks, and rolling them, during the process and at its close, between two marble slabs, in order to give them shape. Moulds of glass encased in gutta percha are sometimes used.

LESSON LX.

SHELLAC.

Shellac is a substance produced by a little insect called coccus lacca, and is deposited on the small branches of the Indian fig tree, for the protection of its eggs. It discharges the gum from its own body, and forms it into cells, in each of which is placed an egg. When the eggs are hatched the young grub pierces through the viscid substance which enclosed it, and flies away; and the material provided for a little insect's well-being becomes a valuable article of commerce.* The lac is first sold on the sticks, when it is called *stick lac*; but after it has been purified and formed into thin sheets or cakes, it is called *shellac*. Its color varies from orange to dark reddish brown, and has a shining lustre. Before the discovery of the cochineal dye, shellac was much used by the dyers of Prussia and Holland in forming their celebrated crimson dyes. It is the principal ingredient in sealing wax and varnish, and is employed in japanning. Its usefulness arises from its being fusible, soluble, and adhesive.

LESSON LXI.

BUTTER.

Butter is prepared from the milk of the cow. When milk has been allowed to stand a few hours, a thick, rich substance, called *cream*, rises to the surface. This is skimmed off, and by being briskly agitated, is converted into butter. The instrument by which this operation is performed is called a *churn*. There is another substance

* The children would be interested in recollecting many instances of this primary and secondary uses of substances, and their attention might be directed to a perception of the difference between man's work and that of the lower creatures; the latter led by instinct, the former by reason and experience, resulting in discovery.

found in the churn besides butter; it is called *buttermilk*, and when fresh is considered by many a refreshing drink. This is very carefully separated from the butter by "working" it either by hand or a wooden ladle; in dairies where large quantities are made, a machine is used for pressing the buttermilk from the butter. The butter prepared for winter store is salted, and packed in barrels and tubs. The place where the milk is kept is called a *dairy*, and great care is taken to keep it free from odors of every description.

LESSON LXII.

CHEESE.

Cheese is prepared from milk which is coagulated or curdled, by mixing it with a liquor called rennet; the curd thus formed is a white, solid substance; this is separated from the *whey* or watery particles of the milk, and then pressed and dried. Large and rich cheeses often require to be bound with strong linen cloth to prevent their bursting in the drying process. Rennet is made by steeping the inner membrane of a young calf's stomach in water. This is salted, dried, and kept for some time before using. A color is sometimes given to cheese by saffron, or by a substance called *annato*, which is the seed vessel of a shrub growing in the West Indies. The latter ingredient is so often adulterated with red lead, which is poisonous, that its use is generally abandoned.

LESSON LXIII.

FELT.

Felt is the substance of which hats are made. It is composed of hairs; those of the rabbit are chiefly used by hatters. The operation of *felting* depends upon a peculiar construction in all hairs, which, however smooth and even they may appear, have in reality a tiled or scaly texture on the surface. The scales are so placed that they yield to the finger, if drawn along the hair from the root to the point, but present a resistance when moved in a contrary direction. In consequence of this peculiarity, if the hair be seized in the middle between two fingers and rubbed, the root will gradually recede, and the point will approach the fingers, exhibiting a progressive motion toward the root; the imbricated surface preventing all motion in the opposite way. From this property hairs, when beaten or pressed together, begin to move in the direction of the root, and are disposed to catch hold and twist round each other, and thus to cohere and form a continuous mass, which is called *felt*. It is in consequence of this tendency to felt that woollen cloths increase in density, and contract in dimensions by being washed; and also that they do not ravel out when cut.

This material was formerly made by hand. By this process a man was occupied a day in making four or five hat "bodies," as they are called before the "sizing" and "shaping" is done. Machinery is now employed by which three men and a boy can make four hundred in a day. The

rabbit's fur used in this manufacture is principally imported from the German States of Europe.

TEXTILE OR WOVEN FABRICS, AND THEIR MATERIALS.

Introduction.—The materials for our clothing are derived both from the animal and the vegetable kingdoms; as, however, the processes these materials undergo in the course of manufacture are very similar, it has been thought desirable to describe them under one head, and to give, at the same time, a short account of spinning and weaving.

The process of spinning consists in twisting the loose fibres of cotton, flax, wool, or other fibrous material, into threads fit for the use of the weaver, and is one of the greatest antiquity; it is alluded to by Moses in Exodus xxxv, 25, and was not then spoken of as a new art. Originally, it was performed with a distaff and spindle, the former being a stick about a yard in length, with a knob or enlargement near one end; the flax or other substance to be spun (having been previously combed so as to lay the fibres parallel) was loosely twisted around it; thus charged, the distaff was held under the left arm, and some of the fibres were pulled out by the right hand, and twisted into a thread; this thread was wound upon the spindle, a rod of wood about a foot in length, having a notch at one end, in which the thread could be secured; to this spindle, a piece of metal or stone was attached, to increase its weight and enable the spinner to keep it twirling round as it hung from the thread, while a fresh supply of fibres was pulled out from the distaff; when a sufficient length of thread was spun to permit the spindle to reach the ground, the thread was removed from the notch, wound on the spindle, fastened by being again secured to the notch, and a new length commenced. This process of spinning was superseded by the spinning wheel, in which contrivance the cotton or other substance, after having been combed or carded so as to straighten the fibres and lay them perfectly parallel, is attached to a spindle that is made to revolve with great rapidity, by a strap of leather, which also passes around a large wheel turned by the hand or foot of the spinner.

At the present time the spinning wheel is very rarely seen, all the varieties of cloth being now woven from thread spun by the aid of powerful and very complicated machinery, which acts on the same principle as the spinning wheel, but is far too intricate to be understood without diagrams and a much longer description than falls within the plan of the present work.

Weaving, or the art of making cloth by the interlacement of threads, has also been practised from the earliest times. It is in all probability older even than spinning, for rushes and the fibrous stems of plants were probably woven together into a sort of coarse matting, such as is now used by some of the least civilized nations, long before the twisting or spinning together of fibres to form threads was had recourse to; however this may be, representations of hand looms for weaving are found upon the tombs of the ancient Egyptians, constructed on precisely the same plan as those in use at the present day, and

these paintings were probably made in the times of the patriarchs.

If we examine any piece of plain woven material, as calico, silk, or canvas, we find a number of parallel threads running the whole length of the piece of cloth; these form the warp, and those which pass across them at right angles in the direction of the width of the cloth, form the weft, the threads of these pass alternately over and under those of the warp; in reality, there is but one thread of weft, which is doubled back at the edge of the cloth, and returns, passing over those threads it passed under before, and under those which it previously passed over; the arrangement of the threads being similar to that which is produced in darning, when that operation is performed to fill up the vacant space in a worn stocking.

The hand loom is still used occasionally, but is rapidly giving place to larger instruments worked by steam power, in which all the various processes in weaving are performed by means of machinery. The larger machines are known by the name of power looms.

LESSON LXIV.

COTTON.

This extremely valuable substance, which is now raised in such abundance as to furnish the cheapest and most extensively used clothing, is produced in the seed vessels of the cotton plant, of which there are many varieties; some are herbaceous annual plants, growing from eighteen to twenty-four inches high; others, shrubs, about the size of our currant bushes, and of from two to ten years' duration; while a third kind attain the growth of small trees, of an altitude of from twelve to twenty feet.

The leaves of the cotton plant are of a bright dark green color, deeply divided into five lobes; the flowers are large and showy, of a bright sulphur or lemon color, and closely resembling in appearance and botanical structure those of the single hollyhock; each flower is succeeded by a triangular, three-celled seed vessel, which attains the size of a small walnut, and, when ripe, bursts open from the swelling of the cotton contained in the three cells; the seeds, which are rather larger than those of grapes, are enclosed in the cotton wool, which adheres very firmly to them. One variety of cotton, cultivated in China and some parts of America, has a yellow tint; this tint it preserves when woven into the fabric called nankeen.

The cotton plant is largely cultivated in India, China, the United States, West Indies, on the shores of the Mediterranean, and, in short, in almost all the warmer parts of the world; it flourishes readily in soils too poor for the growth of grain and other crops, and succeeds well in moderately dry seasons. It is cultivated in the Southern States from the seed which is sown by hand in March and April.

The cotton, when perfectly ripe, is gathered by women and children, the seeds and wool being picked out of the pod; it is dried in the sun, and is then ready for the removal of the seeds. This was formerly done by hand, but a more rapid process is now adopted. The cotton is placed in a box, one side of which is formed of stout parallel

wires, placed about one eighth of an inch apart; by the side of this box is a roller, carrying a number of circular saws, with curved teeth, which project through the wires into the box. On the roller being made to revolve, the teeth of the saws drag the cotton through the wires, the seeds remaining behind; after being thus separated, the cotton is powerfully compressed into bags, and is ready for transport to various manufacturing countries.

The spinning and weaving of cotton into calicoes and other fabrics are now almost entirely accomplished by means of machinery, moved either by steam or water power. The fibres of the cotton are first separated from each other, and cleared from dust, by means of a contrivance called a willow, a machine formed of rollers, in which iron spikes are fixed; these are made to turn round rapidly, and the fibres are thus separated, and then laid parallel by the carding machine, in which they are passed between two brushes (or cards, as they are termed) made with iron wire; thus prepared, they are transferred to the machines, which spin them into yarn, or thread, fit for the use of the weaver. The strong and firm material known as sewing cotton consists of several yarns twisted together.

In order that the cotton manufacture may be successfully carried on in any particular district, it is essential, first, that it should be situated where fuel is cheap, if steam power is used, or on rapidly descending streams, if the machinery is driven by water power; second, that it should be as near as possible the country from whence the cotton is principally brought; third, that there should be easy means of communication with seaports and other parts of the country. These several conditions are all fulfilled in actual localities of the cotton manufacture. In England, the Lancashire and Cheshire, and in Scotland, the western portion of the central coal fields are its seats. England obtains her greatest and earliest supply of cotton from America; and the coal fields on which the cotton is manufactured are to the west of Britain.

LESSON LXV.

FLAX.

The fibre of the flax plant has been employed as a material for clothing from very remote times; it was in common use among the Egyptians. In Gen. xli, 42, we read that Pharaoh arrayed Joseph in vestures of fine linen. Representations of flax, and of its different stages of manufacture abound amongst the paintings on the Egyptian tombs, and the various specimens of mummy cloth hitherto examined have been formed entirely of this substance.

It is produced extensively in Russia, the United States, and Ireland, but the best flax in the world is found in Holland and Belgium. Flax is used in the manufacture of linen sheetings, shirtings, handkerchiefs, table linens, and some kinds of lace and edgings.

The variety of flax most commonly cultivated is an annual, with slender, green, herbaceous stems, about two feet in height, bearing small, narrow pointed leaves, destitute of stalks, and crowned by a number of elegant blue flowers, each of which is succeeded by a globular seed-vessel, containing ten flat oblong seeds of a dark brown color.

The flax plant is cultivated as well for the sake of its seeds, which are the well known "linseed" of commerce, as for the valuable fibres yielded by the stem; when the latter are the principal objects of cultivation, the plants are sown thickly, so as to cause the stems of the crowded plants to run up high; on the contrary, when the seeds are required, the plants are sown less thickly, and allowed to remain a longer time in the ground before they are gathered. When ripe, the leaves of the plant fall off and the stems turn yellow; the flax is then pulled by hand, carefully dried in the sun, and either stacked under cover, or deprived of its seeds at once by pulling the tops of the stems through a coarse iron comb, fixed perpendicularly in a block of wood; the seed vessels, being too large to pass through the teeth of the comb, are torn off.

The seeds of the flax plant thus obtained are extremely valuable to man; they are known, as before observed, under the name of linseed, and, when pressed, yield a very useful oil.

The stems of the flax, freed from the seeds, undergo a series of processes to prepare them for the use of the weaver; they are first steeped in shallow pools of water until partially rotted, to cause the fibres of the bark (the only part used in weaving) to separate readily from each other; they are then usually exposed to the action of the sun and air by spreading them out on the grass for about a fortnight; the central woody portion of the stem, which has been rendered brittle by steeping, is then removed by an instrument termed a brake, the simplest form of which consists of a long slit in a block of wood, with a wooden sword fitting loosely into it; a bundle of flax is laid across the slit and forced into it by the sword; the brittle, woody part of the stem is broken by the bending to which it is thus subjected. The brake in general consists of three or more swords fitted into one handle; these pass into a corresponding number of slits, and break the stem with great rapidity; the broken woody portions are readily separated from the tough uninjured fibres either by beating with a short staff, or by rubbing out with the hand.

To render the flax fit for the purposes of the spinner, it is next hatchelled, a process necessary to lay the fibres parallel, and separate those which, from their shortness, are not used. The hatchel may be compared to a brush formed of sharply pointed needles instead of bristles; it is fixed on a low stand, with the points upward; the workman, taking a bundle of flax in his hand, throws it on to the hatchel, and drawing it toward himself through the teeth, the long fibres become parallel, while the short broken ones are retained by the instrument; these latter form the well known substance called tow. At the present time these processes are very extensively performed by machinery.

After hatchelling, the flax is fit for the use of the spinner; nearly all the flax now used in this country is spun by machines, the spinning wheel being rarely seen.

LESSON LXVI.

HEMP.

The plant yielding the hemp of commerce is an annual, the native country of which was probably the East, but it

is now extensively cultivated in most parts of the world; the stem is simple or unbranched, and rises to a height of about five or six feet, bearing numerous leaves, each divided into a number of narrow pointed leaflets, deeply notched at the margin; the whole plant is covered with stiff hairs, which give it a peculiar harshness to the touch.

The flowers are of two kinds, barren and fertile; these grow on distinct plants, and are green and inconspicuous; the plant bearing the barren or male flowers is of quicker growth than that which bears the female or fertile, and rises several inches higher; by this means the fertilizing powder that it produces is more readily scattered over the fertile plants; the flowers of the latter plants are succeeded by the small seed-like fruits enclosed in the green cup of the flower; these are collected and sold under the name of hemp seed; this seed, when crushed in a press, yields a large quantity of oil, much used in the preparation of varnishes, and occasionally employed in the formation of some kinds of soap.

Hemp seed, being extremely nutritious, is much sought after by birds, and frequently given to those kept in confinement. The plant, when grown in tropical climates, possesses a peculiar narcotic power, and an extract of the leaves, when swallowed or smoked, produces intoxication; it is employed for this purpose by the inhabitants of some parts of the East, to whom the use of wine is forbidden by the Mohammedan religion.

Hemp is chiefly cultivated for the sake of its fibres, which are very tough and flexible, and particularly adapted for the manufacture of coarse, strong fabrics, such as canvas, sail cloth, sacking, as well as for making twine, cordage, ropes, and cables; the quantity used for these purposes is extremely large; from 20,000 to 30,000 tons are annually exported from Russia to English and American markets alone.

English hemp is chiefly woven into coarse sheeting, and into the cloth called huckaback, of which coarse towels are made.

Hemp is most profitably cultivated in a rich, light soil, the coarseness and strength of the fibres depending on the amount and the richness of the manure. When required for the use of the weaver, it is, like flax, sown broadcast; the stems are in consequence crowded, and rise higher; they are also less coarse than when the plants are sown in drills at a greater distance apart. The full-grown plants are pulled up by the roots, those bearing barren flowers being first selected; the fertile ones are left some weeks later to ripen their seeds, which are readily rubbed out by the hand. After the plants are gathered, the tops and roots are cut off in the fields, to be left as manure, and the stems, tied up in bundles, are placed in water; this rots the woody and useless parts, and leaves the fibres in a state in which they can be more readily separated. This process, which is termed rotting, renders the water poisonous, and occasions a very offensive odor. When it is completed, the hemp is dried, and the woody portion, broken by hatchelling, is removed, as described under the head of flax; after this it is ready to be spun into yarn for weaving.

Hemp is largely used for the formation of string, cordage, &c., the fibres being twisted so as to unite firmly together. This process was formerly performed by hand; the spinner took a bundle of hatchelled hemp and wrapped it around his waist; he then drew out a few fibres, and twisting them together, fastened them to a hook, which was twirled round with great rapidity by a large wheel generally turned by a boy; the spinner walked backward from the hook, and as he did so the twisting yarn drew out additional fibres from the bundle round his waist, while with his hand he regulated the number of these fibres, and caused the yarn to be of uniform size; the yarns so made were again twisted into strands; three of these strands form a rope, and three ropes united make a cable. Horse power was employed in twisting the ropes and cables. Steam machinery now performs all these operations, from the hatchelling of the hemp to the twisting of the rope or cable.

LESSON LXVII.

SILK.

The formation of raw silk, and the amount, have been described under the head of the silkworm moth, and it remains only to trace its further progress into spun silk, adapted for the use of the weaver and the sempstress. The hanks of raw silk, having been washed in warm water, are wound upon bobbins or reels; this is accomplished by a winding machine, the effect produced by this machinery being the same as when a skein of thread is held on the outstretched hands of one person and wound on a reel by another. The silk is then twisted, or *thrown*, as it is termed, so as to unite several filaments together into a single yarn, and for the stouter threads several yarns are again twisted together, or *doubled;* the tendency of the filaments to untwist after being twisted is counteracted by exposure to steam, which gives the threads a permanent *set*.

The only silk fabrics requiring a particular notice are changeable silks, satin, and velvet. Changeable silks are formed by having the warp and the weft of differently colored yarns; a peculiar play of colors is thus produced when the fabric is moved, or seen from different points of view. Satin owes its peculiar softness and lustre to the circumstance of its being so woven that the threads of the warp alone are visible, those of the weft scarcely coming to the upper surface; this is accomplished by carrying the thread of the weft under five or six threads of the warp, and over one; again under five or six threads, and over one, and so on across the warp; by this means the warp threads alone are seen, and a rich, unbroken glossy surface is produced. Velvet, the soft pile of which is so peculiar, is formed by weaving short loops of silk into the fabric; these loops, which stand at right angles to, and hide both the weft and the warp, are afterward cut open by a sharp instrument, and the cut ends of the silk standing up from the pile give rise to the peculiarly soft appearance of the velvet; this arrangement may also be observed in hearth rugs, where the cut ends of short worsted threads rise up from a coarse canvas foundation.

Silk fabrics are manufactured mostly in England, France, Italy, and China.

LESSON LXVIII.

WOOL.

The clothing manufactured from wool is particularly adapted to cold countries; not that it communicates warmth, but, being a non-conductor of heat, it prevents that of our bodies from escaping. Wool is the hairy covering of sheep, which has a peculiar felting property; it is taken from the living animal in the summer season, by an operation called *sheep shearing*, and in that state is called the *fleece*. The wool of the Spanish sheep is particularly fine; the flocks in that country are often very large, containing as many as a thousand sheep.

The first operation performed on the raw wool is to pick and sort it; this is particularly needful, as the same sheep produces wool of various qualities. It is next cleansed from its impurities, and committed to the *wool comber*, who, by means of iron-spiked combs of different degrees of fineness, draws out the fibres, smooths, and straightens them. It is then prepared for the *spinner*, who forms it into threads, the more twisted of which are called *worsted*, and the less twisted *yarn*. It is then employed in the manufacture of every description of hosiery, stuffs, carpets, flannels, blankets, and cloths. England manufactures so much woollen clothing, that it was formerly considered the staple commodity of the country; and to mark its importance the Lord Chancellor sits upon a woolsack.

MINERALS.

GENERAL CHARACTERS OF MINERALS.

The objects derived from the mineral kingdom afford one of the most obvious means of supplying material wealth to a country. In fact, some countries derive their chief importance from the abundant supply of mineral wealth which they export to other countries less richly furnished than they in this particular.

Minerals are distinguished from each other by the possession of certain characters, the most important of which will be briefly described here, in order to prevent repetition in speaking of the several species in detail.

Lustre.—Many minerals possess a high degree of brightness, but in characterizing them, the kind of lustre is more important than its degree. The most important varieties are—

The metallic lustre, as in	Black lead.
Vitreous, or glassy lustre, as in . .	Rock crystal.
Resinous, or waxy lustre, as in . .	Amber.
Pearly lustre, as in	Satin spar.

When minerals are destitute of any lustre, they are termed dull.

Color.—The colors of minerals are very numerous, and it frequently happens that several different tints may occur in the same mineral, from the mixture of small portions of other substances. Color, therefore, is not to be regarded as a character of great value in distinguishing minerals, except when it occurs in connection with metallic lustre; it is then more definite, as, for example, in lead ore or galena, which is always gray.

Some minerals are distinguished by peculiar appearances connected with color,—such as the rainbow-like variety of tints found in several of those possessed of metallic brightness,—for example, in the copper ore, called from this circumstance, peacock copper ore, and the reflection of a floating milky light from the interior of some others, which is called opalescence from the fact that it is very distinct in the opal.

Hardness.—While different minerals vary very much in their degree of hardness, this character is generally constant in the same species. Hardness is, therefore, regarded as of great importance in distinguishing minerals. Its degree may be readily ascertained by the ease or difficulty with which one mineral will scratch another. In describing hardness, the following scale is employed:

SCALE OF THE DEGREES OF HARDNESS OF MINERALS.

No. 1.	Yields easily to the finger nail, as for example, .	Chalk.
2.	Yields with difficulty to the nail, but does not scratch a copper coin, ...	Rock salt.
3.	Scratches a copper coin, and is also scratched by it, being of about the same degree of hardness, .	Lime spar.
4.	Not scratched by a copper coin, but not hard enough to scratch glass, . . .	Fluor spar.
5.	Scratches glass with difficulty, and yields easily to the knife, ...	Apatite.
6.	Scratches glass easily, and yields with difficulty to the knife, ...	Felspar.

7.	Does not yield to the knife, and to a fine file with difficulty,	Flint.
8.	Harder than flint.	Topaz.
9.	Harder than flint.	Emery.
10.	Harder than flint.	Diamond.

The diamond is the only mineral of the highest degree of hardness, and is therefore used for cutting glass, &c., the natural edges of the crystal being employed for that purpose. If the edges artificially made by cutting a diamond are used, they are soon worn down; consequently diamond rings are much injured if employed for scratching glass.

Weight, or specific gravity.—The weight of minerals, and, in fact, of all solid and liquid substances, is compared with that of water as a standard, and is termed their specific gravity, or peculiar weight. Thus, for example, the weight of sulphur is almost twice that of water, flint nearly three times, &c. It is a more convenient and accurate mode of calculation to consider the weight of water as expressed by 1,000; that of sulphur would then be 1,990; flint, 2,700. These numbers are termed the *specific gravities* of these substances.

In the following list, the specific gravity of several of the most common mineral substances is given:

Water,	1,000
Coal,	1,200 to 1,[illegible]
Clay,	1,600 to 2,[illegible]
Sulphur,	1,980
Rock salt,	2,250
Granite,	2,600

Limestone,	2,250 to 2,500
Chalk,	2,500
Slate,	2,750
Flint,	2,700
Emery,	4,000

The specific gravity of water being taken at 1,000 gives peculiar facilities for ascertaining the weight of any substance, as it so happens that one cubic foot of water weighs almost exactly 1,000 ounces. It follows that the specific gravity of any substance gives the actual weight of a cubic foot in ounces, sufficiently accurate for all practical purposes. Thus, for example, the specific gravity of granite being 2,600, a cubic foot of it will weigh 2,600 ounces, or 162½ lbs.; a cubic foot of clay, in like manner, 2,000 ounces, or 125 lbs., &c., &c.

Those minerals which are five times heavier than water are mostly metallic ores, as lead or galena ore, &c.

The following table shows the number of cubic feet in one ton of the undermentioned minerals:

Sand,	23½ cubic feet.
Gravel,	21½ "
Granite,	13½ "
Marble,	13 "
Chalk,	13 "

Form.—By far the larger number of minerals are naturally formed in determined shapes, called crystals; when this is not the case, they are termed massive. Minerals, whether crystalline or massive, have usually a certain internal arrangement of their particles, which causes them, when broken, to separate in some directions more readily than in others. This is termed their *cleavage;* for example, rock salt and lead ore invariably break up into cubes, &c.

When broken by a blow, minerals exhibit several varieties on the broken surface. This is termed their *fracture*, and should not be confounded with the forms into which they cleave.

LESSON LXIX.

LIME.

The substance called lime is never found pure in nature, owing to its great affinity for carbonic acid* and for water. All the earths of which lime forms the basis are called *calcareous.*† It is the most universally diffused of all substances, and one of the most abundant; it is computed that it constitutes one eighth of the crust of the earth. In this distribution we have great cause to admire the wise and good providence of the Creator, as the utility of lime in various arts, in agriculture, in manufactures, and in medicine is very great. Lime, united with carbonic acid, forms common limestone, chalk, marble, &c.; with sulphuric acid, it constitutes gypsum or alabaster; and with fluoric acid, fluor or Derbyshire spar. These are its most interesting

* Carbon is charcoal in its purest and colorless state; it is most abundant in the vegetable kingdom, and is chiefly obtained from wood. The diamond is the only pure carbon that is known. United with oxygen, carbon forms carbonic acid.

† Calcareous, from the Latin *calx*, lime.

combinations with mineral substances. It enters also into the composition of animal matter, as shells, bones, and the hard coverings of insects; our bones contain eight parts in ten of lime; and the shells of birds' eggs, nine parts in ten.

Pure lime is procured from chalk, or limestone, by means of burning. Alternate layers of calcareous earth and fuel are arranged in a kiln; a fire being kindled, the carbonic acid and water become volatilized, and are driven off, leaving the lime pure. In this state it is called *quick lime,* and is white, caustic, acrid, pungent, and infusible; corroding and destroying animal matter. When water is poured upon it, it swells, falls into a powder, and gives out great heat. This last operation is called *slacking* the lime. The water combining with the lime becomes solid, and the heat is occasioned by its changing from a fluid to a solid state, for in doing this it parts with some of its caloric. The uses of lime are numerous and important. It is formed into mortar, the cement used in building. The lime being slacked, is made into a paste by tempering it with water; to this is added sand, and sometimes chopped hairs; as it dries it becomes solid, hard, and durable. Examples have been known of buildings a thousand years old, in which the mortar is as hard as the stones which it unites.

Lime is used as a manure, to loosen soils which are too tenacious, and to render them more friable and capable of receiving vegetable fibres; it also hastens the dissolution and putrefaction of animal and vegetable substances, of which mould is chiefly composed, and gives it the power of acquiring and retaining moisture, so necessary to the growth of vegetables. Lime is also employed in the manufacture of sugar, to deprive it of a portion of its acid. Tanners use it in removing hairs from the hides, and cleansing them from fat and grease; it is used also in bleaching, and as a flux in the smelting of metals.

LESSON LXX.

ALUMINE, OR ARGIL.

This substance obtained the name of alumine from its forming the base of common alum; and argil,* on account of its being the constituent of all clays, which are therefore termed *argillaceous* earths. The distinguishing qualities of clays are, that they have an earthy texture, give out a peculiar odor when breathed upon, which has been thence called the argillaceous odor; they adhere to the tongue; are never found crystallized, but sometimes slaty; are generally opaque, and their weight is about twice as great as that of water. When tempered with water, most argillaceous substances become soft, tenacious, and plastic; † but shrink and harden by the application of heat. Alumine is never found pure in nature; but it is considered to be the most plentiful earth next to silex.

Common clay is a nearly equal admixture of alumine and silex; it is found in most countries, and is very valuable in various arts; for these it is peculiarly fitted, as it may be moulded into any form, which it retains unchanged after exposure to heat. The beds of lakes, ponds, and springs, are almost entirely of clay; instead of allowing the filtration of water, as sand does, it forms an impenetrable bottom, and by this means water is accumulated in the caverns of the earth, producing those natural reservoirs whence springs issue and spout out at the surface. Clayey soils, in consequence of their absorbing and retaining moisture, are heavy and sticky. Clay is often used by the poorer classes in some countries in forming their cottages.

* Argil, from Latin argil-*la*, clay.

† Plastic, from πλασσ-ειν (plass-ein), to form.

It is the substance of which bricks and tiles are constructed; when well baked in a kiln, or in the sun, it becomes very hard and durable. A proof of this is furnished in the existence at the present day of those mighty Egyptian pyramids, which many suppose to have been the work of the Israelites in their bondage.

Porcelain clay is that employed in china manufactories; it absorbs moisture rapidly, and becomes very tenacious when kneaded. It is distinguished from other clays by the fineness of its texture and its friability. A coarser kind, called *potter's clay*, is used in making common earthenware.

Another description of clay, of a plastic nature, is called *pipe clay*, from its being used in the manufacture of pipes; it is cast in a cylindrical mould, a wire being afterward run through it to form the hollow through which the fumes of the tobacco are inhaled; when baked, it becomes hard and white. This clay is also used in extracting grease out of different substances. *Fuller's earth* is another argillaceous substance, which was formerly similarly employed.

The soil or mould which covers our fields and gardens, contains more or less of these three substances, alumine, silica, and lime. They occur in very different proportions; a mixture of all forms the best soil, each correcting and keeping within their due proportion the qualities of the other; thus, in a clayey soil filtration is carried on by means of sand, while clay, on the other hand, gives consistency to a sandy soil, and lime loosens the texture of heavy lands, and corrects the coldness occasioned by their retaining water. The fertilizing property of our soils, however, greatly depends upon the admixture of decayed animal and vegetable matter.

LESSON LXXI.

ALUM.

Manufacture.—The substance known as alum is a compound of alumina, or the base of clay, united with sulphuric acid and a proportion of potash or ammonia. It is prepared from a dark gray slaty clay, termed alum shale, or alum slate. This, when exposed to air and moisture, gradually crumbles to pieces, and suffers much change in its character. The soluble parts are then dissolved by water; a solution containing potash is added; on boiling away the water, the alum crystallizes,—it is purified by being again dissolved and crystallized. Many varieties of the slate require to be burnt before use. This is effected by setting it on fire in enormous heaps, containing, in some

cases, many thousand tons. Sometimes the shale possesses sufficient inflammable matter to burn spontaneously; in others, small coal or cinders are added.

Properties.—Alum is a transparent, colorless, saline substance, readily soluble in eighteen times its weight of cold and its own weight of boiling water, the excess dissolved by hot water separating in crystals as the solution cools. When the crystallization is slowly conducted, the crystals are regular octohedrons, but in the alum of commerce they are more or less connected together and irregular in form. These crystals contain nearly half their weight of water, and, when heated, the alum first dissolves in this water, which, if the heat is continued, boils away, leaving a dry mass—the burnt alum of the druggist.

The taste of alum is astringent, but somewhat sweetish; when swallowed, it has an astringent action; and, although of value as a medicine, is unwholesome when not required.

Uses.—In the arts alum is a substance of great value. It is much employed in converting skins into leather (see *Leather*); it is also used in paper making; in the manufacture of some kinds of candles, to harden and whiten the tallow; in dyeing and calico printing it is absolutely indispensable; and it is employed by paper hangers in making paste, &c.

Alum is employed by bakers in the manufacture of wheaten bread, rendering it whiter in color, and causing the loaves to separate more readily. Its chief use, however, arises from the fact that it enables inferior flour, which has been damaged by being harvested in wet weather, and would otherwise yield a clammy bread, to be made into a light, spongy loaf. Such bread is, however, very indigestible, and produces dyspepsia.

Linen and other cloth, steeped in a solution of alum and then dried, cannot be set on fire; hence it is sometimes used for making curtains and other fabrics incombustible.

LESSON LXXII.

EMERY.

Occurrence.—Emery is found in shapeless granular masses, at the base of mountains, in several of the islands of the Grecian Archipelago. The chief supply is obtained from the island of Naxos, at Cape Emeri, whence its name. A considerable quantity, however, is procured from the neighborhood of Smyrna, the East Indies, and in some mines in Saxony. In Jersey and in England small quantities of it are occasionally found.

Properties.—Emery is a grayish black, or brown, opaque mineral, with a glistening lustre and an uneven fracture. Its specific gravity is about 4,000, and it is distinguished by its extreme hardness, inferior only to that of the diamond.

Preparation.—In order to prepare emery for use, it is first crushed under heavy iron stampers, then ground in steel mills, and mixed with water; the coarser particles having been allowed to subside, the water is poured off with the finer portions; these after a time sink, and are collected for use. Sometimes the emery is burnt or calcined for the purpose of enabling it to be reduced to powder with less labor.

Uses.—The use of emery depends upon its extreme hardness, which enables it, when in a state of fine powder, to be used by lapidaries for grinding and polishing precious stones; by cutlers, in finishing steel instruments; by opticians, for polishing glasses, &c. Sprinkled over paper or stout calico which has been previously covered with a layer of glue, it forms emery paper or cloth; this is much employed in cleaning iron instruments and articles of domestic use.

LESSON LXXIII.

ROTTEN STONE AND TRIPOLI.

Occurrence and Properties.—Rotten stone and tripoli are two minerals resembling each other, in having their particles in a state of very fine division. Rotten stone, which is found in considerable quantity in Carmarthenshire and Breconshire, South Wales, and at Ashford, in Derbyshire, England, is friable. It is found mixed with pieces of black marble, and it has recently been ascertained that an acid existing in the soil, decomposes the marble, thus producing rotten stone. Tripoli is so called from its being first found in that country. The small particles of both are very hard; and when the minerals are reduced to powder they are extensively employed in polishing metal articles.

Rotten stone is not found except in England. The amount obtained yearly barely equals 400 tons; and the annual value is stated at about 750*l.*

Tripoli is remarkable as consisting almost entirely of the shelly coverings of small animalcules, their length not exceeding 1-3500th of an inch.

LESSON LXXIV.

PUMICE STONE.

Occurrence and Properties.—Pumice is a stone of volcanic origin, which is found in large quantities at Campo Bianco, about thirty miles from the port of Lipari; it is also abundant in the island of Vulcano. Pumice is a porous stone, sufficiently light to float upon water. It is formed of silky fibres, which are interlaced in all directions. In color it is usually gray or white. To the touch it is harsh, and, although brittle, is sufficiently hard to scratch glass and steel.

Uses.—The use of pumice in the arts is entirely as a polishing material; it is employed in smoothing wood, glass, slate, stones, marble, &c.; by painters it is much used for rubbing down the roughness on old work previous to new painting. It is also employed in smoothing leather, vellum, and skins, during their manufacture; and in some countries it is regularly used for smoothing the skin of the hands, and rubbing corns on the feet. In the East, the domes of temples have been built with it in consequence of its great lightness.

LESSON LXXV.

SLATE.

Slate is a mineral substance; it is never found crystallized, but generally of a foliated structure; it is either of a gray, blueish, or blackish color, often streaked by a different tint from that of the ground; it is opaque, dull, compact, and brittle. It consists chiefly of alumine, with a small quantity of silex. It is dug out of quarries; when first taken from them, it is comparatively soft, but becomes hard by exposure to the air. It is used for writing upon, for whetstones, and for roofing houses. In order to ascertain its fitness for the latter purpose, it is weighed as soon as it is excavated, and is then put into water for some days; if after being well dried it is found to have increased in weight, it is laid aside as unsuitable for the purpose, the trial having proved that it was porous, and consequently absorbent. Such slate would not only allow water to pass through it, and so destroy the woodwork of buildings, but it would also be liable to be covered with lichens and moss, in consequence of the moisture which it retains. If its quality is ascertained to be good, it is split into thin plates for roofing. The tiles are fastened to the rafters by pegs driven through holes, which have been previously made in them; the edge of one is laid over the other, in the same manner as the scales of fishes. Slate which is dark-colored, compact, and solid, is the best adapted for writing upon. In order to prepare the slate for this purpose, it is rendered smooth with an iron instrument, and it is then ground with sandstone, and slightly polished. That which is softer and more friable, is used for pencils.

The principal slate quarries in the United States are in Vermont, New York, Pennsylvania, and Maryland. Quarries of great extent are also worked in various parts of the British Isles.

The school slates, when split out from the blocks, are taken to the factory, where a man provided with patterns of the six sizes usually made, marks out upon each sheet such slates as it will make to the best advantage. Another workman then cuts them out with a circular saw, made of soft steel, and they are dressed, smoothed, and polished by a third. Before machinery was applied to these operations they were shaved out like shingles. The smoothing is finished by rubbing the slate with a rag filled with its own dust. The slate is now washed and is ready for the frame. Slates are either quarried by blasting, or, where practicable, by splitting them off with large wedges.

SILICIOUS MINERALS.

LESSON LXXVI.

SAND AND SANDSTONE.

Occurrence.—Sand is a substance abundantly distributed, forming in many places the bottom and shores of the ocean, and not unfrequently the beds of rivers; on the surface of the earth it often forms tracts of vast extent, which are usually termed deserts, such as those of Arabia and Africa.

Sand is also found in beds, or layers, alternating with other substances. When at the surface of the ground, sand forms that kind of country found in some parts of Europe, termed heath, which is distinguished by its sterile character and the nature of the plants (chiefly heath, furze, and ferns,) growing on it. When the grains of sand are cemented together into a firm mass, they form the valuable stone called sandstone, many kinds of which are found in this country, where they are extensively used for building. From the hardness of the grains of sand, they are also valuable as grind stones, mill stones, scythe stones, and from their porosity they are frequently employed in the manufacture of filters.

The variety known as Potsdam sandstone can be quarried in slabs of any required size, and is much used for paving.

Properties.—Sand consists of silica, in small rough grains of various sizes. When pure, it is white or colorless, but it is usually tinted by the admixture of other materials. It is perfectly insoluble in water, and infusible in fire.

Uses.—Sand is a substance of great value. It is found in all fertile soils, rendering them sufficiently porous to allow water to percolate and the air to gain access to the roots of the growing plants, and it is frequently added with great advantage to heavy, clay soils. Pure sand, as before mentioned, is unfitted to the growth of plants.

In artificial processes sand is used extensively; the whiter kinds are employed in glass making, the coarser in making mortar and bricks. From its infusible nature, and the property that some kinds possess of forming a mass when firmly pressed together, it is used for making the moulds into which melted metals are poured in the process of casting; and its hard, gritty nature renders it useful in cleaning and scouring coarse metal and other articles.

LESSON LXXVII.

GLASS.

Materials.—The substances which form the basis of glass are sand, and one or other of the alkalies, potash, or soda. The purest variety of sand is obtained from Lanesborough, Mass. Other qualities are procured from various parts of the country. It is essential that the sand be perfectly free from colored impurities, otherwise the glass receives a tinge. Red lead and litharge are employed in certain kinds of glass, as they are found to render it more readily fusible and tenacious when melted. They have, however, the disadvantage of rendering it softer, and, therefore, more liable to be scratched. In addition to these substances, small portions of manganese, arsenic, borax, and other minerals, are occasionally employed to produce more ready fusion and to remove color, and, in almost all cases, a considerable amount of broken glass, or *cullet*, as it is termed, is added. In the coarser kinds lime is also used in place of a dearer alkali.

The localities of the glass manufacture are determined by the nearness to coal fields, and by the ease of obtaining the materials required; for these reasons, it is frequently

established in seaports. Newcastle, Bristol, and Glasgow, with Birmingham, are the chief towns in which it is carried on in England.

It is also manufactured in different sections of our own country, particularly in South Boston, East Cambridge, and Sandwich, Mass.; Brooklyn, N. Y., where flint glass is manufactured. The most important manufactories of window glass are located in the southern part of New Jersey, about Pittsburg, Penn., and the river towns below and in central New York. The only manufactory devoted exclusively to plate glass, is at Lenox, Berkshire Co., Mass. Our best plate glass is imported from England and France.

Preparation.—The materials, having been mixed in the requisite proportions, are made to unite together by exposure to a moderate heat, which is increased until they melt into a pasty mass, termed *frit.* The ingredients of flint glass, however, which are of the purest kind, do not always require to be *fritted.* The materials are melted together in large crucibles, or pots, as they are usually termed. These are made of the most infusible materials, and each pot is capable of holding about fourteen hundred-weight of glass. These are built into a dome-shaped furnace, with openings in the sides, corresponding to the situation of each pot. In about forty-eight hours after having been placed in the furnace, the glass is in a state of the most perfect fusion, and is ready to be worked into any desired form.

Manufacture.—As the mode of manufacture varies with the kind of glass, and the purposes for which it is designed, it will be described under the heads of flint, crown, and plate glass.

Flint glass is formed of sand, potash, or pearlash, and litharge, or red lead, and is manufactured into the immense variety of articles required for domestic use, by the aid of a hollow tube and a few very simple tools. The ease with which it is worked arises from its possessing an extraordinary combination of properties, being excessively ductile and tenacious, and of so soft a consistency that it may be bent, blown, pressed, or extended, and, in short, made to assume any form which the will of the workman dictates. The tube is dipped into the melted glass, and care is taken that the quantity collected on the end of it, is sufficient for the desired article. The mouth of the workman is then applied to the other end of the tube, and the glass is blown into a hollow form, being either placed in a mould, or rolled, pressed, cut, twisted, &c., so as to assume the form required. No substance possesses in so remarkable a degree the plastic property. After the articles are formed, they are placed in the annealing oven, at a great heat, which is gradually diminished, by which means they lose that liability to crack in sudden changes of temperature which they would possess if cooled suddenly.

Crown glass, which is ordinarily used for windows, is harder than flint glass. No preparations of lead are used in its manufacture; it therefore requires a higher temperature for fusion. The materials are sand and soda, or soda ash, with small quantities of borax, arsenic, and manganese; these are *fritted* for about four hours. On melting the fritted materials, a quantity of saline matter rises to

the top, which is skimmed off, and a considerable amount of broken glass, or *cullet*, as it is termed, is added, and in about forty hours the glass is ready for working. The workman takes about ten or eleven pounds on the end of an iron tube, blows it into a large, hollow, pear-shaped form; then, by pressure against a plane surface, flattens the part opposite the tube; an iron rod, called a punt, is then dipped in the melted glass of the furnace, and attached to the centre of the flattened part, and the iron tube is removed by wetting the glass around it; the soft yielding glass is now carried by the punt and exposed to the heat of a furnace, the workman twirling it round with gradually increasing rapidity, which causes the hole left by the removal of the tube to enlarge in size, and at length the whole flattens out into a plane surface of four or five feet in diameter, of uniform thickness, except where the iron rod is attached in the centre; a lump is there formed called the *bull's eye;* the glass is then annealed, and each disc divided into two parts for the convenience of carriage.

The dark green glass used for wine bottles is made without lead, and of the coarsest materials; common river sand and soap-boilers' waste, consisting of lime and a small proportion of alkali, being usually employed.

Plate glass is a very pure glass, capable of flowing freely when melted, without streaks or air bubbles. The materials forming it are the whitest sand, soda, small portions of lime and the minerals manganese and cobalt, together with broken plate glass, the waste of previous operations. The glass, when perfectly fused, is poured upon an iron table of the size required, and the thickness is regulated by the height to which the sides of the table are raised. Immediately after it is poured out, the melted glass is flattened by having a metal roller passed over the upper surface; it is then annealed for several days; after this it is ground perfectly smooth by rubbing two plates together with finely powdered flint and water between them; each plate is again ground with emery powder, and finally polished by a polishing powder, applied with a woollen rubber.

The process of the manufacture of glass beads is interesting from its great simplicity. Tubes of glass of the required color are made by blowing cylinders, which are drawn out while still plastic to the required length. These tubes are cut up into very short pieces on the upright edge of a fixed chisel. They are then stirred over a furnace in a mixture of fine sand and wood ashes, heated to such a degree that the fragments of glass are softened, and lose their angular and sharp-edged form.

Colored glasses are produced by the addition of small quantities of various mineral ingredients to the melted mass. A small quantity of soot gives a yellow color; preparations of copper a red tint; blue is produced by cobalt; manganese gives an amethyst; green is produced by iron, as in the common bottle glass; tin produces an opaque white, and gold an exquisitely beautiful ruby tint.

Properties.—The peculiar properties of glass in a melted state have been already alluded to. When solid, it is strikingly distinguished by its beautiful transparency, hardness, and freedom from porosity; its lustre, which is so

characteristic that it is termed vitreous; its being insoluble and incorrodible by all substances in ordinary use, even the strongest acids; it is brittle when in thick masses, but when in very thin threads it possesses an extraordinary degree of elasticity, which, unlike that of any other substance, does not seem impaired by repeated bending.

Uses.—The uses of glass in domestic economy are well known. Its employment for making vessels to hold liquids depends greatly on its transparency and polish, the former allowing the contents to be seen, and the latter enabling it to be readily cleaned after use. Its employment as a material for glazing windows depends on its transparency and insolubility, which enable it to admit the light and warmth of the sun, while it excludes the wind and rain.

Glass is frequently ground upon revolving wheels of sandstone, or polishing slate, into small circular pieces, with one or both sides concave or convex; in these forms it alters the direction of the rays of light which pass through it, either bringing them to one point or focus, or dispersing them. These glasses are termed lenses, and are employed in making optical instruments—as microscopes, telescopes, &c., and also for spectacles.

It is our familiarity with glass that alone renders us usually so insensible to the great value and exceeding beauty of this extraordinary substance.

LESSON LXXVIII.

MICA.

Occurrence and Properties.—Mica is a mineral that possesses the property of being readily split into exceedingly thin layers, which are transparent, possess a pearly metallic lustre, and are flexible and elastic. The glistening appearance of granite, and some other minerals, is due to the presence of small scales of this substance.

It occurs in large masses in many parts of the world, especially in Siberia, Sweden, and Norway. It is also found in New Hampshire, and some of the other States, and Canada, in sufficient quantities to be quarried for economical purposes.

Uses.—The transparency and flexibility of this substance have led to its employment as a substitute for glass, particularly under circumstances where it is exposed to violence; hence it has been used in Russia for vessels of war, in which glass windows were apt to be broken by the concussion caused by firing the guns. As it is not altered by exposure to a very high temperature, it is not unfrequently used to form transparent doors to stoves and lanterns, and it is now largely employed to form covers over gaslights, to protect the flame from draughts of air, as well as to prevent the smoke rising to and soiling the ceiling.

LESSON LXXIX.

GRANITE.

Granite is a compound rock, formed by an aggregation of grains of quartz, felspar, and mica. The proportions in which these component parts occur vary much; but felspar is the predominating, and mica the least considerable, of these ingredients. The grains are also of different magnitudes; when they are large, the granite is of a very coarse texture; but sometimes they are so small, as almost to give the appearance of a uniform mass. These circumstances occasion a great variety in the character of granite. When hornblend occurs in the place of mica, the rock is called syenite, from Syene, in Upper Egypt, where it was first known and quarried. Some felspar is liable to decomposition, and when this is the prevailing substance in the rocks, they yield to the effects of the weather, and become more or less of a rounded form; but when the granite is hard and close-grained, which is more usually the case, they rise in bold prominent peaks, giving grandeur and boldness to the scenery. Granite is found in most countries where there are mountains of any considerable elevation. It forms the flanks of a considerable portion of the Andes, and it may be traced along the eastern spurs of the Appalachian range through the Southern States. It is finely developed through South Carolina and Georgia. The Stone mountain of the latter State is a naked mass of granite, rising four or five hundred feet above the surrounding country, and is so steep that it can be ascended only at one point. All New England abounds in granite, but the most famous quarries are along the coast of Maine, and at Quincy, Mass.; from the latter place it is exported for building purposes to the principal cities on the Atlantic coast, the Gulf of Mexico, and in the West Indies.

Granite is valuable on account of its great hardness and durability; it is used for building, paving, submarine works, mill stones, troughs, and steps.

INFLAMMABLE MINERALS.

LESSON LXXX.

SULPHUR.

Occurrence.—Sulphur occurs native in the neighborhood of all active volcanoes, from which it is discharged in vapor, and condenses in considerable quantities in the gravel and ashes of the interior of the craters. At Pouzzales, near Naples, the mixture of sulphur and gravel is dug up and distilled to extract the sulphur. The gravel is then returned to its original place, and in the course of years becomes so far charged with sulphur as to serve the same purpose again. It is also found more abundantly in beds, as in Sicily, from whence almost all the native sulphur of commerce is obtained.

Sulphur, when combined with metals, forms minerals, which are termed sulphurets; these occur in most parts of the world; some of them—as the sulphurets of lead,

copper, and zinc—are valuable ores, the sulphur itself being burnt away and lost during the preparation of the metals. One sulphuret—that of iron—also termed iron pyrites, is useless as an iron ore, but of great value as a source of sulphur, containing rather more than half its weight.

When this sulphuret is heated in the open air, the sulphur burns away with a blue flame; but if it is heated in close vessels, half the sulphur it contains is driven off in vapor. This is collected in a solid or liquid state in a cold part of the apparatus; the residue of the mineral is converted, by mere exposure to the air, into green vitriol, a preparation of iron largely used in dyeing black and in making ink.

The usual form in which sulphur is prepared is in cylindrical sticks, known as roll sulphur, or roll brimstone. These are formed by casting it in hollow wooden moulds, so made as to divide into two parts longitudinally.

Properties.—Sulphur is a mineral of a bright yellow color, nearly twice as heavy as water, in which it is quite insoluble; tasteless, and without smell when cold, but odorous when rubbed or warmed: it is brittle, and a very bad conductor of heat, so that, if a roll is grasped in the warm hand, the outer part only becomes heated, and, increasing in size, is forced away from the inner portion, and the mass breaks.

Heated to a degree somewhat above that of boiling water (232 degrees Fahrenheitt) sulphur melts, forming an orange-colored limpid fluid; if the heat is increased, its color becomes a deep red, and it thickens to such an extent that the vessel may be quickly inverted without its being spilled; if in this state it is poured into water, it forms an elastic soft solid, which, after a time, becomes brittle. Heated to a still higher degree, it becomes somewhat more fluid; and if in a close vessel, it boils away in vapor, which, by a greater or less degree of cold, may be condensed into a solid or liquid state. Heated in the air, it takes fire, burning with a blue flame, and producing a very irritating, poisonous gas or vapor. Sulphur has a great disposition to unite with metals; this may be shown by carrying a piece in the pocket with silver coins, when the formation of a black sulphuret of silver rapidly takes place. The same result occurs if an egg is eaten with a silver spoon, as sulphur is contained in the yolk.

Uses.—The uses of sulphur in the arts are of the highest importance. The manufacture of soda from salt, dyeing and bleaching, the making of leather, gunpowder, and congreve matches, are but a few of those manufactures which mainly depend on sulphur, or its compounds, for existence.

The ready inflammability of sulphur leads to its use in the making of lucifer matches, which are first dipped in melted sulphur before the compound of phosphorus is added, as the latter, from its rapid burning, would be unable to set fire to the match if unassisted by the brimstone. The same property leads to its employment in gunpowder, to which it imparts the power of igniting with the slightest spark. The poisonous fumes which arise from its burning are largely employed in bleaching silk in the raw state, isinglass, walnuts, straw plait, and bonnets; it is also occasionally used in destroying rats and vermin when they have accumulated in ships and other close places.

Its fusibility leads to its employment in taking casts from medals, coins, and similar objects, for which purpose it is used in its most liquid state.

Flowers of sulphur, which are formed when the vapors arising during its distillation are allowed to condense in a solid form, are much used as a domestic medicine, and enter also into the preparation of vermilion and other chemical substances.

Oil of vitriol, or sulphuric acid, an exceedingly corrosive, poisonous liquid, is made by burning sulphur in furnaces constructed for the purpose, the combustion being assisted by the presence of other substances. Some idea of the use of this acid in the arts and manufactures may be gained from the fact that 300,000 tons are annually made in England, the value, at the lowest computation, amounting to several hundred thousand pounds.

It is the most extensively used in the arts of all the acids, and is an important branch of manufacture in chemical works in Philadelphia, Newark, N. J., Roxbury, Mass., and other parts of the country.

LESSON LXXXI.

PLUMBAGO.

Occurrence and Properties.—Plumbago, which is also termed graphite, and black lead, occurs in many parts of the world; large quantities are found in Ceylon, the East Indies, and several localities in the United States; particularly at Sturbridge, Mass., Brandon, Vt., Fishkill, and Ticonderoga, N. Y. In England the most celebrated mine was at Borrowdale, in Cumberland, as much as 100,000*l.* having been realized from it in a year; but the mine is now closed. Plumbago is of a dark leaden color, having a dull metallic appearance. To the touch it is very smooth; and when placed between rubbing surfaces, enables them to glide easily over one another. It adheres to substances on which it is rubbed, staining them of a dark color, and imparting its own peculiar appearance. It is perfectly insoluble in water, and is quite infusible in the fire; but heated strongly, and exposed to a current of air, it slowly consumes.

Uses.—The purer varieties of plumbago are entirely used in the manufacture of black lead pencils, being cut up by fine saws into thin slips, which are glued into grooves cut in cedar wood. A method has also been devised of purifying the more gritty varieties, and condensing the powder into blocks, from which slices are cut that are as good as the best original specimens. The leads for pencils intended for the finest work, before being placed in the wood, are heated, and then immersed in hot wax or suet. From the dearness of the finest plumbago, compositions of clay, with black lead and other substances, are substituted in the cheaper pencils.

The harder pencils have only half as much graphite powder as clay; softer ones have equal parts of each. The hardest pencils, however, are made of an alloy of metallic lead, antimony, and mercury. Common pencils are made of graphite powder, mixed with melted sulphur, and run into moulds. Gum arabic and resin are sometimes used as ingredients.

A large quantity of black lead is employed in polishing cast iron work, particularly stoves and ranges, giving to them a uniform color, and concealing any rust they may have on the surface.

Finely powdered, it is frequently used instead of grease to prevent the friction between rubbing surfaces; hence it is not unfrequently applied to wooden screws, &c., &c. It is also a valuable material for crucibles and portable furnaces. It is sometimes adulterated with lampblack.

LESSON LXXXII.

COAL.

Coal is of two kinds, anthracite and bituminous; the former being the most condensed and the richest in carbon. Coal may be considered as a mineral, both from its subterraneous situation and the qualities which it possesses; many circumstances, however, justify the now prevalent opinion that it is of vegetable origin: the following are, perhaps, the most convincing. Carbon, which is the chief constituent of all vegetable matter, particularly wood, composes three-fourths of this substance. Coal is also found in the various stages of mineralization. Sometimes it possesses a completely fibrous texture and ligneous appearance, even the knots of wood being discernible, while the same bed produces specimens of perfect mineral coal. Some remarkable instances of this have been found in the coal mines of Pennsylvania; the roots of trees were imbedded in fire clay, and forming the substance of them (which generally underlies the coal measures), while the trunks passed into the anthracite beds, and almost imperceptibly from these into the bituminous coal. In some instances the bark only was converted into coal, while the woody texture of the interior was still plainly to be seen. In Ireland a standing forest has been discovered at the depth of one hundred feet below the soil. To this we may add the inflammability of this substance; the numerous vegetable remains and impressions that accompany it; and that it has never been discovered above the line to which vegetation reaches. These vegetable remains generally belong to extinct species, and differ so much from any living species that they cannot always be referred even to the class to which they belong.

Coal is of a black color, bright, and frequently irridescent; the structure is slaty; it occurs always amorphous; it is very combustible, a quality which few minerals possess. The places from whence it is taken are called *coal mines;* they abound in different portions of the world; especially in the United States, England, and Belgium, and have contributed much to the wealth of these countries. Both the persons employed in the mines, and the vessels which transport the coals, are called *colliers;* the place where the trade is carried on, a *colliery.* The access to coal mines is generally through a narrow, perpendicular tunnel called a *shaft*, up which the workmen and coals are drawn by machinery. The mines at Whitehaven, England, are some of the most extraordinary in the world. The principal entrance is by an opening at the bottom of a hill, through a long sloping passage which is hewn in the rock, and leads to the lowest vein or bed of coal; the descent is chiefly through spacious galleries intersecting each other, formed by the excavation of the coal, large pillars of which are left to support the ponderous roof. These mines are very deep, and are extended under the bed of the sea, even to where the depth of the water is sufficiently great to admit ships of burden. In these mines there are three strata of coal, which lie considerably apart from one another, and are made to communicate by pits. Miners are frequently impeded in their progress by veins of hard rock called *dykes*, and the coal is seldom found in a direct line on the other side of them; to ascertain its precise situation is often a work of considerable labor and expense. Coal is generally situated at the foot of mountains, and in hollows, which vary much in extent; it rarely lies much above the level of the sea.

Several dangers attend the labor of miners; the greatest is that arising from *fire damp*, which is occasioned by the hydrogen gas or inflammable air produced in the mine, and which, when mixed with atmospheric air, explodes with great violence if brought into contact with any lighted substance. To avoid this danger, safety lamps are used, which were invented by Sir Humphrey Davy. They are of a very simple construction, consisting of wire gauze so closely interwoven, that gas of sufficient quantity to cause ignition cannot enter them. Another danger arises from the formation of carbonic acid gas, or fixed air, which, being heavier than the common air, occupies the lower part of the mines, and occasions death by suffocation.

Coal is used to raise the temperature of rooms; to cook food; to supply the fuel for railway locomotives, ocean steamers, manufactories (particularly where steam is required), and in the working of metals. Bituminous coal furnishes us with the gas so much used, which is the substance called hydrogen, and exists in coal in union with carbon; it is easily driven away or volatilized by heating the coal in a close place, and when caught and preserved, it forms the gas now used to light our streets and buildings; when this has been extracted from the coal, the residue is called *coke*, which is employed where intense heat is requisite.

Coal tar is also produced in the evolution of gas, and was for a long time considered useless. It is now used to protect iron work exposed to the weather, and by distillation it yields paraffine, which is made into candles, and also the coal oil which we use in lamps.

SALINE MINERALS.

LESSON LXXXIII.

SALT.

Salt is a mineral substance, beautifully white, sparkling, and crystalline; it is soluble, fusible, granulous, and of a peculiar flavor called *saline*. It is a most beneficent provision of nature that salt—the only mineral substance required as an article of food by man and the higher orders of the animal kingdom—is almost everywhere accessible. There are several varieties of this useful mineral, which

are distinguished by the different situations in which they are found. The principal are *sea salt*, called also *bay salt*, which is produced from the ocean; the best comes from Portugal; salt drawn from brine springs; and *rock salt*, which is dug out of the earth. Amongst the most extensive salt mines hitherto discovered are those at Wieliczka, a picturesque little town situated on the sides of a gentle valley, about eight miles from Cracow, formerly the chief city of Poland. The traveller who visits these subterraneous deposits of salt, being furnished with a guide and two lamp bearers, is let down a shaft of about 150 feet by a rope. At the depth of 90 feet he arrives at the rock of pure salt, which is of a dingy soot color, here and there glistening by the light of the lamps. The swing is now abandoned, and the ear is assailed by the busy sound of spades, mattocks, and wheelbarrows, in every direction. This is the *first floor* of a large cavern, containing in different parts a stable for twenty horses, quantities of salt, some in bare masses, some in casks ready to be hoisted to the surface, stores of implements for the miners, &c. This excavation is about 100 feet long and 80 broad (besides the stable), and about 20 feet high. From hence a long gallery, 12 feet high by 8 broad, leads toward the interior of the mine, where lateral avenues branch off in various directions, each named after some Austrian prince or princess, and resembling more in appearance the avenues of a subterraneous palace than the passages of a mine. A flight of steps conducts down another hundred feet to the *second floor;* in this descent the bed of salt is interrupted by a narrow stratum of pure clay; sometimes by a mixture of salt and the same earth; these strata are, in places, very curiously curved, as though a rolling wave had been arrested in its course, and preserved in its original form. The miners are here found at work, some hewing pillars of salt from the rock, some cutting them into masses for home consumption, and some stowing the masses in barrels for exportation. The cavern on this floor is rather smaller than the first; it consists of one spacious hall, and has no pillar to support the roof.

Proceeding on his subterranean journey, the traveller arrives at a wooden platform, from whence he looks down upon an abyss, which the simple lights of the conductors fail to illuminate, though the spars of the mineral reflecting the rays of light produce a novel and beautiful effect. When princes or other great personages visit the mines, a chandelier of crystal salt, hanging in the centre, is furnished with 150 lights, which display a stupendous cavern, having the appearance of a castle in ruins; at the bottom are some rows of seats, rising like the benches of a theatre; opposite to these is an orchestra: here, on such occasions, a small band plays a few airs of slow and simple music, which has a most singular effect, and harmonizes well with the surrounding scene. Long galleries and flights of steps, all spacious enough to allow free course to the fresh air, lead deeper and deeper in the saline rock; the scene now and then is varied by a cavern full of workmen, and some along the galleries, wheeling their little carts full of salt, each with its lamp in front. On the *fourth floor* there is a little subterraneous lake, about 80 feet long and 40 broad, over which illustrious personages are ferried on rafts of

fir logs, lighted by numerous flambeaux. Here terminates the bed of *green salt*, the most common sort, and easiest to be cut. The next to it is called *spica salt*, which is harder and more close grained, and next succeeds a white and finer-grained variety. This part of the mine is 700 feet below the surface of the earth; 300 feet beneath this lies the finest crystal salt, which is reached by long flights of steps and inclined planes. The cavern in which it is found is sufficiently spacious for a regiment of soldiers to perform their manœuvres in it. This is the deepest part of the mine: the air is quite pure, rather cooler than that of the open day, but much warmer than it is about halfway down. The return is through a different series of corridors and caverns. On the third floor is a simple tomb of salt, with the name of the late Emperor of Austria inscribed with letters of wood neatly gilt. On the second floor is a large saloon with all the implements of mining, and the mode of letting them down with men and horses exhibited in transparency. On the first is a chapel presenting an altar, statue of the Virgin, crucifix, and figures of Casimir I and his wife, all cut out of the solid salt; before the chapel is a small pulpit in the Gothic style. To visit the whole of this extraordinary and extensive mine, with all its galleries and caverns, no less a distance than 300 miles must be traversed.

The salt used in the United States is chiefly obtained from salt brine springs. The principal springs are at Syracuse, N. Y., in Western Virginia, and Pennsylvania, in Michigan, and the States bordering on the Ohio river. The most productive springs are about Onondaga Lake, at Syracuse. To obtain this, wells are bored or sunk in the low lands about the lake, to various depths, from 200 to 300 feet, and from these salt water is pumped up into reservoirs, from which the evaporating works are supplied. It is allowed to remain in these reservoirs until some of its impurities, particularly the oxide of iron, are deposited. To hasten this they put in a little alum, or clay, or heat the brine. About one eighth of the whole salt product is separated by solar evaporation, and seven eighths by boiling. The great reservoirs for the former process cover an area of 700 acres. They are divided into tanks of about 16 by 18 feet each, and 6 inches deep. These are provided with covers, or movable sheds, which are removed in pleasant weather. About fifty bushels of coarse salt, such as is used for packing and curing provisions, may be made annually in one of these tanks. Seventy pounds is called a bushel of solar salt. Of the boiled salt, fifty-six pounds or five of these bushels make a barrel.

The boiling is conducted in large iron kettles, containing about one hundred gallons, and set in "blocks" of brickwork, close together, either in a single line, or in two parallel rows, the whole length of the block. A double block may contain eighty kettles, and may make from 20,000 to 25,000 bushels a year. To make forty-five bushels of salt requires a cord of hard wood or a ton of coal. There are here 312 blocks, containing 16,434 kettles, and capable of making 12,480,000 bushels of salt yearly. Just before the salt begins to crystallize, the sulphate of lime separates, and is caught in a pan at the bottom of the kettle. It is further purified and made perfectly white, when it is scooped into a basket, drained back into the kettle, and put into bins, where it is allowed to drain for two weeks. It is then barrelled for sale. The cost of manufacture is about one dollar per barrel.

The conservative properties of salt render it invaluable for household purposes, and for preserving meat during voyages; and its stimulating properties give a relish to food and help digestion. When fused, it is used in glazing pottery; it improves the whiteness and clearness of glass, and gives hardness to soap; it is used by the dyer in fixing colors; also, sometimes as a manure.

It was employed in all the Jewish ceremonies, being emblematical of purity and incorruptibility. Our blessed Lord calls his disciples the salt of the earth; thereby signifying to them that having, by divine grace, their own hearts purified, they are to exercise by precept and example a purifying influence on the hearts of others.

LESSON LXXXIV.

SODA.

Manufacture.—Until within the last few years, soda was obtained from a substance termed kelp, formed of the ashes of burned seaweeds. In Scotland alone, twenty-five thousand tons of kelp were annually produced. At the present time soda is prepared by fusing the native peroxide of tin with caustic soda in an iron crucible.

Properties.—Soda, in its ordinary state, is in the form of large crystals, more or less perfect. These are transparent and colorless, containing more than half their weight of water. Exposed to a dry air, the water flies off, leaving the soda as an opaque, white powder. If the crystals are heated, the soda dissolves in the water they contain, and the whole becomes liquid; on increasing the heat, the water evaporates, and at last the dry soda remains only as a white powder, without any trace of a crystalline form.

Soda is very soluble in water, its taste is alkaline and unpleasant. It has considerable cleansing properties, as it renders grease and dirt soluble in hot water, and so enables them to be removed by washing. This power may be much increased by adding quicklime to soda, when the latter is rendered caustic. This mixture has been sometimes employed for washing clothes, but it is far too corrosive to be used with safety, destroying the texture of the linen, &c.

Uses.—The employment of soda in domestic economy depends on its cleansing properties. It is used to assist the action of soap in washing clothes, paint, wood, &c. In the chemical arts, such as making glass, soap, &c., it is of the very highest importance; it also forms, in combination with other substances, many valuable medicines.

MANUFACTURED ARTICLES.

LESSON LXXXV.

PORCELAIN.

Clay and flint are the chief ingredients of porcelain. The first gives the plasticity and tenacity requisite for the moulding it into a shape; the latter renders it hard, and allows of a slight degree of vitrification. The following is the usual process carried on in the English manufactories of china. Flints are first calcined, then mixed in certain proportions with Cornish granite,* and ground to a very fine powder; water is poured upon this mixture, and it is twice strained through silken sieves. It is then boiled till it is of the consistency of cream, and the watery particles being evaporated, it becomes a tough paste. A portion of this substance is then placed upon a turning wheel, and moulded by the hand with a precision and rapidity which practice only can give. Vessels of a circular shape are formed in this manner, as bowls, plates, cups, and saucers; utensils of other forms are made in moulds of gypsum, the pores of which absorbing the moisture of the clay, the vessels are contracted in size, and in consequence may be easily loosened from the mould. Each vessel thus formed is placed in a separate clay case. The furnace is filled with these, and then bricked closely up, and they are subjected to a red heat for sixty hours. The temperature

* It is to the large proportion of felspar in a state of decomposition that Cornish granite owes the preference which is given to it.

is then gradually lowered, and the porcelain is withdrawn; in this state it is called *biscuit*, and is white, dull, and porous. This process greatly diminishes the size of the vessels; and it fits them to receive the blue color, called cobalt,* which has the appearance of a dirty gray till glazed. The *glazing* consists of lead and glass, ground to an impalpable powder, mixed in water with some other ingredients, which are kept secret. The biscuit is merely dipped into the glazing, and is then baked again for forty hours. It is now ready to receive other colors, and the gilding which the pattern may require. It is baked a third time for ten hours or more. Lastly, the gilding is burnished with bloodstone or agate, and the china is ready for the *wareroom*. The colors are changed by baking, appearing very different when first laid on than when they have been subjected to heat. Comparatively little of this ware is manufactured in the United States.

LESSON LXXXVI.

NEEDLES.

Manufacture.—The material from which needles are made is soft steel wire of the requisite degree of fineness. This is obtained by the manufacturer in large coils, each containing sufficient wire to form several thousand needles. These coils are first cut up into pieces of the length required to make two needles, usually about three inches, large shears being used capable of cutting a coil of one hundred wires.

* Cobalt is an oxide of the metal of that name.

Five or six thousand of these lengths are made into a bundle, kept together by a ring of steel at each end; they are then heated to redness in a furnace, and afterward laid upon a flat iron plate, and rubbed backward and forward with a steel bar, until each wire is perfectly straight.

The next stage is to grind a point at each end of the wire. This is done by the aid of a grindstone about eighteen inches in diameter and four inches thick; they are made to revolve so rapidly that they are liable to fly into pieces, and are therefore partially enclosed in iron plates to avoid injury to the grinder, should such an accident occur. The grinder takes from fifty to sixty wires between the thumb and forefinger of his right hand; and as he presses them against the stone, he causes all the wires to roll round, and thus each is ground to a point. So expert do the grinders become by practice, that they point a handful of these wires, usually about sixty, in half a minute, or about seven thousand in an hour. During the grinding every wire gives out a stream of sparks, and these together form a bright glare of light.

Pointing these wires is the most unhealthy part of the manufacture; the fine dust is carried into the lungs of the workmen, and destroys them in a few years, very few living beyond the age of forty.

Wet grindstones cannot be used, as the points of the needles would be rapidly rusted.

The wires thus pointed at each end are stamped by a heavy hammer, raised by a lever moved by the workman's foot. The under surface of this hammer is so formed, that when it falls on the wire midway between the two ends, it stamps on one side the gutters or grooves in which the eye is afterward made; and the anvil on which the wire rests when the hammer strikes it forms the two grooves on the opposite side. This stamping also makes a slight depression or pit on each side at the spot intended for the eye.

The wires are then passed to a boy, who takes a number of them in his left hand, while with his right he works a press moving two hard steel points or piercers. These come down upon the wire as it is placed beneath them, and pierce the eyes for the two needles. Each wire now resembles two rough, unpolished needles, united together by their heads; and as it would require much trouble to divide them separately into two needles, a number are threaded upon two very thin wires, and are separated by filing and bending.

Any needles which may have been bent in the several processes are straightened by rolling under a steel bar, and are hardened by heating in a furnace and suddenly cooled in cold water or oil. After hardening they are tempered by being slightly heated, and, if any are bent during hardening, they are straightened by being hammered on anvils with small hammers; finally, the whole are polished by laying twenty or thirty thousand side by side upon a piece of thick canvas, smearing them with oil and emery, rolling up the canvas, and rubbing them under a press for several hours or even days.

Drilled-eyed needles undergo another operation—a fine drill is made to revolve rapidly in the eye of each,

to take off the rough edge and prevent their cutting the thread when used; finally, the points are finished on a revolving hone and polished on a wheel covered with leather, and enclosed in a paper for sale.

Simple as the construction of a needle may appear, the steel which forms it has to pass through the hands of one hundred and twenty workmen from the time it leaves the iron mine until its manufacture is completed.

The manufacture of needles is now carried on to a great extent in many villages in England, but principally at Redditch, about fourteen miles from Birmingham, and from this obscure place a large portion of Europe, the British Colonies, and the United States are supplied.

LESSON LXXXVII.

NAILS.

Manufacture and Varieties.—Three distinct kinds of nails, adapted to various uses, are manufactured in this country. It is stated that of these kinds there are three hundred different varieties, each variety being formed, on an average, of ten sizes.

The three kinds are, wrought nails, cast nails, and cut or punched nails.

Wrought nails are made of sheet iron, which is cut by machinery into rods of various thicknesses, according to the size of the nails required. The persons who convert these rods into nails are called nailers, and men, women, and even children follow the pursuit, each person usually making one form of nail only, and by so doing acquiring a remarkable degree of skill and rapidity in its production.

The first process in making these nails is to heat in a forge one end of the nail rod to redness; it is then hammered to a point, and the required length cut off with a chisel. If the nails are large, the rod is immediately returned to the forge, but if of moderate size, two nails are made at one heating. During the time the rod is being reheated, the nailer forms the heads of those cut off, by hammering them, while still red hot, into the hole of a steel instrument used for the purpose, called a bore, this hole being the shape of the head.

The nailers become so expert by long practice, that one man has been known to make seventeen thousand nails in a week without assistance. To do this would require more than half a million blows of the hammer. The usual number made by each nailer is about six thousand weekly.

The different sorts of nails are named either from the use to which they are applied, or from their shape: as shingle, floor, ship carpenters', horseshoe, rose heads, diamonds, sprigs, brads, and spikes. Sprigs are a small, sharp, taper nail, without heads, used by shoemakers. Brads are nails with the head on one side, and are used for nailing floors and ceilings. Very large nails are called spikes. Rose nails have a broad, spreading, circular head, and are made of various degrees of strength, and for various uses.

Horseshoe nails are thin and flat on the sides. They are made of the very purest and toughest iron, and, after having been used, the old iron is in considerable demand for making gun barrels.

Tacks are a useful flat-headed nail, adapted for nailing down carpets, &c. They are usually small, and are frequently tinned over by boiling them in a solution of tin and sal ammoniac, to prevent their rusting.

Cast nails are adapted only for coarse purposes, as for garden walls, nailing up lathing for plasterers, &c. They are rough, and have the disadvantage of being much more brittle than wrought nails.

Cut nails are usually punched out of sheet iron, the most common form being the sparables, or sparrow bills —so called from their resemblance to the beak of that bird —and brads, which have a slight projecting head on one side.

The employment of nails in connecting various substances, and the uses of the several parts, as the point, the shank, and the head, are too obvious to require description.

LESSON LXXXVIII.

KNIVES.

Manufacture.—Knives, or cutting instruments of various kinds, have been used by men, from the earliest ages, for the purposes of war, and for slaughtering animals, cutting food and other substances. In ancient times, as at the present day among some barbarous nations, shells, sharp-edged flints, and other hard stones were employed; at a later period cutting as well as warlike instruments were formed of brass or bronze, but at the present time, in all civilized nations, they are formed exclusively of steel or iron.

Clasp knives—so called from the blade shutting into the handle—consist of four distinct parts, viz., the blade, the spring, the iron sides, and the scales, or ornamental outsides.

Penknife blades, which ought to be made from the best cast steel, are forged with a small hammer, from the end of a steel rod heated to redness, and are cut off with sufficient metal attached to form the joint; the blade is then held in a pair of tongs, and heated a second time, when the part forming the joint is finished; the notch called the nail hole, used in opening the blade, is also made by striking with a chisel of the required shape; the maker's name is at the same time impressed by punching. The blades are then hardened by heating them to redness and dipping the cutting part in water, and they are afterward tempered, to prevent their being too brittle. The spring and iron sides of the knife are forged by hand. The scales, as they are termed, whether formed of ivory, bone, wood, or mother-of-pearl, are fitted to the sides, and drilled with holes for the rivets; these are put in and tightened by hammering, after the various parts are exactly fitted to each other by filing.

The sides and back of the handle are afterward scraped, and polished on a revolving wheel covered with leather; lastly, the blade is ground and polished ready for use.

LESSON LXXXIX.

SCISSORS.

Manufacture.—Scissors are forged from bar steel, heated to redness, each blade being cut off with sufficient metal to form the shank and bow; for the latter a small hole is punched; this hole is afterward stretched to the required size by hammering it on a conical anvil; the shank and bow are then filed into a more perfect shape, and the hole bored for the rivet; the blade is next ground, and the handles filed smooth and burnished with oil and emery; after this, the blades are screwed or riveted together, and fitted, so as to work pleasantly over one another. The screw or rivet is then removed, and the two blades, bound closely together with fine iron wire to prevent their warping, are heated to redness, hardened by sudden cooling, and tempered. After this the wire is removed, the blades are again ground and adjusted, so as to bring the edges to a perfect state; they are then polished by emery and oil, ground for the third time, put together, and the edges whetted, when they are ready for use, although some of the more costly kinds undergo the additional process of burnishing, by rubbing with polished steel tools, which is done by women.

Uses.—The use of scissors does not require any detailed description; it may be noticed, however, that the edges of the blades are not sharply ground like those of knives, and that in cutting they crush or bruise more than that instrument. This does not interfere with their use in cutting thin articles, as paper or cloth, but it prevents their being usefully employed in dividing thicker substances.

LESSON XC.

STEEL PENS.

Manufacture.—Steel pens, which are chiefly manufactured at Birmingham, England, are made from the best steel, which is first rolled into narrow strips of the required width and thickness; these are then cleaned by the action of some dilute acid, and cut by means of a punch worked by a screw press, into flat blank pieces of the requisite size; the hole in the centre is then made, and the maker's name stamped on each pen; after which, the blank is curved into a nib, or a cylinder if a barrel pen is required. Up to this stage the steel has been worked in a soft state; the pens are now hardened by being heated and cooled suddenly by immersion in oil; afterward they are tempered to the required degree of elasticity, polished by being placed with fine sand or some other polishing material in a revolving cask, and the nib ground to a fine point on a grindstone, or emery wheel; after this, the slit is cut by a chisel worked by a screw press, and the pens made ready for sale by being colored and varnished. The manufacture is chiefly carried on by women, men being employed only to repair the tools. It is estimated that 1,000,000,000 pens are manufactured at Birmingham annually. The principal demand for steel pens in the United States, and many countries of Europe is supplied from this source.

LESSON XCI.

ZINC.

Occurrence.—Zinc is not found in a native state. The ores from which it is extracted are of two kinds. In one, which is termed *blende*, or, by the miners, *black jack*, it is combined with sulphur. This ore occurs in tolerable abundance distributed amongst other ores, particularly those of lead, in Cornwall, Derbyshire, and in the north of England. The other, which is the mineral known as *calamine*, is by far the more valuable ore; it is found in the Mendip Hills, and also in Flintshire, Derbyshire, &c., England.

Preparation.—Zinc is obtained from its ores by first heating them to redness in an open furnace. This operation drives off the sulphur from the blende, and some gases from the calamine. The roasted ore is then mixed with coke or charcoal, and put into large earthen pots resembling oil jars in form; these are placed in a circular furnace, and from the bottom of each pot a large iron tube passes through the floor of the furnace into a vessel of cold water. When the jars are heated to redness, the metal is reduced to the metallic state, and, being volatile, flies off in vapor, which, passing by the iron tube into the water, is condensed into a solid form. The metal so obtained is remelted, when the impurities are skimmed from the surface, and it is then cast into bars for use.

Properties.—Zinc is a bluish-white metal, possessing a high lustre when polished, and tarnishing slowly on the surface when exposed to the air. The thin coat of rust so formed appears to protect the metal beneath from any further change. Zinc is about seven times heavier than water.

As obtained by casting, it is brittle, and on being broken shows a crystalline fracture, but heated to a degree somewhat above that of boiling water, it becomes malleable, and may be rolled into sheets, which retain their malleability when cold; the sheet zinc so obtained is flexible, and possesses some degree of elasticity. Heated to a high degree, but still short of the point at which it melts, zinc becomes brittle, and may be powdered.

It melts below a red heat, requiring a higher temperature than tin or lead; at a bright red heat, in a covered vessel, it boils rapidly, passing away in vapor; but if the air is admitted, by uncovering the vessel, it takes fire and burns with a splendid greenish flame.

Zinc possesses a very considerable degree of hardness, considerably greater than that of any of the common metals except copper and iron.

Uses.—Zinc being only superficially acted on by air and water, and being much lighter than lead, has to a great extent, superseded that metal for such purposes as gutters, rain-water pipes, &c. Its lightness and cheapness has also led to its employment as a covering for roofs, and it is much employed in making baths, cans, and other utensils for holding water. It is not usually employed in lining cisterns, as it is apt to impart an unpleasant flavor to the water.

Its hardness enables it to be used for making saws for dividing blocks of salt; and as it does not rust, it is preferable to iron for that purpose. It is also used instead of lithographic stone in producing prints, which are termed zincographs. Its lustre has led to its employment instead of brass for name plates on doors, &c.

The slow action of air and moisture on zinc has also led to its employment as a covering to sheet iron, for protecting the latter from the action of the weather. The iron so protected is known as *galvanized iron.* It is made by a similar process to that used in making tinned plate, the iron goods being first cleaned by an acid, and dipped in a bath of the melted metal.

Sheet zinc, perforated with holes, admitting the passage of light and air, is used largely in the place of wire-gauze for window blinds, meat safes, and other purposes.

Preparations of zinc are now largely used in house painting, as substitutes for white lead; and, although they do not make as opaque a paint as that substance, they possess the advantages of being cheaper, uninjurious to the workmen, and are less liable to become discolored.

A very large quantity of zinc is annually consumed in the galvanic batteries required in working the electric telegraph.

The only alloy into the composition of which zinc enters largely is brass. (See *Brass.*)

LESSON XCII.

BRASS.

Composition.—Brass is an alloy of copper and zinc, various proportions of the metals being employed in order to obtain different degrees of hardness and color in the resulting compound. The best proportions for common brass are about two parts of copper to one part of zinc. Formerly brass was made by heating copper with calamine (the ore of zinc) and charcoal, but it is now formed by melting together the two metals; it is then cast into plates, which are either broken up for recasting into any desired form, or rolled into sheets.

Properties.—Common brass is very malleable, and ductile when cold. It is melted more easily than copper, and readily cast into any required form. It admits of a very high polish, and does not tarnish or rust on exposure to the air, and although sufficiently soft to yield without difficulty to the files and other tools of the workmen, is durable in wear.

Uses.—From its malleability, ready fusibility, and ductility, brass is so easily worked that it is employed to an immense extent in the manufacture of machinery, wheels for clocks and watches, and for articles of domestic use, as candlesticks, pins, buttons, door handles, &c.

LESSON XCIII.

PINS.

Manufacture.—The making of pins is, from their extensive use, a very important article of manufacture. Two manufactories in Connecticut, located at Birmingham and Waterbury, produce about eight tons of pins a week. They make their own brass and wire, for which they require a ton of copper daily; this they obtain exclusively from Lake Superior. In England, for home use and exportation, upward of fifteen millions are made daily. The old method of manufacture furnishes a remarkable instance of the division of labor, fourteen persons being engaged on each pin, without including those who formed the wire from which it was made.

This method of making pins may be briefly described as follows:—Brass wire of the required size was cleaned by soaking it in water, rendered acid by oil of vitriol or sulphuric acid; it was then straightened and cut into short lengths, each being sufficient for four or six pins; these pieces were pointed at each end by grinding on two small broad wheels, the first used being made of steel, and cut like a file; the second a fine grit stone; the grinder would take from fifty to eighty pin wires in his hands, and, spreading them out flatly, apply them first to the revolving file, and afterward to the stone to polish them, rolling the wires during the whole time between his hands, so as to bring them to rounded points at the ends; from the wires thus pointed one pin's length was cut off at each end; they were then pointed again, and two more pins' lengths cut off, and finally they were pointed and divided in the centre; the stems of the pins were thus complete, and the next step was to form the head; this was effected by winding, in a lathe, some soft small brass wire in a close spiral, around a piece of steel wire, the same size as the pins; this steel wire having been withdrawn, the coils were cut up into short pieces of two or two and a half turns each, when they are ready to fix on the stems; this was done by the worker, usually a boy or girl, who would take up several of the headless pins, and plunge them into the heads, which are contained either in a bowl or in his apron; the wires in this way would each catch a head, or sometimes more than one; the superfluous ones, if any, were pulled off, and the pins placed one at a time, points downward, in a small steel die, and a heavy iron bar, raised by a treadle moved by the foot, was allowed to fall on each, striking the top of the pin, and thus moulding or fastening on the head; the pin was then removed from the die and another operated upon; quick workers could head fifteen hundred pins an hour, and from twelve to fifteen thousand a day.

The pins were cleaned by boiling them in an acid liquor, such as sour beer or wine lees, and were tinned by boiling in a solution of tin; after this, they were polished by being shaken in bags partly filled with bran, which was afterward separated by winnowing, leaving the pins dry, clean, and ready for papering. The paper in which pins were stuck for sale was folded by a crimping iron, and the folds were placed between the jaws of an iron vice, across which grooves are fixed as a guide; the paperer passed a horn comb into a heap of pins in her lap, catching up a number by the heads; these were thrust through the folds of the paper, one in each groove. The improvements introduced into the manufacture by American inventors have entirely changed its character and led to a more rapid production of pins, and at a much less cost of labor. The machinery for sticking pins saves much time and labor. The only attention the machine requires is to supply it with paper and pins.

Solid-headed pins are made of a single piece of wire, the heads being pressed by the aid of machinery. The pins so made are more elegant, and the heads cannot come off; but they bend easily, as this mode of manufacture necessitates the use of a softer wire than for the common kinds.

LESSON XCIV.

PEWTER.

Composition.—Pewter is an alloy, the composition of which varies according to the purposes for which it is required. Its base is always tin, to which is added, for the inferior kinds, about one quarter of its weight of lead; this latter metal, however, is not used in making the best pewter, which consists of tin with very small proportions of antimony and copper.

Properties.—Pewter is soft, flexible, but inelastic; capable of being bent to a considerable extent, and again straightened, without cracking. It is of a whitish color, with a very considerable degree of brilliancy, and, although it becomes dull, it does not readily tarnish when exposed to air or moisture. It is very fusible, and may be readily cast in any desired form.

Uses.—Formerly pewter was in almost universal use for plates and dishes, but it has gradually been displaced by the great cheapness of pottery ware. It is still employed for beer and other measures which are exposed to violence, as it is not liable to crack, and if pressed out of shape, can be restored by beating on a mould. Its softness also allows the engraving of names and addresses without much labor, and, therefore, cheaply.

Britannia metal may be regarded as a harder and superior kind of pewter, containing a larger proportion of antimony. The best consists of ninety parts of tin, ten of antimony, and one and a half of copper. Like pewter, it is readily cast into moulds or rolled into sheets; it is sufficiently soft to be stamped with cast iron, or even hard brass dies; it is also capable of being turned in a lathe, and fluted or moulded by pressure; hence it is extensively employed in making spoons, teapots, pitchers, and other domestic articles. The superior kinds are often plated with silver, by the electro process.

VOCABULARY.

AROMATIC, derived from the Greek ἀρωμα, arōma: spice having a pungent spicy smell.

ADHESIVE, derived from the Latin ad-hær-ĕre, to stick to: composed of particles which not only unite together, but attach themselves to other substances, causing them to stick together;—thus the particles of gum have a strong mutual cohesion; it also easily attaches itself to paper and other substances, causing them to hold together.

AFFINITY, derived from the Latin affin-*is*, related: the tendency which some bodies have to unite with others.

ABSORBENT, derived from the Latin absorb-ĕre, to suck up: sucking up liquids. An absorbent substance must be also porous, for if there were no pores, the liquid could not enter the substance.

AGGREGATION, derived from the Latin aggreg-*are*, to collect together in one flock. A collection of things brought together in one.

ARGILLACEOUS, derived from the Latin argilla, clay: partaking of the nature of clay, or consisting principally of clay.

ALLOY, an inferior metal mixed with one more precious; or the compound of two metals.

ASTRINGENT, derived from the Latin ad-string-ĕre, to bind to: binding, contracting.

AMORPHOUS, derived from the Greek α (a) not, and μορφη (morphe) a form: without any regular form.

ACIDULATED, derived from the Latin acid-*ulus*, slightly acid: made slightly acid.

ACRID, from the Latin acri-s, sharp: hot, or sharp to the taste.

ANNEAL, to heat glass after it is blown, that it may not break.

AMALGAM, the combination of mercury with any other metallic substance.
AQUAFORTIS, signifies literally strong water, but is applied to a weak nitric acid.
ALKALI, a substance which, uniting with acids, neutralizes their acidity: it derives its name from a plant called kali, from the ashes of which alkaline substances are procured.
ATMOSPHERE, derived from the Greek ἀτμος (atmos) vapor, and σφαιρα (sphaira) a globe or sphere: the air that surrounds our globe is composed of oxygen and nitrogen.
BRITTLE, easily broken: hard substances only are brittle.
CONGEAL, derived from the Latin con, together, and gel-*u*, cold: to turn from a liquid into a solid by the influence of cold.
CIRCLE, a circle bounded by a curved line, which is equally distant at every point from the centre.
CIRCULAR, in the form of a circle.
CONE, a solid bounded by a flat circular surface called the *base*, and a curved surface tapering to a point, called the *apex*.
CONICAL, having the form of a cone.
CALCINED, burnt in a fire and reduced to a calx, or friable substance.
CULINARY, derived from the Latin culina, a kitchen: belonging to the kitchen.
CHALYBEATE, derived from the Greek χαλυψ (chaly-*bs*) iron: impregnated with iron or steel.
CORROSIVE, derived from the Latin rod-*ĕre*, to gnaw: having the power of eating away anything.
CONTAGION, derived from the Latin con, together, and tan-*gere*, to touch: something proceeding from body to body, by which disease is communicated.
CONCAVE, the inner curve of a hollow sphere.
CONVEX, the outer curve of a sphere.
CONSERVATIVE, derived from the Latin con, together, and serv-*are*, to keep: having the power of preserving or preventing decay.
CAUSTIC, derived from the Greek καυστικος (causticos), burning: having the power to destroy the texture of parts by burning or eating them away.
COHERE, derived from the Latin co, together, and hær-*ĕre*, to stick: to stick together.
CALORIC, derived from the Latin cal-*or*, heat: heat.
COLLISION, derived from the Latin collis-*us*, struck together: the act of striking two bodies together.
COMPACT, firm, solid, close.

CARBON, derived from the Latin carbo, charcoal: the pure inflammable part of charcoal.
CARBONIC ACID, carbon united with a certain portion of oxygen.
CALCAREOUS, derived from the Latin calx, lime: consisting principally of lime.
COMPONENT PART, derived from the Latin con, together, and pon-*ĕre*, to place: a part forming with others a compound body.
CYLINDER, derived from the Greek κυλινδω (kylindo), I roll: a solid bounded by one curved surface and two flat ends.
CYLINDRICAL, having the form of a cylinder.
DUCTILE, derived from the Latin duc-*tĭlis*, capable of being drawn out in length.
DECOMPOSITION, the separation of the particles of a compound body.
DILATABLE, derived from the Latin dilat-*are*, to extend: capable of being expanded.
DENSE, close, thick: the opposite to rare.
DILUTED, derived from the Latin dilu-*ĕre*, to wash: having been made thinner or weaker.
ECONOMICAL, derived from the Greek οικονομια (oikonomia), household management: relating to the management of a family.
ELEMENT, a substance not compounded, having but one constituent part.
EMOLLIENT, derived from the Latin moll-*is*, soft: having the power to soften.
EXPORTED, derived from the Latin ex, out, and port-*are*, to carry: to carry out of the country.
EXOTIC, derived from the Greek ἐξω (exo), without: not produced in our country: particularly applied to plants.
EVAPORATE, derived from the Latin *e*, out from, and vapor, vapor: to pass off in a vapor.
EXCRESCENCE, derived from the Latin ex, out, and cresc-*ĕre*, to grow: something growing out of another body, not useful to it, and contrary to the common order of production.
EXHALE, derived from the Latin ex, out, and hal-*are*, to breathe: to send out vapors or fumes.
ELASTIC, having the power, when bent or stretched, of returning to its original position.
EFFERVESCENT, derived from the Latin effervesc-*ĕre*, to boil up: bubbling up with internal commotion.
EDIBLE, derived from the Latin ed-*ere*, to eat: fit for food, eatable.
FRAGRANT, having a sweet scent.

FLUID, derived from the Latin flu-*ere*, to flow: having parts easily separable, and flowing about.
FUSIBLE, melting in fire.
FRIABLE, easily crumbling.
FOLIATED, derived from the Latin foli-*um*, a leaf: composed of leaves, or laminæ.
FRACTURE, derived from the Latin fract-*us*, broken: the appearance of a mineral when broken.
FRAGILE, derived from the Latin frang-*ere*, to break: easily broken or injured.
FLEXIBLE, derived from the Latin flex-*us*, bent: easily bent.
FRICTION, derived from the Latin fric-*are*, to rub: the act of rubbing two bodies together.
FARINACEOUS, derived from the Latin farina, flour: mealy, of the nature of flour.
FILTRATION, derived from the Latin filtr-*um*, a colander: the process of passing a liquid through the interstices of another body.
FERMENTATION, derived from the Latin ferment-*um*, leaven: internal commotion in the particles of a body: plants undergo fermentation when they decompose.
GLUTINOUS, derived from the Latin gluten, glue: tenacious, viscid.
GLOBULE, derived from the Latin glob-*ŭlus*, a small globe: small globe or sphere.
GRAMINIVOROUS, derived from the Latin gramen, grass, and vor-*are*, to eat: feeding on grass.
GRANULOUS, derived from the Latin granŭl-*um*, a little grain: separating into small particles, or grains, as sand.
GENERIC, derived from the Latin genĕr-*a*, kinds: relating to a genus, or kind of things.
GRADUATED, derived from the Latin gradu-*s*, a step: marked by a regular increase of degrees.
HORIZON, derived from the Greek ὁριζων (horizon), bounding: the line that bounds our view.
HORIZONTAL, in the same direction as the horizon.
HERMETICALLY sealed, so sealed as entirely to exclude the air.
HYDROGEN, derived from the Greek ὑδωρ (hydor) water, and γενναειν (gen-*naein*) to produce: the lightest gas: with a certain portion of oxygen it forms water.
IRIDESCENT, derived from the Latin irid-*escere*, to become like a rainbow: shining with the colors of the rainbow.

IMPALPABLE, derived from the Latin in, not, and palp-*are*, to feel: not to be perceived by touch.
IMBRICATED, derived from imbric-*are*, to cover with tiles: arranged in the manner of the tiles of the house.
IMPORTED, derived from the Latin in, into, and port-*are*, to carry: carried into a country.
IMPRESSIBLE, derived from the Latin in, and press-*us*, pressed: easily receiving and retaining an impression.
INDIGENOUS, derived from the Latin indig-*ĕna*, native: the natural production of the country. This term is applied to vegetables, as native is to animals.
INSIPID, derived from in, not, and sap-*ere*, to savor: having but little flavor.
INCOMBUSTIBLE, derived from in, not, and combust-*us*, burned: not to be consumed by fire.
INTERSTICE, derived from the Latin inter, between, and stit-*um*, placed: small space between the different parts of the body.
IMPREGNATED, filled with any quality or thing.
INCISION, derived from the Latin incis-*us*, cut in: a cut or wound made by a sharp instrument.
IMPERVIOUS, derived from the Latin in, not, per, through, and via, a way: presenting no passage. A substance is impervious to a liquid when it presents no pore or passage by which it can enter.
IGNITED, derived from the Latin igni-*s*, fire: having been kindled or set on fire.
INFUSION, derived from in, into, and fusus, poured: a liquid in which something has been steeped to draw out its properties.
LIQUID properly signifies that which has been melted: anything which we drink, or which forms into drops. Air is a fluid. Water is both fluid and liquid; when we speak of it as a stream or current, it is properly called a fluid, but when we speak of it as passing from a congealed to a dissolved state, it should properly be called a liquid.
LAMINA, a thin plate.
LAMINATED, formed of thin plates or laminæ.
LATERAL, derived from the Latin latera, sides: at the side.
LIGNEOUS, derived from the Latin lign-*um*, wood: made of wood, or having a woody structure.
LUBRICOUS, derived from the Latin lubric-*us*, slippery: slippery, smooth.
LAYER, that which is spread over a substance.
MAGNIFYING, derived from the Latin magn-*us*, great, and fi-*eri*, to be made: making things appear larger than they actually are.

SMELTING, the process by which the pure metal is separated from the earthy particles with which it is combined in the ore.
SILICIOUS, derived from the Latin sil-*ex*, flint: consisting principally of silex or flint.
SECRETION, derived from the Latin secret-*us*, separated: that which is separated from any other substance. Tears are an animal secretion: the honey in flowers is a vegetable secretion.
SOLUBLE, derived from the Latin solv-*ere*, to loosen: melting in a liquid.
SOLVENT, having the power of dissolving things.
SOLUTION, that which contains anything dissolved.
SPHERE, derived from the Greek σφαιρα (sphaira), a globe or sphere: a solid bounded by one curved surface, which is equally distant in every part from the centre.
SPHERICAL, having the form of a sphere.
SOLID, filling up space: in this sense it is opposed to hollow.
SOLID, having particles adhering closely together: in this sense it is opposed to fluid.
SONOROUS, derived from the Latin son-*us*, a sound: capable of producing sound.
SUMMIT, derived from the Latin summ-*us*, highest: the top or highest part.
SAPID, derived from the Latin sap-*ere*, to savor: having a flavor.
SPARKLING, bright in parts and not over the whole surface.
SATURATE, derived from the Latin satur, full: to fill anything till it can receive no more.
SEMI-TRANSPARENT, derived from the Latin semi, half, trans, through, and par-*ens*, appearing: presenting an imperfect passage to the rays of light, so that objects do not appear clearly through.
TRANSPARENT, derived from the Latin trans, through, and par-*ens*, appearing: yielding a free passage to the rays of light, so that objects appear through.
TRANSLUCENT, derived from the Latin trans, through, and lux, light: yielding a partially obstructed passage to the rays of light, so that light only appears through.
TENACIOUS, derived from the Latin tenax, holding: having particles uniting firmly together. Gum being tenacious, the particles cannot easily be separated, and on this account it acts as a cement; glue, being more tenacious, acts as a still stronger cement.
TUBULAR, derived from the Latin tubul-*us*, a small tube: having the form of a hollow cylinder.
TOUGH, capable of being bent or extended without breaking.

TARTAR, a hard substance deposited on the sides of a cask during the fermentation of wine.
TARTARIC ACID, tartar combined with a certain portion of oxygen.
TRIANGLE, derived from the Latin tres, three, and angul-*us*, an angle: a form that has three angles.
TRIANGULAR, having the form of a triangle.
TRANSMITTED, derived from the Latin trans, across, and mitt-*ere*, to send: sent from one person or place to another.
VACUUM, derived from the Latin vacu-*us*, empty: space completely unoccupied.
VELOCITY, derived from the Latin velox, swift: speed, swiftness.
VISCID, derived from the Latin visc-*us*, bird lime: glutinous, tenacious.
VITRIFIABLE, derived from the Latin, vitr-*um*, glass, and fi-*eri*, capable of being converted into glass.
VOLATILE, derived from the Latin vol-*are*, to fly: passing or flying off naturally by evaporation.
UNCTUOUS, derived from the Latin unct-*us*, anointed: fat, clammy, oily.