HANDY BOOK OF OBJECT LESSONS.

SECOND SERIES.

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From a Teacher's Note Book.

BY J. WALKER.

SECOND SERIES.

LONDON:
JARROLD & SONS, 3, PATERNOSTER BUILDINGS.

PREFACE

THE favourable reception which the First Series of Object Lessons has met, has led the Author to compile the present volume, in the hope that it may prove equally acceptable.

A four-fold classification has been adopted, as in the previous course, in order to facilitate reference; the first part consisting of Lessons in Physiology; the second, Physical Geography; the third, Manufactures; and the fourth, Miscellaneous Subjects.

Respecting the lessons in the first two parts, the Author wishes it to be understood that they by no means embrace the *whole*, or even the greater part of the Sciences to which they belong, but that he has chosen the most salient points of each; and, it should be the aim of the teacher to draw from those of the first part, useful practical lessons for the management of health, while the matter contained in the second, if treated in an intelligent manner, and taught so as to suit the capacities of his pupils, will enable them to become conversant with, and explain many natural phenomena, of the causes of which they had previously been altogether ignorant, or only partially informed.

The lessons in these two parts are intended for advanced classes, as are also the more difficult subjects of Part Four, while the remainder will be found more suitable for the lower classes of the school.

St. Stephen's Schools, Paddington,

November, 1875.

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PART I.—Physiology.

PART II.—Physical Geography.

PART III.—Manufactures.

PART IV.—Miscellaneous.

SECOND SERIES.

Handy-Book of Object Lessons.

PART I.—PHYSIOLOGY.

LESSON I.

THE BUILD OF THE HUMAN BODY.

MATTER.

THE human body may be divided into three parts :—I. The head; II. The trunk; III. The limbs.

I. The Head.

This is composed of:—(1) The cranium; (2) The face.

(1) THE CRANIUM is also called the brain case.[1] The brain being a very delicate organ, requires great protection. To ensure this it is encased in a bony shell of great strength, the bones of which are dovetailed together, as it were, by means of joints called *Sutures*,[2] the projection of one bone fitting into the corresponding indentation of its neighbour.[3] As a consequence of this arrangement a severe blow on the head does not necessarily damage the *whole* skull.[4]

(2) THE FACE contains fourteen bones; hence the whole head contains twenty-two.[5]

II. The Trunk

May also be divided into two parts: (1) The thorax or chest; (2) The abdomen.

(1) THE THORAX. This is a very important part of our body. It contains the heart, lungs, and upper portion of the alimentary canal.[6]

(2) THE ABDOMEN contains the stomach, kidneys, pancreas, liver, spleen, intestines, and the lower portion of the alimentary canal.

N.B. The thorax and abdomen are separated by a strong fleshy partition, termed the *Diaphram* or *Midriff*. It is convex[7] towards the former, and concave towards the latter.

METHOD.

1 Why? Because it contains the brain.

2 From the Lat. *Suo* = I sew. Why so called?

3 Illus. by carpenter's dovetailing.

4 Draw attention to the wisdom of the Creator in the construction of our bodies.

5 How? The cranium has eight.

6 i.e. The tube or pipe down which our *aliment* or food passes into the stomach.

7 Explain this term, and illus. by a railway arch.

(*a*) *The Stomach* is a muscular bag lying across the abdomen, and having its left extremity enlarged. This is called its *Cardiac Dilatation.*[8] The stomach is convex below, which is its greatest curvature, and concave above. Towards its right extremity the stomach narrows, and here it joins the intestines.

(*b*) *The Kidneys* are two oval-shaped[9] organs. They lie one on each side of the lower portion of the spine.

(*c*) *The Pancreas* is a long, soft gland, which lies under the back of the stomach. It is six or seven inches long, and secretes a juice called the "*Pancreatic juice.*"

(*d*) *The Liver* is the largest gland of the body. It weighs from 50 to 60 ounces,[10] and is situated on the right side, the lower part touching the intestines and the right kidney. It secretes a fluid called "*Bile.*"

(*e*) *The Spleen* is an oval, reddish body, lying on the left side of the stomach. It probably assists in the formation of white corpuscles. See Lesson IV.

(*f*) *The Intestines* are situated in the cavity of the abdomen, where they lie coiled up.[11] Their average length, if untwisted, would be found to be about four times that of the person to whom they belong.

(*g*) *The Alimentary Canal* is the passage along which our food passes. It enters the stomach nearly in the centre of that organ. Its upper extremity is termed the œsophagus[12] or gullet.

The Limbs.

Of these there are two pairs :—(1) The arms, in the upper portion of the body. (2) The legs, in the lower portion of the body. The bones of the arms correspond to those of the legs. See Lesson, No. 2.

8 From *kardia* (Gr.) = the heart. Show why so called.

9 Ask what shape this is. Illus. by reference to an egg.

10 Let the class reduce this to pounds.

11 Refer to those of the pig, which are commonly known as "chitterlings."

12 Gr. *oiso*=I carry, and *phago* = I eat; hence deduce the meaning of the word.

LESSON II.

THE HUMAN SKELETON.

MATTER.

The human skeleton may be divided into three parts :—I. The Head; II. The Trunk; III. The Limbs.

METHOD.

We are about to have a lesson to-day on the frame-work of our bodies. What are the bones of an animal termed? **Its skeleton.**

I. The Head

Consists of 22 bones. These are divided into (1) Those of the cranium or brain case, containing 8 bones; (2) Those of the face, containing 14 bones.

(1) THE CRANIUM. The bones forming the brain case are—

(*a*) The frontal,[1] forming the forehead.
(*b*) „ two temporal „ temples.
(*c*) „ occipital[2] „ back of the head.
(*d*) „ two parietal[3] „ sides „
(*e*) „ sphenoid, or wedge bone; so called because it is *wedged* in like the keystone of of an arch.[4]
(*f*) „ ethmoid, or sieve bone, forming the base of the skull.[5]

(2) THE FACE consists of 14 bones, the chief of which are the two jaws, called the upper and lower maxillary. The lower one is movable, the upper is immovable.[6]

II. The Trunk

Is composed of several bones, viz.,—the spine, also called the backbone or vertebral column;[7] the sternum, or breastbone; the ribs; the scapula, or shoulderbone; the clavicle, or collarbone;[8] and the pelvis. This latter is the large bone at the bottom of the spine.[9]

(1) THE SPINE consists of 33 vertebræ, or joints, which are fastened together by means of a gristly substance called *cartilage*. The bones of the spine are thus enabled to bear pressure without injury.[10] Each vertebra is provided with a hole, through which the spinal cord passes upwards through the neck and into the brain. The various bones of the spine are thus named:

(*a*) The cervical[11] (7) or those of the neck.
(*b*) „ dorsal (12) „ back.
(*c*) „ lumbral (5) „ loins.

The above 24 bones are movable vertebræ.

(*d*) The sacrum (5) or, holy bones.
(*e*) „ coccyx[12] (4).

N.B. The two upper bones of the cervical vertebræ are called the Atlas[13] and Axis: the former supports the head, the latter enables it to turn.

(2) THE STERNUM, or breastbone, is the bone in the centre of the chest, to which most of the ribs are attached.

(3) THE RIBS. These form the frame-work of the chest. They are 24 in number, 12 on each

[1] Because it is situated in *front*.

[2] From L. *occiput*= the back of the head.

[3] L. *paries*=a wall.

[4] Explain and refer to architecture by way of illustration.

[5] Why so called? Because it is full of holes like a sieve. Why? To allow the blood-vessels to pass upwards to the brain, and so to nourish it.

[6] Allow the class to prove this statement, by causing each pupil to open and close the mouth alternately.

[7] So called because it is made up of several vertebræ or joints.

[8] From its resemblance to a Roman key (L. *clavis*=a key.)

[9] Why so large and massive? To support the weight of the bones which rest upon it.

[10] Explain and illus. by reference to buffers of railway carriages.

[11] The teacher should be prepared with the derivation of these words. By this means the situation of the various portions of the spine will be the more easily understood.

[12] So called from its resemblance to a cuckoo's bill.

[13] So called from a heathen god, named Atlas, who was supposed to carry the world on his shoulders.

side. Seven of them are fastened, by means of cartilage, to the sternum in front, and behind to the backbone; hence they are called "*true ribs.*" The other 5 are fastened to the spine, but not to the sternum. Two of these latter are called "*floating ribs.*"[14]

(4) THE SCAPULA is the large bone which forms the shoulder.

(5) THE CLAVICLE, or Collar-bone.[15] This bone prevents the arms from falling forwards on to the chest, and thus assists in keeping the lungs expanded.[16]

(6) THE PELVIS, or Basin, consists of several strong bones called the "*ossa innominata,*" or nameless bones.

III. The Limbs.

These consist of two pairs, the arms and the legs.

(1) THE ARMS. Each contains 30 bones, viz.,

(*a*) *The Humerus*, or bone of the upper part of the arm. This works in a socket of the shoulder, called the "Glenoid cavity," which is shallow.[17]

(*b*) *The Radius* } These are the bones of the
(*c*) „ *Ulna* } forearm.

(*d*) „ *Carpal Bones*, or bones of the wrist. They are 8 in number.

(*e*) *The Metacarpal Bones*[18] (5 in number), or bones below the wrist.

(*f*) *The Phalanges*, or Digits. Two for the thumb and three for each of the four fingers, thus making 14 in all.[19]

(2) THE LEGS also contain 30 bones each.

(*a*) *The Femur*, or Thighbone. This is the largest bone in the body, and is fixed into the pelvis by means of a round knob at its upper extremity: the socket in which it works being a deep one,[20], and known by the name of the "*acetabulum.*"[21]

(*b*) *The Tibia* } These are bones of the foreleg.
(*c*) „ *Fibula* } The Tibia is the shinbone.

(*d*) „ *Tarsal* bones, or those of the ankle. These are 7 in number.

(*e*) „ *Metatarsal* bones (5 in number) or those beyond the ankle. They form the instep of the foot.[22]

(*f*) *The Phalanges* of the foot. 14 in number.

(*g*) „ *Patella*, or Knee-pan, in front of the knee joint. This bone, though small, is so

14 Because not being so securely fastened they appear *to float.*

15 Let the pupils place their hand on this bone.

16 Show how.

17 Why? To enaable us to move the arm *freely:* hence the arm is easily dislocated.

18 From *meta* = beyond.

19 Show that the total of the bones in the arm is 30.

20 Why? To prevent dislocation. (Contrast with the humerus.)

21 From its supposed resemblance to the drinking cup of the ancients.

22 Show that the bones of (*d*) and (*e*) correspond to those of the hand.

important that probably any bone in the body could be better spared than it.[23]

N.B. All the bones of the human skeleton are enabled to work freely by means of a fluid called "*synovia*," the oily nature of which prevents the wearing away of their several parts by friction.[24]

The foot is *arched* because of the heavy weight it has to support.[25]

The above subject will afford sufficient matter for two or three lessons, according to the class for which it is intended. The teacher should, if possible, provide diagrams to illustrate the several parts of the skeleton; or, in the absence of these, prepare sketches for the black board.

[23] Show that the total of the bones in the leg is 30.

[24] Explain and illustrate by reference to oil poured into machinery.

[25] Ask for examples to illustrate this principle. (*a*) The brick-work over windows. (*b*) Railway bridges, &c.

LESSON III.

THE VESSELS OF THE HUMAN BODY.

MATTER.

The vessels of the human body comprise what is termed the Vascular System. It consists of Capillaries,[1] Arteries, and Veins.

I. Capillaries.

These are the smallest tubes in the body, hence their name. Some are not more than $\frac{1}{1500}$ or $\frac{1}{2000}$ of an inch in diameter. There are two kinds :—

(1) BLOOD CAPILLARIES. So called because they contain blood.

(2) LYMPHATIC CAPILLARIES. So called because they contain lymph.

They run in every direction through our bodies, forming in some places a kind of net-work; in others they appear as tubes coiled up, every now and then, into round balls, termed "*glands*,"[2] from which a new set of capillaries springs. The capillaries form the only medium of communication between the arteries and the veins. In them the blood becomes changed in character.

II. Arteries—

Are strong elastic muscular tubes, which possess the property of dilating[3] when full, and of remaining distended when empty.[4] The function of the arteries is to convey blood *from* the heart *to* the veins by means of the capillaries.

III. Veins—

Are smaller tubes than arteries. They are employed in carrying blood *to* the heart. Their

METHOD.

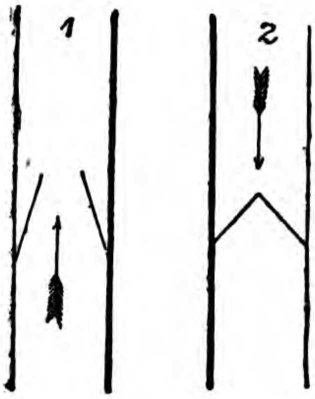
[1] L. *capillus*=a hair.

[2] L. *glans*=an acorn, or chestnut.

[3] i.e., expanding, or enlarging. Illustrate by reference to the nostrils of a horse.

[4] Hence the name, "artery," from Gr. *aer* = air. The ancients supposing the arteries to be *always* filled with air, thus named them.

walls are thin, and collapse when empty.[5] In order to prevent the *backward* flow of the blood, veins are furnished with valves, the action of which will be more easily understood by reference to the annexed diagrams, where *Fig.* 1 represents a vein with its valves allowing the free passage of the blood towards the heart; and *Fig.* 2, a similar vein, with its valves closed, preventing the return of the blood.[6]



The following table will show, at a glance, the

Differences between Arteries and Veins.

ARTERIES	VEINS
(1) Have thick, tough, and elastic walls, and *do not* collapse when empty.	(1) Have thin walls and *do* collapse when empty.
(2) Convey blood *from* the heart.	(2) Convey blood *to* the heart.
(3) Have *no valves*, except the pulmonary artery and the aorta.	(3) Are supplied with valves to prevent the return of the blood.
(4) Contain pure (arterial) blood.	(4) Contain impure (venous) blood

N.B. The pulmonary arteries and veins are exceptions, being just the reverse.[7]

ARTERIES	VEINS
(5) Are generally found *empty* after death.	(5) Are found *full.*
(6) Generally lie *deep* in the flesh.[8]	(6) Lie, mostly, *near the surface.*

N.B. The above table should be committed to memory.

[5] Explain and illus. by reference to a tube of thin india-rubber, filled with water and then emptied.

[6] Let the teacher dwell upon this portion of the lesson in order that it may be clearly understood.

[7] The teacher must be very careful to see that this is understood and remembered.

[8] Draw attention to the wisdom of the Creator, as exemplified in this arrangement. (Explain.)

LESSON IV.

THE BLOOD AND ITS USES.

MATTER.

I. Composition.

The Blood consists of solids, liquids, and gases.

(1) THE GASES are the same as those contained in the air, viz:—Nitrogen, Oxygen, and Carbonic Acid, but they are combined in different

METHOD.

I described to you in our last lesson the arteries and veins. What did I tell you they contain? **Blood.**

proportions; for while the air is found to be composed of $\frac{3}{4}$ Nitrogen, nearly $\frac{1}{4}$ Oxygen, and a mere trace of Carbonic Acid, (See Lesson IV. of Part I), the blood contains of Oxygen nearly $\frac{1}{3}$, Nitrogen $\frac{1}{10}$, of and of Carbonic Acid $\frac{2}{3}$.

(2) THE LIQUID is water.

(3) THE SOLIDS are corpuscles, albumen, saline and fatty matters, and fibrin.

(*a*) *Corpuscles* are very small bodies[1]. There are two kinds, red and white.

Red. These are not more than $\frac{1}{3200}$ of an inch in diameter, and $\frac{1}{4}$ of this in thickness. It has been estimated that there are three millions in a single drop of blood, and that a cubical box of one inch would contain eighty thousand millions. It is these which give to the blood its bright, scarlet colour.[2]

Shape. In *shape* the red corpuscles are round, and disc-like, being flatter in the centre than at their edges.[3]

In man these corpuscles are always *round,* in birds *oval,* and in some animals *elliptical.* A knowledge of these facts enables the analyst to decide whether a stain is human blood or not. He moistens the spot with a little white of egg, (which is of about the same consistency as the albumen of the blood), and then examines it under a powerful microscope. If the corpuscles be round the blood is that of a human being.[4]

Properties. They are elastic, possessing the property of contracting or expanding, according to circumstances, hence they can be squeezed through channels, having a smaller diameter than their own.

The red corpuscles become flattened if subjected to the influence of saline, or saccharine[5] matters or oxygen, and thus reflect the light more strongly; hence the bright appearance of arterial blood. On the contrary, if distended by Carbonic Acid, they assume a spheroidal[6] shape, and look darker, and hence the colour of venous blood.

Origin. They are supposed to be formed from the white corpuscles, becoming detached from them when they decay.[7]

Uses. They play an important part in the economy of nature, carrying within their walls (as they are borne along by the current of the blood) the nourishment which supplies our bodies, distributing it according as it is needed.[8] They then die and others are produced.

WHITE CORPUSCLES. These are not so numerous as the red, but are larger, being about $\frac{1}{2500}$ of an inch in diameter. They differ from

[1] L. *corpus*=a body, and *cles* is the diminutive particle. Illustrate by reference to icicles, manacles, &c.

[2] Illustrate by a glass jar filled with water and red currants: the whole of the contents would, at a little distance, appear red, because of the presence of the fruit.

[3] Illustrate by reference to an india-rubber air cushion.

[4] Shew the advantage of this knowledge in deciding cases of murder: e.g., if the accused stated the spilt blood to be that of a bird.

[5] Ask what such matters are, and require examples to be given.

[6] L. termination *al* =belonging to; hence "spheroidal," = "belonging to" (or like) "a sphere."

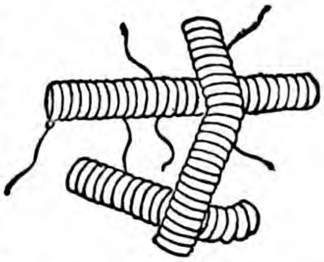
[7] Hence we may regard the white corpuscle as the parent of the red.

[8] Illustrate by comparing the corpuscle to a boat plying down a river, leaving portions of its cargo for the inhabitants of the various towns which it passes. (Shew where the analogy fails:—the boat *continues* to ply the river, the corpuscle dies).

the red in that they are continually changing their shape. They are supposed to be produced in the spleen and mesenteric glands. (Vide Lesson 12, "Absorption.")

(b) Albumen. Is a glutinous substance[9] resembling the white of an egg. It possesses the property of hardening when raised to a temperature of about 170°.

(c) Fibrin is another glutinous substance.[10] It causes the corpuscles to adhere in rolls, thus :—



They then present the appearance of coins. Fibrin forms only a very small proportion of the blood (not more than 2 parts in 1000), but it is very powerful in its effects, and is poured out with the blood directly a wound is inflicted. Intoxicating liquors, if indulged in too freely, have the effect of diluting our fibrin.[11]

The following table will shew the composition of the blood :—

Out of 1000 parts of blood, there would be

Of Water	784 (⅘ nearly.)
„ Red corpuscles	131
„ Albumen	70
„ Fatty and extractive matter	6·77
„ Saline	6·03
„ Fibrin	2·2
	1,000

II. Coagulation of the Blood.

If a drop of blood be obtained from the tip of the finger and placed upon a strip of glass, and left for a few minutes, it will be found to adhere to it, so that the glass may be turned in any direction without disturbing the drop, which may be removed with the point of a penknife. This property of the blood is termed *Coagulation*[12] and is very different from the *drying* of the blood.

Coagulation is hastened by :—

(1) A high temperature.[13]
(2) Contact with non-living matter.[14]
(3) Exposure to air.[15]

If a quantity of human blood be placed in a basin and left for a few minutes, it will be found

9 i.e. sticky, e.g., glue; hence the word.

10 On account of this it is termed "Nature's glue."

11 Persons in the habit of drinking intoxicating liquors to excess often die from wounds which, if the blood had been in a healthy condition, might have healed.

12 L. *coagulo* = I curdle.

13 Hence persons with slow circulations should not live in hot climates (Explain).

14 This can be proved by whisking blood in a basin, when it will be found that the solid constituents will adhere to the whisk. (Illustrate by beating eggs.)

15 Show that the opposites of these will *retard* coagulation.

that the solid portions have sunk to the bottom, leaving a pale, yellowish liquid, floating at the surface. This is called the *Serum*, and on account of its colour, the *buffy coat.*

III. Uses.

(1) The chief use of the blood is to nourish our bodies. When the quality of the blood is deteriorated, the body becomes enfeebled.

(2) It warms us, maintaining our bodies at an uniform temperature of about 98°.[16]

REMARKS. (1) *Weight of blood in the human body.* This is about $\frac{1}{10}$ of that of the whole body; hence, taking the average weight of a man to be 154 lbs. (11 stone), his body would contain about $15\frac{1}{2}$ lbs. of blood.[17]

(2) *Transfusion.* Some years ago it was a common practice to inject the blood of one person into the veins of another in order to prolong life.[18] To render this experiment successful the blood must be that of a species closely allied to the subject of the experiment, otherwise death would ensue.[19]

N.B. For a mode of examining the blood microscopically, see Huxley's "Elementary Lessons in Physiology," page 63.

The above subject will furnish sufficient matter for two or three Lessons.

16 Hence "in the Polar regions of N.E. Asia, the human body resists a cold which freezes mercury."
(*Vide* Collins' Elementary Physical Geography, page 144).

17 This has been determined by weighing a criminal before and after decapitation, the difference between the two results giving, *approximately*, the weight of blood which his body contained.

18 Shew how useful this plan might be found in war, if only a volunteer reserve of civilians could be found willing to sacrifice their lives for the sake of their fellows.

19 Why? Because the corpuscles contained in the blood must be of the same kind.

LESSON V.

THE STRUCTURE OF THE HEART.

MATTER.

I. Situation and Size.

The heart is situated in the *centre* of the thorax, with its apex or point turned towards the left. It is broader at its upper extremity which is termed, the base. It is kept in its place by the great vessels of the body, the aorta and diaphragm prevent it ascending or descending, and the lungs from moving either to the right or to the left. It is about the size of the closed hand of the person to whom it belongs.

II. Structure.

The heart is enveloped in a fleshy bag, called the *pericardium.*[1] It contains four chambers, which are divided into two pairs, those of the upper portion being called the *Auricles,* and those of the

METHOD.

Let the pupils be asked to place their hands on their hearts. In all probability they will lay them on the *left* side. The teacher will then proceed to show the fallacy of this notion.

1 Gr. *peri* = round, and *kardia* = the heart.

lower the *Ventricles.*[2] They are right or left, according to the side of the heart in which they are situated.

(1) THE AURICLES have thin walls, because they have not so much work to do (Vide Lesson 6).

(2) THE VENTRICLES are larger than the auricles, and have thicker walls, those of the left being thicker than those of the right (Vide Lesson 6).

(3) THE VALVES. Between the auricles and ventricles are valves or trap-doors, as it were; that between the right auricle and ventricle is called the *tricuspid* valve,[3] and that between the left auricle and left ventricle, the *bicuspid*,[4] or mitral valve. It receives this latter name from its supposed resemblance to a bishop's mitre. The object of these valves is to prevent the backward flow of the blood into the auricles above them.[5] These valves are not fixed to the walls of the heart, but to fleshy pillars, called *carneæ columneæ*, by means of cords called *chordeæ tendineæ*,[6] which are kept in a state of tension. This arrangement is a check upon the action of the valves.[7] There are two other sets of valves, termed *Semilunar*, (because they are of a half-moon shape). They are situated between the pulmonary artery, (the artery leading to the lungs) and the right ventricle, and between the aorta and the left ventricle.

III. Phenomena connected with the heart's action.

(1) THE BEATING OF THE HEART.[8] This arises from the drawing up of the apex by means of the muscular fibres with which the heart is provided. The apex then taps against the walls of the chest, and hence the "beating" of the heart.

(2) SOUNDS OF THE HEART.[9] These are two in number; a short sharp sound, then a dull, heavy one, succeeded by a pause. They take place in rhythmical order.[10] Physiologists are not yet agreed as to the cause of the first sound, but the second arises from the closing of the semi-lunar valves after the blood is pumped from the heart.[11] (Vide Lesson 6).

(3) THE PULSE[12] is caused by the alternate distending and contracting of the walls of the arteries as each wave of blood is propelled along them.[13] The pulse of an adult (when in health)

---

2 L. *auris* = an ear, *venter* = the belly.

3 L. *tri* = three, and *cuspis* = a point; so called because it has three points.

4 L. *bis* = two, and *cuspis* = a point.

5 Refer to the wisdom of our Creator as seen in this arrangement, and shew what would be the effect if such valves did not exist. (Illustrate by a diagram on the blk. bd.)

6 Shew that these terms are simply the Latin names for the English given in the text.

7 Shew how.

8 Let this be felt by the pupils.

9 Shew that these have been discovered by means of the *stethoscope.* Derive the word and allude to its use by medical men, in order to ascertain the state of the heart.

10 Explain the term "rhythmical," by reference to musical sounds.

11 That this is the case has been proved by *hooking back* these valves in a sheep's heart, when no second sound was heard.

12 L. *pulso* = I beat.

13 Illus. by taking a few feet of garden hose, and having stopped one end with a piece of sponge, pump water into the other. On applying the hand to any part of the tubing a phenomenon similar to the pulse will be observed.

beats on an average from 70 to 80 times per minute, that of children from 100 to 120.[14]

N.B. If possible, let the teacher obtain a bullock's heart, and experiment upon it, thus affording to his class *ocular* demonstration of the truth of his statements.

Having well mastered this lesson, the class will now be prepared to understand the circulation of the blood.

[14] Hence doctors feel the pulse to ascertain the state of the patient's health (shew why).

LESSON VI.

THE CIRCULATION OF THE BLOOD.

MATTER.

I. Discovery.

The circulation of the blood was only guessed at prior to the time of James I., and it was not until the year 1616 that Dr. Harvey, with great caution propounded this doctrine after 26 years of patient research. He was derided by the rest of his profession as a quack, but nevertheless lived to see his system taught in every University of the world.

II. How brought about.[1]

Commencing with the portion of blood contained in the right auricle, at any moment we may observe that the contraction of the walls of this chamber forces the blood into the right ventricle (the valves preventing its return). The contraction of the right ventricle forces the blood into the pulmonary artery, whence it is conveyed to the lungs to be purified. The four pulmonary veins[2] return it to the left auricle, which, contracting, sends it into the left ventricle, and thence into the aorta, which distributes it throughout the whole body, except the lungs. The capillaries and veins return it once more to the right auricle, and thus the circulation is completed. This is called the *systemic circulation*;[3] there is a lesser one which takes place in the vessels of the abdomen.

III. Proofs of the Circulation.

(1) "Poisons injected into the veins in one part of the system can be readily detected in blood drawn from *remote* veins in the course of a few seconds only."

METHOD.

What is meant by "circulation?" Illus. by reference to a "circulating library."

[1] Here the teacher must either be provided with a large diagram of the heart cut open, or sketch one upon the blk. bd.; tracing the course of the blood as he proceeds with his lesson.

[2] Here refer to lesson 3, observing that these are the only veins of the body containing *pure* or arterial blood.

[3] Because it concerns the body *as a whole*.

(2) "If a vein be wounded, pressure applied *between* it and the heart will not affect the bleeding; whereas pressure on the *remote* side of the wound will immediately arrest it."[4] (Vide Collins's Elementary Physiology, page 104.)

N.B. The reverse of this is the case when pressure is applied between a wound in an artery and the heart.

(3) The circulation of the blood is visible, almost to the naked eye, in the web of a frog's foot.

"The web between its toes is very transparent, and the particles suspended in its blood are so large that they can be readily seen as they slip swiftly along with the stream of blood, when the toes are fastened out, and the intervening web is examined under even a low magnifying power." (Vide Huxley's Elementary Lessons in Physiology, page 62.)

[4] Explain this to the class.

LESSON VII.

RESPIRATION.

MATTER.

This subject will furnish matter sufficient for two lessons, the first embracing the Respiratory Machinery, the second, the manner in which breathing is effected.

I. The Respiratory Machinery.[1]

The exterior air passes, by means of the mouth, into an opening in its hinder part, called the *pharynx*, and, when the mouth is closed, through the *nostrils* and the *posterior*[2] *nares* (or orifices in the back part of the nose), into the same cavity. It then passes downwards into the *larynx*, or voice box[3] into the *trachea*, or wind pipe.[4] This is about 4½ inches long and ¾ of an inch in diameter. At its lower extremity the trachea bifurcates, that is, divides into two branches, each of which is termed a *bronchus*, or a bronchial tube.[5] Each of these tubes gives off several branches,[6] which ultimately terminate in innumerable air sacs[7] of which

(1) THE LUNGS are composed, and which, becoming inflated with air, expand, and hence the heaving of the chest with which we are all familiar in the act of breathing. There are two

METHOD.

[1] Let the teacher shew that this means the organs concerned in breathing.

[2] L. *post*=after.

[3] Why so called? Because in it voice or speech is produced.

[4] This is the pipe attached to the lungs. Illustrate by reference to a butcher's shop.

[5] Plur. "bronchi," hence the disease of this part known as "*bronchitis*."

[6] Compare to a tree and *its* branches.

[7] Very diminutive bags or cells.

lungs, right and left; the former consists of three parts, called *lobes*, the latter of two. The lungs are light, conical, pinkish, spongy, and elastic[8] organs, enveloped in a membrane termed the *pleura*.[9] The cavity in which the lungs are situated is termed

(2) THE THORAX. This may be regarded as a conical box, having its small end turned upwards, the spinal column forming its back part, the ribs its sides, the roof of the neck its cover, and the diaphragm its floor.[10]

(3) THE RIBS (See Lesson 2) are attached to the spine behind, and to the breastbone in front. They are moved by muscles termed "*Intercostals*,"[11] which are divided into two classes, external and internal. The former extend downwards and forwards from the rib above, the latter downwards and backwards. The effect of the former is to *raise* the ribs, that of the latter to *depress* them. Their action will be more easily understood by reference to the annexed diagram :—

Fig. A.

THE RIBS AT REST.

BB=back bone.

1 3 }
2 4 } =2 ribs.

5 6 = the external intercostals extending downwards and forwards.

7 8 = the internal intercostals extending downwards and backwards.

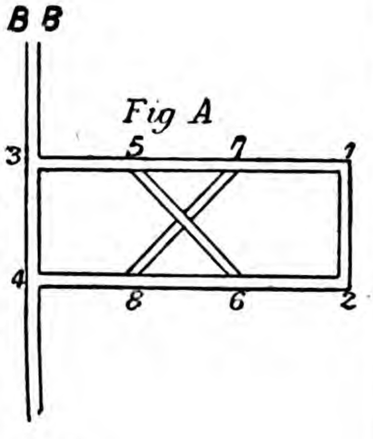
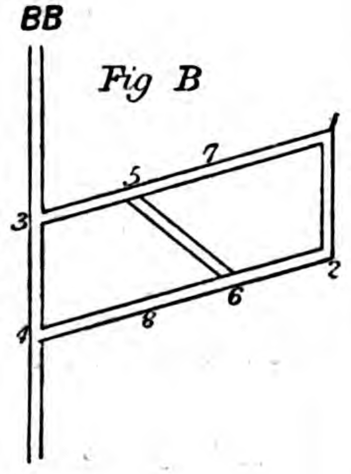


Fig. B.

INSPIRATION.

In which the ribs are raised and the diaphragm descends, hence the cavity of the thorax is enlarged.



[8] Experiment to prove this: Blow down the trachea into the lungs of a sheep, and if not injured, they will immediately become distended.

[9] Hence the disease called "*pleurisy*."

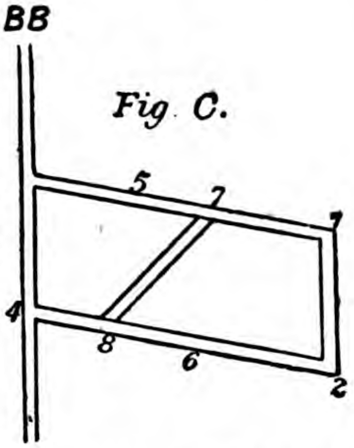
[10] See that this is clearly understood.

[11] L. *inter*=between, and *costa*=a rib; hence they are so called on account of their situation.

Fig. C.

EXPIRATION.

In which the [redacted] ribs are lowered and the diaphragm ascends, hence the cavity of the thorax is diminished.



(4) THE DIAPHRAGM[12] (See Lesson 1) is a partition separating the thorax from the abdomen. It is convex towards the former, and concave towards the latter. It is furnished with strong muscular fibres, which, in contracting, tend to flatten it and thus increase the capacity of the thorax.

II. How breathing is effected.

We inhale and exhale air; that is, breathing is the result of the action of inspiration and expiation combined.

(1) INSPIRATION.[13] Here the diaphragm *descends*, driving the contents of the abdomen downwards, and enlarging the walls of that cavity. At the same time the external intercostals *raise* the ribs, and thus produce a distension of the thorax; that is, it becomes inflated with air.

(2) EXPIRATION. Here the diaphragm *ascends*: at the same time the internal intercostals descend, the consequence is that the cavity of the thorax is diminished and the air is driven out of the lungs.

REMARKS. Expired air differs from air inspired; in,

(1) Having a higher temperature (98° or 100°).

(2) Being charged with moisture.

(3) Gaining about 5 per cent. of Carbonic Acid, and losing 5 per cent. of Oxygen.[14]

From (3) it follows that when the air contains too great a proportion of Carbonic Acid, it becomes injurious, if not fatal to animal life. Such air, if continually inhaled, produces *Asphyxia*, or suffocation. It is the result of two influences:—

(a) Scarcity of Oxygen.

(b) Accumulation of Carbonic Acid.[15]

[12] Gr. *dia*=through, and *phragma*=a fe nce

[13] L. *spiro*=I breathe
in=in.
ex=out.

The teacher must be very careful to see that these actions are understood.

[14] Proof: breathe upon the palm of the hand when placed before the mouth.

Proof: breathe upon a pane of glass, or a slate, when the vapour deposited will present an appearance analogous to the formation of dew.

Proof: breathe through a weighed quantity of transparent lime water; it will be cloudy, and if reweighed will be found to be heavier. (Why?)

[15] Refer, by way of illustration, to the "Black Hole of Calcutta."

LESSON VIII.

THE SKIN AND ITS USES.

MATTER. | **METHOD.**

The whole body is provided with a tough covering, called the Integument or Skin.

I. Structure.

The skin consists of two layers :—

(1) THE EPIDERMIS,[1] also called the cuticle, or scarf skin. It is the outside layer, and is of a horny texture. It is often shed in the form of scales.[2] It is destitute of nerves and blood vessels, and consequently does not bleed when wounded. Underneath this lies

(2) THE DERMIS, OR VERA CUTIS.[3] This, as its name implies, is the *true* skin. It is abundantly supplied with nerves and blood vessels, and is consequently very susceptible of injury.[4] Between (1) and (2) a third layer is found, termed

(3) THE RETE MUCOSUM. This gives to the skin its real colour, the cuticle of a negro being as white as our own.[5]

(4) THE PORES. Examined under the microscope the surface of the skin is found to contain an immense number of very diminitive holes, termed *pores*. They are the extremities of tubes about ¼ of an inch long, which lie embedded in the dermis. They terminate in coils, called

(5) SWEAT GLANDS,[6] and it is by means of these that the perspiration finds its way to the surface of our bodies. These glands are not distributed equally all over the body, *e.g.*, in the back and neck there are not more than 400 to a square inch, while on the palm of the hand and sole of the foot there are as many as 2,000 or 3,000 in the same space. In addition to the sweat glands, the skin also contains

(6) SEBACEOUS GLANDS,[7] so called because they consist of minute sacs of fatty matter. Their function is to keep the skin soft.

(7) THE PAPILLÆ are little conical elevations on the surface of the true skin, immediately below the cuticle. It is by means of these that we are enabled to feel, and this sense of touch is found to be most acute in those parts where the papillæ are most numerous. (Vide Lesson 22).

[1] Gr. *epi* = upon. Why so called? Illustrate by reference to *epidemic*.

[2] Ask for examples: cutting corns; portions of dry skin peeling off, &c.

[3] L. *vera* = true, *cutis* = the skin.

[4] As a proof refer to the effects of shaving with a blunt razor, in which the edge of the instrument penetrates to this skin, thus causing the part to bleed.

[5] Proof: A blister raised on the skin of a negro is *white*.

[6] Ask why so called.

[7] L. *sevum*=suet.

II. Uses.

These are the following:—

(1) THE SKIN REGULATES THE TEMPERATURE OF THE BODY.[8] "Man is thus enabled under the scorching rays of a tropical sun, upon the banks of the Senegal, to support a heat which causes spirits of wine to boil." (Collins's El. Phys. Geog., page 143).

(2) IT EXCRETES, OR GETS RID OF IMPURITIES FROM OUR BODIES.[9]

(3) IT IS THE ORGAN OF TOUCH.

REMARKS. It is a curious fact illustrating the necessity of keeping the pores of the skin open, that if a coat of varnish, or other substance impervious to moisture, be applied to the exterior of the body, death will ensue in about 6 hours. The experiment was once tried on a child at Florence. On the occasion of Pope Leo the Tenth's accession to the Papal chair, it was decided to have a living figure to represent the Golden Age, and so a child was selected and varnished all over and gilded with gold leaf. The child died in a few hours.[10]

[8] Show how, and refer to the case of Sir C. Blagden, who remained without any great inconvenience in a room heated to 264°. (See Chambers' "Animal Physiology," p. 50), and illustrate by the fact that a *live* animal might live in a *hot* oven, while a dead one would be cooked. (Why?)

[9] Hence it is one of our *excretory* organs, the lungs and kidneys, being the others. Ask what would be likely to happen if the pores were closed by dirt, and hence deduce the importance of keeping our bodies clean.

[10] Shew the application of this.

LESSON IX.

HOW THE BODY IS NOURISHED.

MATTER.

N.B. This subject should follow the Lesson on "Teeth" in the First Series, page 90. It will be found to embrace matter sufficient for *four* lessons, and it is usual to regard it as consisting of 8 processes :—

(1) PREHENSION,[1] or the taking of the food into the mouth.

(2) MASTICATION, or the grinding of the food by the teeth.

(3) INSALIVATION, or the mixing of the food with the saliva.

(4) DEGLUTITION,[2] or the swallowing of the food.

The above processes take place *before* the food enters the stomach, and may, therefore, be considered as preliminary.

(5) CHYMIFICATION, or the digestion of the food in the stomach.

(6) CHYLIFICATION, or the digestion of the food in the intestines.

METHOD.

[1] L. *prehendo* = I seize. Illustrate by reference to the monkeys of S. America, which have *prehensile* tails, enabling them to *seize* hold of the branches of the trees among which they live.

[2] L. *de*=down, and *glutio*=I swallow.

(7) ABSORPTION,[3] or the passage of the nutritious portion of the food into the blood.

(8) DEFŒCATION,[4] or the getting rid of the innutritions portions of the food.

The organs concerned in the nourishment of the body, constitute the alimentary apparatus.

(1) PREHENSION. This implies the seizing of the food by the mouth, which is a cavity having for its roof the hard palate, for its floor, the lower jaw, which is movable, and being bounded on each side by the cheeks. The space between the two jaws is occupied by the tongue. At the back of the mouth lies the pharynx, which is the upper portion of the œsophagus (See Lesson 1) or gullet, down which the food passes, being prevented from entering the glottis (the upper portion of the respiratory apparatus) by means of a trap-door, termed the epiglottis.[5]

The food, having been taken into the mouth is now subjected to the process of

(2) MASTICATION, or chewing, at which stage the saliva[6]

(3) INSALIVATION of the mouth comes into play and moistens the mass, the teeth of the upper jaw working upon those of the lower, grinding it to a pulp, and the muscles of the cheek with the assistance of the tongue forcing backwards on to the teeth any portions of food which may happen to slip off. The saliva is poured forth from four sets of glands :—

(a) The Buccal glands, which are distributed over the lining of the mouth.

(b) The Parotid[7] *glands*, one under each ear. These pour their contents into the mouth opposite the second grinding tooth.

(c) The Submaxillary[8] *glands* } Each open un-
(d) The Sublingual[9] *glands* } der the tongue,
the latter duct being nearer the front of the mouth than the former.

The saliva acts *only* upon the starchy portions of our food, converting them into sugar.

The food having been thus sufficiently ground and moistened, is now passed backwards to the pharynx, and here commences the act of swallowing, termed

(4) DEGLUTITION, the epiglottis inclining backwards and downwards over the glottis, thus forming a bridge by which the mass of food can travel over the opening of the air passage without any risk of tumbling into it, the soft palate guiding it from above, and keeping it out of the

[3] L. *sorbeo*=I suck.

[4] L. *de*=down, and *fæces*=dregs.

[5] Gr. *epi*=upon. So called because it rests *upon* the glottis. Here draw attention to the fact that when food happens to enter this tube, it is said to have gone the "wrong way."

[6] Commonly called "*spittle*."

[7] Gr. *para* = beside, *ous*=an ear.

[8] L. *sub* and *maxilla*=under the jaw.

[9] L. *sub* and *lingua* =under the tongue.

[10] Here explain that food and drink *do not fall down* the gullet, but that they are forced gradually downwards

the nose. It is thus propelled down the pharynx, and into the œsophagus, the muscular fibres of which by their contraction, contribute to its downward motion, until it reaches the stomach.[10]

N.B. In man (2 and 3) always precede (4), but birds swallow their food and masticate it in their gizzards, which act as grindstones.

by muscular contraction.

Proofs: Horses and oxen drink with their mouths lower than their stomachs, and jugglers drink while standing on their heads.

LESSON X.

HOW THE BODY IS NOURISHED.

CHYMIFICATION.

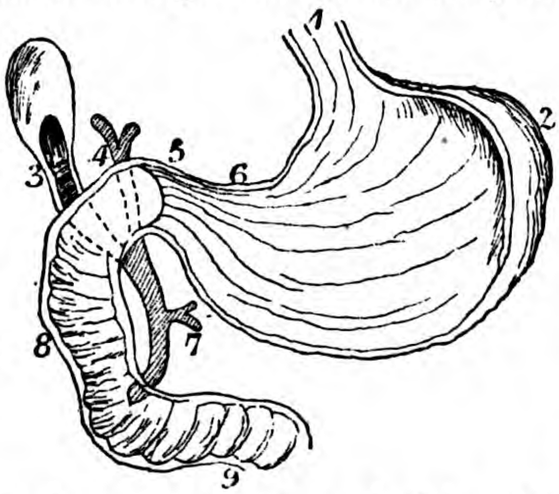
MATTER.

The food having reached the lower end of the gullet, enters the stomach, the structure of which we must now consider.

I. Structure of the Stomach.

The stomach is a curved bag or pouch lying across the abdomen, and capable of holding, when full, from 3 to 5 pints of food. It has muscular walls, and is provided with two openings, one of which communicates with the œsophagus, and the other called the pylorus,[1] with the intestines. This latter is provided with a powerful muscle termed a *sphincter*, the relaxation of which allows digested food to pass it.[2]

The stomach is largest at its left side, and gradually narrows towards its right. Its interior is furnished with numerous minute glands containing a fluid termed *Gastric Juice*.[4]



When the food reaches the stomach it is rolled from side to side by the contraction of its muscles, until it becomes thoroughly mixed with the gastric juice, which process reduces it to a pulpy mass

METHOD.

Let the teacher briefly recapitulate the preceding lesson before proceeding to a consideration of this portion of the subject.

[1] Gr. *pule*=a gate, *ouros*=a guardian.

[2] Shew the action of this muscle, and hence deduce the importance of thoroughly masticating our food.

[3] Let the teacher provide himself with this diagram on a large scale, or sketch it on the blk. bd.

1=The Œsophagus or gullet.
2=The cardiac dilatation.
3=The gall bladder.
4=The biliary duct.
5=The pylorus.
6=The small curvature.
7=The pancreatic duct.
8, 9=The duodenum.

[4] Gr. *gaster*=a belly; hence the gastric fever, arising from the derangement of this portion of the system.

termed *chyme*, which is about as thick as pea soup. The gastric juice assists in the process of digestion which the saliva had commenced, but it has no effect upon fatty matter, nor upon any *living* body.

The following statements are furnished by Chambers's Animal Physiology, page 22, as illustrative of the action of the gastric juice :—

(1) A German, who boasted of his power of swallowing stones, &c., was made to swallow silver balls, in which were placed various articles of food, such as raw meat, fish, potatoes, turnips, &c. All these substances were entirely dissolved in from 24 to 36 hours.

(2) Live leeches and worms were enclosed in a similar manner, and were also completely dissolved, the animals being first killed by the high temperature of the body.[5]

N.B. The above experiments were performed by Dr. Stevens, of Edinburgh.

(3) Dr. Beaumont, in America, hired a young Canadian, named Alexis St. Martin, as his servant. Through a hole in his stomach, which had been caused by a gun-shot wound, and had not healed, he was enabled to watch the action of the gastric juice, and he found that

(*a*) A dinner of roast beef, bread and potatoes, was reduced in half-an-hour, to a mass resembling thick porridge.

(*b*) In five and a half hours, after a breakfast of sausages, coffee and bread, the stomach contained only a few small pieces of gristle and the spice of the sausages.

[5] Refer to the property of the gastric juice above alluded to.

LESSON XI.

HOW THE BODY IS NOURISHED.

CHYLIFICATION.

MATTER. | **METHOD.**

In the last lesson we saw how the food was subjected to the process of digestion in the stomach : we now proceed to consider what takes place in

I. The Intestines.

These consist of a long, fleshy tube,[1] with muscular coats. In physiological diagrams they

[1] See lesson 1.

are seen coiled up in the lower part of the abdomen.[2] They are divided into two kinds, (1) small, and (2) large.

(N.B. The large intestines will be spoken of in the next Lesson.)

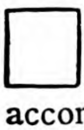
(1) SMALL. Commence at the pylorus, and consist of:—

(*a*) *The Duodenum*, so called because it is about 12 in. long.[3] It is provided with muscular flaps, which prevent the food from passing along too rapidly.[4]

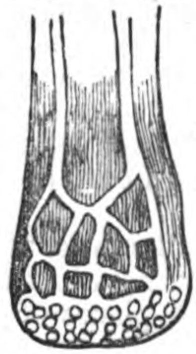
(*b*) *The Jejunum*, and

(*c*) *The Ileum*. All these are of equal size.

The interior of the intestines is covered with an immense number of very small hollow projections, each furnished with a small vessel, the function of which will be seen hereafter. These projections are termed "*villi*,"[5] because when viewed in a mass they present the appearance of velvet. They are very minute, being about $\frac{1}{30}$ of an inch long, and are so closely set that 4 or 500 of them would be contained within a space equal in area to the annexed figure.



The structure of the villi[6] will be more easily understood by reference to the accompanying diagram, in which *a* are clusters of cells arranged about the point of the villus, and *b* vessels running into them.



II. Chylification.

The chyme, having passed into the small intestines, becomes mixed with the two following juices:—

(1) BILE, which is formed in the liver, and poured into the intestines from the gall bladder, (the receptacle of the bile) by means of the biliary duct, (See the diagram.) The bile is a greenish yellow fluid, oily-looking, and having a bitter taste. It will readily mix with water, frothing like soap, and like soap too, will dissolve oily matters.[7]

(2) THE PANCREATIC JUICE is derived from the pancreas. These two liquids act upon the fatty portions of our food, which the saliva and gastric juice had left unchanged, and convert them into a milky mass termed *chyle*.[8]

[2] Allude to the intestines of a pig, commonly known as "*chitterlings*."

[3] L. *duo* = two and *decem* = ten. Refer to "*duodecimals*."

[4] Show that this arrangement assists in promoting the absorption of the nutritive portions of our food into the adjacent vessels.

[5] L. *villus* = a hair or nap.

[6] As an illustration of the manner in which the villi are supplied with blood-vessels, reference may be made to a piece of French cambric, taking care to explain that the threads of the latter represent the hollow blood-vessels of the former.

[7] Hence an ox-gall is used to remove grease spots from woollen cloth.

[8] Gr. *chulos* = food.

LESSON XII.

HOW THE BODY IS NOURISHED.

ABSORPTION AND DEFŒCATION.

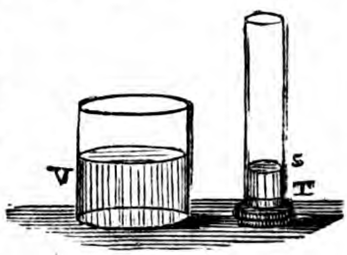
MATTER.	METHOD.

I. Absorption.

Having spoken of the formation of chyle in the preceding lesson, we have now to consider how it finds its way into the villi, *i.e.*, how it becomes absorbed into the system. The walls of the villi consist of a very delicate membrane, through which chyle penetrates, according to a process termed

Osmosis,[1] by means of which the contents of two *adjacent* membranes are enabled to interchange, the lighter passing to the heavier, and *vice versa*.

" The process of osmose may be conveniently observed by tying a piece of bladder closely over one end of a wide glass tube, as represented at T in the sketch. If, then, syrup be poured into the tube until it is about one-fourth full, as shewn at S, and the whole be set into a vessel, V, filled to about the same height with pure water, and be left there for some time, it will be seen that the syrup gradually rises up into the tube, against the force of gravity, at the expense of the water in the outer vessel." * * * *



" Portions of syrup pass outwards into the pure water, as well as portions of the water passing inwards into the syrup." Dr. Mann's " Veg. and An. Life," pp. 72 and 73.

Formation of White Corpuscles.

The vessels with which the villi are furnished (see Lesson 11) are termed *lacteals*,[3] because they contain the chyle which has a milky appearance. They look very much like white worsted threads. The food passes along the lacteals until it enters kernel-like projections termed *mesenteric glands*,[4] which are furnished with a number of very minute cells, not unlike white raspberries, but much more diminutive. When the food passes out of these glands it is found to

[1] Gr. *osmos* = a pushing forward.

[2] The teacher must be careful to show the application of this experiment to the subject under consideration.

[3] L. *lac* = milk.

[4] Gr. *mesos* = middle, *enteron* = the bowels.

be laden with these raspberry-like bodies, which are termed "white corpuscles."[5] These glands are so called because they are situated in the mesentery, a membrane, which, as a connecting web, envelopes and sustains the folds of the lacteals. It is attached to the lower part of the backbone, and its outer edge to the folds of the intestines.

"The lacteal vessels run along this fan-shaped web (taking the place of the rays of the fan) until they all meet together near its attachment to the backbone."—(Dr. Mann's Vegetable and Animal Life, page 154.)

Here they pour their contents into a kind of store-house, termed the *receptacle of the chyle*, which has a tube, about the size of a crow quill, attached to its upper end. This tube is called the *thoracic duct*,[6] and along it the chyle passes until it enters the current of the blood by means of the *sub-clavian vein*.[7]

II. Defœcation.

The nutritious portion of our food having entered the current of the blood, the undigested portion is passed into the

(2) LARGE INTESTINES, between which and the small intestines is placed the ileo-cœcal valve, which prevents the backward passage of the food.

The large intestines consist of three parts :—

(*a*) The ascending colon.[8]

(*b*) The transverse colon.

(*c*) The descending colon.

Two peculiarities mark the large intestines. They are provided with :—

(*a*) *Longitudinal muscular fibres*,[9] which are shorter than the intestines themselves, and produce their puckered-up appearance.[10]

(*b*) *The Rectum*, which is the extremity of the descending colon, and is furnished with a sphincter muscle (see Lesson 10) which relaxes only at the time of defœcation.

[5] Illustrate this by a process which may be seen at Plymouth, for making ship biscuits. Flour and water enter the machine on one side, and stamped biscuits come out at the other. (Explain, showing the application.)

[6] So called because it presses upwards through the back part of the chest.

[7] L. *sub*—under, and *clavis*=the collarbone. (See lesson 2.)

Here show the necessity for good food, for here is the chyle (which is the essence of our food) entering the blood, which has been well called "the river of life."

[8] Shew that these are named from the direction they take.

[9] L. *Longitudo* = length; so called because they are arranged in the direction of *the length* of the intestine.

[10] Illustrate by reference to the "reefing" string of a bag or of a child's pinafore, in which the string represents the muscle and the bag or pinafore the intestine.

LESSON XIII.

THE MUSCLES.

MATTER.

I. What a Muscle is.

A muscle is an accumulation of fibres* of flesh which possess the power of contracting, which

METHOD.

Allow the class to close their hands as in the act of grasping, at the same time drawing property shortens the distance between the two ends of the muscle, but increases its bulk.[1]

The end of the muscle which is attached to the fixed bone is termed its *origin*, and that which is fastened to the movable bone is called its *insertion*.[2]

Muscles are generally arranged in pairs, their actions counterbalancing each other, hence the one is said to be *antagonistic* to the other,[3] *e.g.*, the biceps muscle of the upper arm enables us to bend it, and when we wish to straighten it again, the triceps muscle, at the back of the arm, brings it back to its original position.

II. Classification.

A three-fold classification has been adopted :—

(1) ACCORDING TO STRUCTURE.

(*a*) *Hollow muscles*. Such are the muscles of the heart, of the alimentary canal, the various blood vessels and glands, and those of the eye.

(*b*) *Solid muscles*. These are attached to the bones of the body, thus constituting a system of levers.[4] They are fastened by means of white, tough, and *inelastic* cords, called *tendons*.[5] "These play the same parts to the bones that the harness plays to the carriage. When the muscles contract, they pull the tendons, which pull the bones, just as when the horses pull the harness, the harness pulls the carriage. A good illustration of a tendon is presented in the yellowish white cord in the leg of a fowl, which draws up or closes the foot and claws." (Collins's El. Physiology, page 147).

(2) ACCORDING TO SHAPE.

(*a*) Broad, flat, and strap-like, as those of the trunk.

(*b*) Long and narrow bundles, as those of the limbs.

(3) ACCORDING TO THEIR ACTION.

(*a*) Those which bend the arm are termed *flexors*,[6] as the biceps[7] muscle of the upper arm.

(*b*) Those which straighten the arm are called *extensors*,[8] as the triceps[9] muscle.

(*c*) Those which surround an orifice are called *orbicular*,[10] or sphincter muscles.

(*d*) Those which draw one limb *from* another are *abductors*.[11]

(*e*) Those which draw one limb *towards* another are *adductors*.[12]

(*f*) Those which raise a limb are called *levators*.[13]

the forearm upward towards the shoulder. They will then observe that the centre of the upper arm increases in size. This is owing to the alteration in the shape of its muscle.

[1] Refer to the above experiment.

[2] Refer again to the above experiment, in which the origin of the muscle is found to be at the shoulder (the fixed bone) and the insertion in the upper part of the forearm.

[3] Gr. *anti*=against, and *agou*=a contest. Illustrate by reference to combatants.

[4] Show how and explain.

[5] L. *tendo*=I stretch. Shew that this word "tendons," is a misnomer as applied to the quality of the tendons themselves; but that the name has been given to them on account of the effect which they produce on the muscles, by their *inelasticity*, i.e., their effect is of a *passive* rather than of an *active* nature.

[6] L. *flecto*=I bend.

[7] Because it consists of two parts.

[8] L. *ex* = out, and *tendo* = I stretch.

[9] Consisting of three parts.

[10] L. *orbis*=a circle, Ask for examples.

[11] L. *ab*=from, and *duco*=I lead.

[12] L. *ad* = to, and *duco*=I lead.

[13] L. *levis*=light.

(*g*) Those which lower a limb are called *depressors*.[14]

III. Uses.

Muscles enable us to move our limbs as we require, and also assist us in going from place to place, *i.e.*, our muscles are the chief agents in producing motion and locomotion.[15]

REMARK. The property of muscular contractility may be well illustrated by the following anecdote[16] :—

"In front of St. Peter's Church, at Rome, stands an obelisk of red Egyptian granite, upwards of one hundred and twenty feet in height. It was conveyed from Egypt to Rome by order of the Roman Emperor Caligula, where it remained partly buried in the earth on the spot where it had been deposited, until about 250 years ago, when Pope Sixtus the Fifth, with the assistance of 41 strong and elaborate pieces of machinery, and the further aid of 800 men and 160 horses, succeeded in getting it out of the ground. Four months more were required to remove it to a further distance of 50 or 60 rods, and in that situation it at present stands. When they had at length conveyed it to the spot, the great difficulty was how to raise it. A pedestal was erected for it to stand upon, designed in the form of four lions; and by means of powerful machines and many strong ropes and tackles, its lower end was at length placed upon the pedestal. They then commenced, by the aid of machinery to raise the column; but when it was so far elevated as to be almost ready to stand, the ropes, it is said, had stretched so much by the enormous weight of the huge mass of granite, that the column could be moved no further. What was to be done? Fontana, the master workman, had strictly forbidden all talking; and the men stood still, holding upon the tackle so silently, that a whisper might have been audible. Suddenly an English sailor cried out, "*Wet the ropes.*" To the surprise of everybody, the ropes *contracted* sufficiently to raise the obelisk to its place upon the pedestal, and there it has now remained for nearly 250 years." (Girtin's "House I live in," pp. 95 & 96.)

[14] Shew the principle of *antagonism* as exemplified in these actions.

[15] Draw the attention of the class to the difference of meaning between these two words, the former implying movement of *a part of the body*, the latter of *the body as a whole*.

[16] The teacher must take care to shew its applicability.

LESSON XIV.

THE JOINTS.

MATTER.

I. Classification of Joints with Examples.

There are two classes of joints :—

(1) Immovable. (2) Movable.

(1) IMMOVABLE. The best examples of these are the sutures of the skull (See Lssson 1).

(2) MOVABLE. These are so called because they are capable of movement. They are divided into two kinds :—

(*a*) *Imperfect*, which admit of only partial movement. They are generally united by a layer of soft material. The vertebræ of the spine are examples of this kind of joint. They require great strength, but little movement.

(*b*) *Perfect joints* are distinguished by their freedom of movement. The shape of the bones at their extremities varies with the character of the joints, but generally the convex end of one works in the concave[1] extremity of the other, both being covered with a thin layer of cartilage to allow of free movement. This is further facilitated by the secretion of an oily fluid termed "*Synovia*," (See Lesson 2) which is stored away in small sacs lining the cartilages and sides of the joint.[2]

The principal examples of perfect joints are :—

Ball and socket joints, in which the spheroidal surface of one bone plays in the corresponding cup of the other, *e.g.* :—

The humerus, working in the glenoid cavity, which is *shallow*,[3] admitting of freedom of motion, and

The femur, working in the *deep* cup of the acetabulum.

Hinge joints are so termed because they admit of only two movements, backwards and forwards.[4]

Hinge joints are either *single* or *double*.

Examples of double hinge joints are :—

The head in nodding; the elbow; the knee; and the ankle.

Examples of single joints are :—

The metacarpal bone of the thumb articulating with the trapezium of the wrist.

N.B. The joints of the phalanges of the hand and foot are hinge joints.

METHOD.

In our last lesson we spoke of the muscles which we said are employed in moving our limbs. We will now turn our attention to **the Joints**, i.e., the method by which our bones are fastened together.

[1] Illustrate the meanings of these words by reference to the diaphragm (see lesson 1), or a railway arch.

[2] Shew the analogy between this provision of nature and the oil applied to the joints of machinery, both having the same tendency, viz., to lessen the effects of friction.

[3] Hence the comparative ease with which the arm is dislocated.

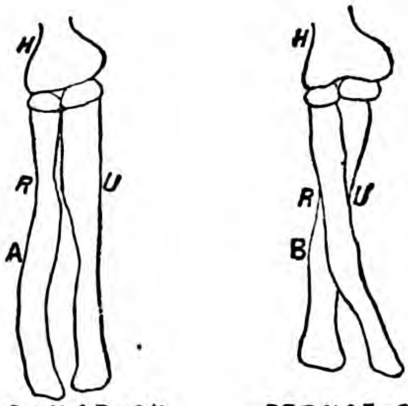
[4] Illustrate by reference to the hinge of a door.

(*c*) *Pivot joints* are formed by the projection of one bone fitting into a ring of the other, thus admitting of a rotatory motion.

Examples of pivot joints are :—

The head in turning upon the axis, and the rotating of the hand when the arm is laid upon a table.[5] Here the radius rotates, while the ulna is stationary.

(See accompanying diagram,) in which A is called supination, when the palm of the hand is upwards; and B is called pronation, when the palm is turned downwards.



SUPINATION PALM UPWARDS   PRONATION PALM DOWNWARDS

Certain checks are provided upon the action of the joints, termed—

II. Ligaments.[6]

Because they *bind* the joints, as it were, to perform only the actions which are required of them. They have different names, according to their shape; the following are the chief kinds of ligaments :—

(1) CAPSULAR,[7] those which cover ball and socket joints.

(2) LATERAL,[8] those which lie along the sides of ball and socket joints.

(3) CHECK,[9] such as that of the axis of the skull.

[5] Perform this experiment before the class, and see that it is understood.

[6] L. *ligo*=I bend.

[7] Refer to the metallic capsules of spirit bottles.

[8] L. *latus*=a side.

[9] Shew that if it were not for this ligament, the head, in nodding, would fall forward upon the chest and could not be raised.

LESSON XV.

THE SENSES.—SEEING.

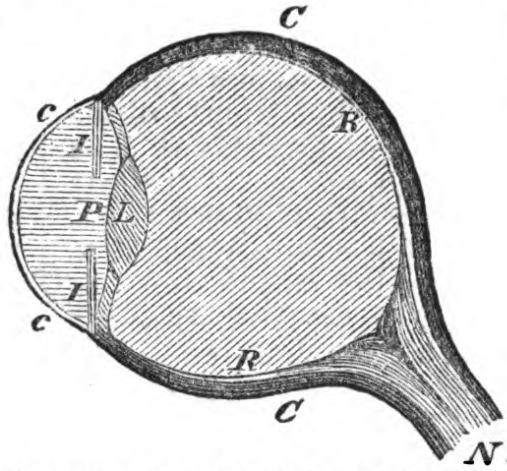
STRUCTURE OF THE EYE.

MATTER.	METHOD.
N.B. This subject will be found to contain matter sufficient for *four* Lessons.	What are those organs called by which we are enabled to see?

I. Structure of the Eye.[1]

The Eyes. In this lesson we will speak of the *structure of the eye.*

(1) THE COATS OF THE EYE. The eye ball is a spheroidal body, consisting of three coats—(*a*) The sclerotic, (*b*) the choroid, (*c*) the retina.



"The walls or shell of the globe are formed of coats of strong and tough fibrous membrane; but these coats are left transparent in front. In the sketch, the coats of the eye-ball are represented at C C. The front transparent portion of them extends from *c* to *c*, and bulges out more than the rest. It is called the cornea[2] of the eye." This portion of the eye is more convex than the remainder, so that the eye projects, as it were, in this part. When the sclerotic is removed, we come to the

(*b*) *Choroid* coat, which is a membrane plentifully supplied with blood vessels and nerves, and provided at the back with a black substance, called the *pigmentum nigrum.*[3] It is this coat which causes the black appearance of the pupil, and when wanting, the blood vessels showing through the aperture of the pupil, produce a pinkish appearance. Persons with such eyes are termed Albinos.

As the sclerotic changes its character in front of the eye, thus forming the cornea, so the choroid changes *its* character in the same part of the eye, forming a curtain called the *iris*,[4] in the centre of which is a hole called the *pupil of the eye.* This hole may be enlarged or diminished (according to the amount of light brought to bear upon the eye) by means of two bands of muscles, one set being circular and surrounding the iris, diminishing its diameter when the light is too strong, the other radiating from the pupil to the edge of the iris, thus increasing the size of the pupil, and admitting a greater number of rays of light.[5]

The pupil of the human eye is *round*, that of the cow and other animals feeding on herbage *elliptical*, with the long diameter horizontal;

[1] Constant reference must be made to a well-drawn diagram (which the teacher should have prepared) in order that the class may readily comprehend the situation of the various parts of the eye.

[2] L. *cornu*=a horn.

[3] From the Latin; signifies "black colour."

[4] From the Latin; signifies a "rainbow," and is so called from its diversity of colour.

[5] By way of illustration refer to the pupil of a cat's eye, which may readily be observed to dilate at night and contract in the day.

while, in the case of cats and other carnivora, which have to seek their prey above or below them, the pupil, though still elliptical, has its long diameter vertical.[6]

(*c*) *The Retina.*[7] This is the inner coat of the eye, and is so termed because it is spread out like network upon the interior surface. It varies in diameter from $\frac{1}{80}$ of an inch to less than $\frac{1}{160}$, and lines the whole of the interior of the eye with the exception of the part occupied by the iris. The retina is composed, partly of a delicate structure of rods and cones, and partly of nerve fibres. The spot of the retina which is most sensitive to the rays of light is termed the *macula lutea*, or yellow spot. It is plentifully supplied with rods and cones, but has no nerve fibres, hence the former are proved to be the chief agents in the transmission of light. This spot lies near the *optic nerve*, which originates in the back of the eye on the nasal side of the centre. Where the optic nerve enters the eye, the nerve fibres predominate, and an image resting on this spot is not perceived, hence it is called the "blind spot."[8]

The same effect would be produced in our own eyes, by standing before a window provided with shutters, having placed a looking glass in front of us. When the shutters are nearly closed the pupil enlarges, and when they are opened it diminishes.

6 Explain this and shew how animals are thus adapted to the mode of life they were designed to lead.

7 L. *rete*=a net.

8 An experiment to prove this will be found in Huxley's Elementary Lessons in Physiology, p. 244, and in Collins' Elementary Physiology, p. 168.

LESSON XVI.

SEEING.—THE STRUCTURE OF THE EYE (*continued*).

MATTER.

In addition to the coats of the eye, it is also provided with three humours :—

(2) THE HUMOURS OF THE EYE. These are :—

(*a*) *The Aqueous*[1] *humour*, so called from its being a fluid resembling water. It is situated between the crystalline lens and the cornea, and its function is to keep the latter in its place.[2]

(*b*) *The Vitreous*[3] *humour* is of about the consistence of thin jelly, hence its glassy appearance and name. Its office is to keep the sclerotic chamber full.

(*c*) *The Crystalline Lens* resembles thick jelly or gristle. This fact, together with its being in the form of a double convex lens (See Lesson 17) has given it its name. It is suspended in its place by bands of muscle. This lens sometimes becomes white and opaque,[4] producing partial blindness.

METHOD.

The teacher should recapitulate the previous lesson before continuing his subject.

1 L. *aqua*=water.

2 Refer to diagram and explain.

3 L. *vitrum*=glass.

4 Ask the meaning of this word, and hence explain the disease known as "cataract of the eye."

(3) THE MUSCLES WHICH MOVE THE EYE. The eye is also furnished with muscles, six in number. By means of them we move our eyes. The first muscle draws the eye upwards, the second downwards, the third outwards, the fourth inwards,[5] the other two enable us to rotate the eye.[6]

We have also

(4) ORGANS FOR PROTECTING THE EYE. These are :—

(*a*) *The Eyelids and Eyebrows.* The eyelids are folds of skin containing thin plates of cartilage, and fringed with hairs called the eyelashes. Along the edge of each lid is a number of little glands, called from their discoverer, *Meibomian* glands. The eyebrows co-operate with the eyelids in preventing the intrusion of particles of dust, etc., by forming as it were a sort of shelf on which these injurious fragments may lodge.[7]

a Lachrymal gland.
b ,, duct.

(*b*) *The Conjunctiva* is a membrane lining the eyelids, and front of the cornea. It is transparent where it covers the latter, and semi-opaque where it covers the former. It does not extend over the back of the eye, but bends forward to form the lining of the eyelids, at the edge of which it becomes continuous with the skin.[8]

(*c*) *The Lachrymal glands.* These are two small glands about the size of an almond. They are situated on the outer side of the eyeball, and they secrete a liquid which serves to moisten and wash the eye. The small canals through which they flow are termed the *lachrymal ducts.* They may be seen (by lifting the lids) close to the inner corner of the eye. These ducts open into the *lachrymal sac,* one end of which has no outlet, the other communicates with the nasal duct.[9] When the quantity of fluid secreted by the glands is greater than that which the ducts can carry off, it continues to accumulate, and ultimately overflows as tears.

REMARK. In connexion with the conjunctiva it may be useful to shew how the upper lid may be everted in order to extract any speck of dust or dirt which might produce irritation. The following method is extracted verbatim from Carpenter's Animal Physiology, page 420—"Close

[5] Shew what is meant by "outwards" and "inwards."

[6] The scientific terms for these muscles have been purposely omitted as being too technical for children.

[7] Here show that if we regard the eye as a window through which we gaze upon nature, the eyelids would be its shutters.

[8] Explain and shew the wisdom of the Creator. By this arrangement particles of dust are prevented from getting behind the eye.

[9] i.e., the duct of the nose: hence the necessity for blowing that organ when we cry.

the upper lid; next make pressure upon its upper part with a pencil, bodkin, knitting needle, or other hard body of small diameter; then, taking hold of the eye-lashes, draw the lower edge of the lid forwards and upwards. A little temporary discomfort is all that the displacement occasions, its lining membrane is then exposed, and any offending particle may be readily removed."

LESSON XVII.

SEEING.—HOW WE SEE.

MATTER.

N.B. In order that the class may the better comprehend the subject matter of the following head, the teacher should dwell at some length on the principle of the *camera obscura*, explaining the action of lenses as applied to photography, after which he may proceed to shew that

I. The Eye is in principle, a water camera.

The rays of light, in falling upon a double-convex lens, are refracted[1] as they pass through it, until, on the opposite side they meet in a point called the *focus*,[2] and afterwards cross each other.

If a watch glass be fitted into the side of a box which is filled with water, a candle may be so placed outside the glass that an image of its flame would fall on the opposite end of the box. If now a double convex lens were placed between the glass and the end of the box just referred to, it would have the effect of bringing the rays more quickly to a focus, because glass refracts light more powerfully than water.

APPLICATION. If for the box above mentioned we substitute the sclerotic, for the watch glass the cornea, for the water filling the box the aqueous and vitreous humours, and for the double convex lens the crystalline lens, we shall then be able to see the analogy between the action of the camera and that of the eye, bearing in mind that the back of the box answers to the retina, the iris, by its alternate dilation and contraction, taking the place of the photographer's diaphragm, or "stop," which is an opaque plate with a hole in the centre, and is used for the purpose of regulating the amount of light falling upon the camera.[3]

METHOD.

We have now considered fully the structure of the eye. In this lesson we shall try to understand how it is that we are enabled to see the objects around us.

[1] L. *re* = back, and *frango* = I break.

[2] Refer to a burning glass held a little distance from the back of the hand.

[3] Here shew the great superiority of the eye over the camera, the iris being *self-adjusting*, whilst the photographer must have recourse to several diaphragms to suit his varying circumstances.

Our camera, however, must be readjusted from time to time, according as the object to be photographed is near or distant.[4]

N.B. The teacher will now be able, by means of a diagram, to shew how objects seen by the eye are depicted on the retina.

The eye is enabled to *adapt itself* to view objects at different distances with equal distinctness.

This principle is called

II. The Adjustment of the Eye.

Many theories have been propounded in order to explain this, the principal being the following:—

(1) It was thought that the eyeball was compressed by the action of its muscles, but this would change the shape of the cornea. Then it was said

(2) That the lens shifted *bodily*, but the hinder part does not move. Others maintained that

(3) The iris pressed upon the front part of the lens; but, had this been so, the lens would not have remained stationary.

"Recent observations have successfully shewn that this adjustment is brought about by an *alteration in the curvature of the crystalline lens;* its convexity being increased when a near object is looked at, and diminished when the gaze is turned towards a distant object."[5] Carpenter's Animal Physiology, page 428.

[4] Refer to the sliding in and out of the lens of the camera. Illustrate by a person looking through an opera glass or a telescope.

[5] The class will experience no difficulty in comprehending this, if the action of lenses has been clearly explained.

LESSON XVIII.

SEEING.—VARIOUS EXPLANATIONS.

MATTER.

I. Luminous Impressions.

The image of an object cast upon the retina may appear to vanish instantaueously when another is looked at, but, in reality it is not so; every image has a certain duration, which lasts about $\frac{1}{8}$ of a second; hence, if two objects are seen by the eye in a less interval, they will appear as one.[1]

II. Colour Blindness.

Some persons are unable to distinguish one colour from another, and are therefore called

METHOD.

[1] Ask for proofs of this. Some of the class may probably mention the fact that a lighted stick turned round rapidly by the hand appears as a circle of fire. The teacher may then give one or two familiar illustrations.

(*a*) When a coach wheel revolves rapidly, the spokes are not *separately visible*, but ap-

colour blind. This failing is supposed to arise from an imperfect retina, in which case *all rays* produce a similar effect upon it.[2]

III. Long and Short Sightedness.

(1) LONG SIGHTED people have the cornea *too concave*, the rays of the image being focused too late, *i.e.*, they are not brought to a focus by the time they reach the retina. This defect (which is common in old age, the cornea flattening with advancing years) is remedied by the use of spectacles with *convex* glasses.

(2) SHORT SIGHTED people have the cornea *too convex*, the rays of the image being focused too soon, *i.e.*, before they reach the retina, hence the object is indistinctly seen. This defect may be remedied by the use of spectacles with *concave* glasses.

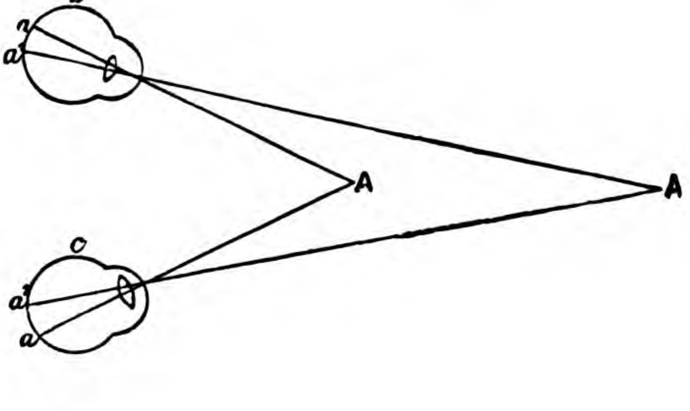
IV. Erect Vision.

Objects depicted upon the retina are inverted;[3] how then do we see them in their true position? Various attempts have been made to explain this; among others it has been suggested that such objects are interpreted by the brain as erect, from the fact that the fibres of the optic nerve *cross* before they reach that organ.

V. Single Vision.

As we have an image of the object in each eye, why do we not see *two objects?*

"When we fix our eyes upon an object, each eye arranges itself in a particular manner, thus:—Let B C be the two eyes and A the object. Draw Aa A,a, through the centre of the crystalline lens, and at right angles to the convex



pear as a *film* within the tire of the wheel.

(*b*) A flash of lightning appears as an unbroken line of fire.

(*c*) A falling meteor presents a similar appearance.

(*d*) Heavy rain appears as many *lines* falling to the ground.

[2] Shew how dangerous such a defect would be if it existed in railway guards or sailors.

[3] Shew that this is so by reference to the action of lenses.

surfaces. These lines are called the *optic axes*, and the angle between them aAa the *optical angle.* The eyes adjust themselves so that the optic axis intersect each other *at* the object. In consequence of this, a precisely similar image of the object is formed in each eye, and therefore a precisely similar impression of the object is conveyed to the mind. If either eye be prevented from thus adjusting itself, by slight pressure on the eyeball,[4] *double* vision results. Hence, persons who *squint* have always double vision. It thus appears that single vision arises from the circumstance that the image is cast upon *corresponding* parts of the retina in both eyes." (Collins's Elementary Acoustics, &c., page 63.)

[4] Let the experiment be performed by the class.

LESSON XIX.

HEARING.

THE STRUCTURE OF THE EAR.

MATTER.

N.B. This subject embraces matter sufficient for two lessons.

I. The Structure of the Ear.

The human ear consists of three parts :—

(1) The Concha, or External Ear.

(2) The Cavity of the Tympanum, or Middle of the Ear.

(3) The Labyrinth, or Internal Ear.

(1) THE CONCHA[1] is cartilaginous and concave.[2] In some animals the concha may be changed in shape according to circumstances, so that sounds may be collected from distances.[3]

(2) THE CAVITY OF THE TYMPANUM. This is joined to (1) by the *Meatus*, a passage about 1½ inch long. Between these two parts stretches the *tympanic*[4] *membrane*, commonly called the "*drum of the ear.*" This second part of the ear is supplied with

(*a*) *Air*, by means of a tube about 1½ inch long (called the *Eustachian*[5] tube,) running obliquely into the pharynx.[6]

(*b*) *Muscles*, one of which tightens the drum, the other relaxes it.[7] They are called the Stapedius and Tensor Tympani.

In this chamber of the ear are four small bones called the

METHOD.

We will speak to-day of the second of our five senses, viz., Hearing. What organs enable us to hear? **The Ears.**

[1] L. *concha*=a shell. So called on account of its shape.

[2] In order that it may the more readily collect sounds.

[3] Illustrate by reference to the ears of a horse, a hare, or a deer. Probably some of the class may have noticed these animals moving their ears.

[4] L. *tympanum* = a drum.

[5] Why so called? From its discoverer.

[6] Shew that the object of this is to keep the air in the cavity of the tympanum of about the same density as the external air, a provision by which the drum of the ear is maintained in its proper position.

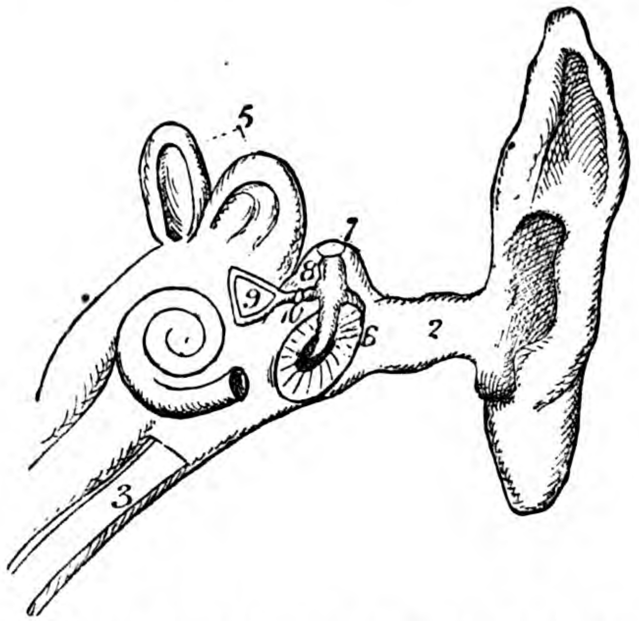
(*c*) *Auditory Ossicles.*[8] They are

The Malleus or hammer bone, one end of which is fastened to the tympanic membrane, while the other, which is round, works in a corresponding depression in

The Incus, or anvil. One end of this bone also is fastened to the wall of the membrane, while the other is in connection with

The Os orbiculare, or ring-shaped bone.

Joined to this is



The Stapes or stirrup bone, the foot plate[9] of which is fastened to a membrane, separating the cavity of the tympanum from the internal ear.

N.B. These four bones form the "*chain of the ear;*" the smallest of them is much less than a grain of mustard seed.

[7] Compare the action of these muscles with that of the muscles of the iris (lesson 15).

[8] L. *os* = a bone: hence *ossicles* = little bones. (Comp. "corpuscles," lesson 4.)

The teacher should either have this diagram already drawn upon a large scale, or sketch it on the blk. bd.

1 The concha.
2 ,, meatus.
3 ,, eustachian tube.
4 ,, cochlea.
5 ,, semicircular canals.
6 ,, tympanic membrane.
7 ,, Malleus or hammer bone
8 ,, incus or anvil bone
9 ,, stapes or stirrup bone
10 ,, os orbiculare or ring-shaped bone

[9] Refer to a stirrup.

LESSON XX.

HEARING—(*concluded.*)

MATTER. | **METHOD.**

I. Structure of the Ear (continued.)

(3) THE INTERNAL EAR OR BONY LABYRINTH. This is deeply set in the midst of a dense, solid mass of stony bone, called the *petrosal bone.*[1] It is divided into three parts :—

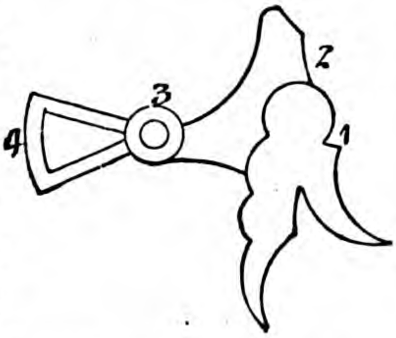
(*a*) *The Vestibule or Porch*, which is about the size of a grain of barley. An oval window (*the*

[1] Gr. *petros* = a stone.

fenestra ovalis) forms the medium of communication between this porch and the cavity of the tympanum. It is set in a membrane forming a partition between the porch and the cavity.

(*b*) *The Semicircular canals*, three in number.

(*c*) *The Cochlea*,[2] which also communicates with the cavity of the tympanum, the window, a round one, (*the fenestra rotunda*) being inserted in a membrance forming a partition. The cochlea is a spiral canal which makes two-and-a-half turns round a pillar.[3] It is divided into two parts:



BONES OF THE EAR.

(*a*) Scala Tympani } both of which are filled
(*b*) Scala Vestibuli } with a fluid called *perilymph*.

These parts run along its length and are divided by a thin partition termed the lamina spiralis. The cochlea is lined with a pulpy substance, upon which are distributed the fibres of the auditory nerve, known as the fibres of Corti. These present the appearance of a keyboard, and are capable of being agitated by the slightest impulse.

The labyrinth also contains a watery fluid, the *endolymph*, which assists in the production of sounds. It is also furnished with a number of diminutive particles, like sand, termed *otolithes or octonia.*

II. How sounds are communicated to the Brain.

All bodies which produce sound are in a state of vibration, or trembling, and these vibrations are communicated to the air, which is thus thrown into a state of undulation.[4] These waves of sound are, as it were, concentrated in the concha,[5] and through the medium of the meatus, carried to the tympanic membrane. Upon this they strike, setting the chain of bones in motion, which, in their turn, communicate the sounds through the bony labyrinth, to the cochlea, and so on to the auditory nerve.

N.B. For a more detailed account of the above, see Huxley's Elementary Lessons in

[2] L.=a snail's shell. Why so called?

[3] Illustrate by spiral staircases: ask for examples.

[4] Illustrate by reference to the motion of water, when agitated by a stick.

[5] Constant reference must be made to the diagram.

Physiology, page 236. The labyrinth is the essential part in hearing, for the tympanic membrane may be destroyed by disease and the chain of bones lost, and yet a certain degree of hearing be left.

REMARKS. Two provisions have been made against injury to the ear :—

(1) THE MEATUS is furnished with a bitter wax, which keeps insects out of it.[6]

(2) THE TYMPANIC MEMBRANE is a further check upon any intrusion.

Solid substances facilitate the transmission of vibrations,[7] thus :—A piece of stick held at each end between the teeth of persons partially deaf will enable each to hear the other's conversation more distinctly.[8]

[6] Why? Because insects love sweets. This affords another proof of the fact that we are "wonderfully made."

[7] Explain.

[8] Illus. by a tuning fork placed between the teeth, in order to hear the note given.

LESSON XXI.

SMELLING.

MATTER.

I. Structure of the Nose.

The nose is divided into two parts by the septum, which is a partition partly cartilage and partly bone. The two orifices thus formed are called the *anterior nares*,[1] (see Lesson 7, "posterior nares.") In its interior the nose is lined with a membrane called the Schneiderian membrane.[2] Spread out upon this is the *olfactory nerve*,[3] which is the first of the twelve pairs of nerves proceeding from the brain to the various portions of the body. In the back part of the nose are the "*posterior nares*,[4] by means of which we are enabled to breathe when the mouth is closed.[5] The upper part of the nose, between the eyes, is separated from the brain by a perforated[6] layer of bone, called the *cribriform plate*.

The nose is also furnished with three other bones :—

(1) The upper or superior turbinal[7] bone.

(2) The middle or superior turbinal bone.

(3) The inferior or lower turbinal bone.

N.B. The Olfactory Chamber, which is the true seat of smell, lies between (1) and (2.)

II. How we smell.

The particles of the air around us are, more

METHOD.

With which of our organs do we smell? **The Nose.**

[1] Commonly known as nostrils. L. *ante*=before; so called because they are in the front or *fore* part of the nose.

[2] Why? From its discoverer, Schneider.

[3] L. *oleo*=I smell, and *facio*=I make.

[4] L. *post*=after.

[5] (See lesson 7, "Respiration.")

[6] Ask for examples: illustrate by sheet zinc for doors of meat safes.

[7] So called from their spongy appearance, being full of small holes.

or less, laden with odours or smells of various kinds. Some of these, as we draw in our breath, enter the nose, but, under ordinary circumstances, only a small proportion of them find their way to the olfactory chamber; hence such odours are but faintly perceived. If, however, we *sniff* the air, a portion is drawn out of the olfactory chamber from behind, while, to supply its place, the air sucked in at the nostrils enters with a sudden vertical rush.[8] But it sometimes happens that the mucous membrane of the nose becomes inflamed, in which case the odoriferous particles are impeded in their progress towards the olfactory chamber. This explains the question "Why do we lose our smell when we have a cold?"

*REMARK. The nose is placed in the front of the face in order that the air which passes through it may be *tested* before it reaches the lungs. In this way the respiratory organs are preserved, to a great extent, from the action of injurious particles of matter.[9]

[8] Shew that this is why we sniff in order to perceive an odour more distinctly.

In all probability it would call forth some curiosity on the part of the class if the teacher were to ask, "Why is our nose in the front of our face?" Receiving no satisfactory answer, he might then proceed with the following.*

[9] Explain this, shewing that the Creator had special reasons for placing the organs of our senses in their respective situations.

LESSON XXII.

FEELING.

MATTER.

N.B. This sense differs from the other four, inasmuch as it is not confined to any particular portion of the body, but is distributed over the whole.

I. Structure of the Skin (see Lesson 8.)

The skin is furnished with multitudes of small, thickly-set projections, which are called *papillæ*, each of which is supplied with a delicate nerve fibre, which telegraphs, as it were, the feeling to the brain.

The sense of touch is most acute where these papillæ are most plentifully distributed, *e.g.*, at the tip of the tongue, and ends of the fingers.

II. Relative degrees of acuteness of touch, how determined.

Where the skin is thinnest, there the sense of touch is *generally*[1] the most acute, the papillæ lying near the surface.

METHOD.

Before proceeding to a consideration of this subject, the teacher should refer to lesson 8, "The Skin," which is the organ of touch or feeling.

[1] This is not *always* the case; hence the word "generally."

"If the ends of a pair of compasses (which should be blunted with pointed pieces of cork) are separated by only $\frac{1}{10}$ or $\frac{1}{12}$ of an inch, they will be distinctly felt as *two* if applied to the tips of the fingers; whereas, if applied to the back of the hand in the same way, only *one* impression will be felt, and on the arm they may be separated for a quarter of an inch, and still only *one* impression will be felt." (Huxley's Elementary Lessons in Physiology, page 214.)

Accurate experiments have been made in different parts of the body, and it has been found that

(1) The tongue, distinguishes two points, separated by only $\frac{1}{24}$ of an inch.

(2) The tips of the fingers distinguish *two* points when separated by only $\frac{1}{12}$ of an inch.

(3) The cheek distinguishes *one* point when separated by *one inch*.

(4) The back distinguishes only *one* point when separated by *three inches*.[2]

REMARKS. When we speak of one body being hot and another cold, we bear in our minds the effects produced by contact with such bodies. Thus—"Suppose three basins be prepared, one filled with ice cold water, one with water as hot as can be borne, and the third with a mixture of the two. If the hand be put into the hot water basin and then transferred to the mixture, the latter will feel cold; but if the hand be kept awhile in the ice cold water and then transferred to the very same mixture, it will feel warm." (Huxley's Elementary Lessons in Physiology, page 215.)[3]

The sense of warmth, as well as of touch, is more acute in some parts of the body than in others :—

Proof:—(*a*) A washerwoman holds an iron to her cheek to try its heat.[4]

(*b*) The palms of the hands are more sensitive to heat than the backs.[5]

[2] Ask what these experiments prove, to ascertain that the principle has been comprehended.

[3] The class will grasp this reasoning the more readily if the teacher sketch the following diagram:

No. 1.	No. 2.	No. 3.
Ice cold.	Boiling.	Mixture of both.

No. 2 and No. 3: A cold feeling.

No. 1 and No. 3: A warm feeling.

Shew from this that heat and cold are *comparative* terms.

[4] Ask why this is so.

[5] Ask how this may be proved; thus furnishing the class with experiments which each may perform for himself.

LESSON XXIII.

TASTING.

MATTER.

I. Structure of the Tongue.

The tongue is covered with mucous membrane, and is furnished, like the skin, with papillæ. These are of three kinds :—

METHOD.

Ask the class to mention the organ by which we are enabled to taste. The answer will be **The Tongue.** The teacher

(1) FILIFORM—found towards the tip of the tongue. They are elongated and pointed.

(2) FUNGIFORM. These occupy the middle of the tongue, and have broad ends and narrow bases.[1] Succeeding these in a backward direction are :—

(3) CIRCUMVALLATE, which are larger than (1) and (2), and are arranged in the shape of a V with its point backwards. Each of these resembles those of (2) surrounded by a wall.[2]

The tongue is supplied with two sets of nerves :—

(*a*) *The Glossopharyngeal Nerve*, which supplies its back part and the palate. This is the 9th pair of cerebral nerves.[3]

(*b*) *The Fifth Pair*, which supplies its front part.

REMARK. The tongue is placed at the entrance to the alimentary canal, because its chief use is to direct us in the choice of our food.[4]

N.B. This Lesson being shorter than those on the other senses, the teacher would do well to spend the remainder of his time on a brief revision of them.

may then explain that the word "*taste*" is derived from "*test*," the French word for trial; and hence shew the suitability of the term.

[1] Ask why they are so called. From their resemblance to that class of vegetation, known as "*fungi*," of which our mushroom is an example.

[2] Hence the meaning of the word as derived from L. *circum*=round about, and *vallum*=a rampart.

[3] i.e., the nerves proceeding from the brain.

[4] Compare the situation of the nose as mentioned in lesson 21.

LESSON XXIV.

THE HUMAN HAIR AND NAILS.

MATTER.

I. Structure of a Nail.

Nails are epidermis under a changed form. (See Lesson 8). Underneath each nail is the *bed of the nail*, which is a kind of groove.[1] It is full of blood vessels, and raised up into minute papillæ, the surfaces of which are covered with cells. As these grow they harden, and become flat scales, and, as these scales are constantly forming in the hinder part of the nail, those nearest the surface are forced to move upwards, thus causing the growth of the nail.[2]

II. Uses of Nails.

(1) They serve to protect the tips of the fingers and toes, which are full of delicate nerves, and

(2) They also afford a support to these extremities.

METHOD.

Let the teacher ask what we have at the ends of our fingers and toes. He will be told **Nails.**

[1] Illustrate by reference to the groove in which a watch glass fits.

[2] That the scales of which the nail is composed, were originally *cells*, may be proved by treating them with a dilute solution of soda, when they will swell out and resume their globular shape.

REMARKS. The nails should be kept properly trimmed, and not allowed to grow too long, "for when their edge projects too far, it interferes with the extreme point of the fingers being used, and is a hindrance in writing, drawing, &c." (Cassell's "Our Bodies," page 94.)[3]

I. Structure of a Hair.

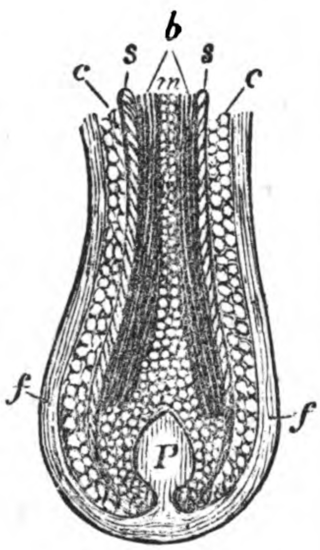
The formation of hair commences deep in the skin, in a kind of bag called a *hair sac* or *hair follicle*.[4] The lower portion of the hair, containing a number of cells, is termed the *bulb*. Continuous with this, in an upward direction, but narrower, is *the shaft*, consisting of :—

(1) A MEDULLARY[5] SUBSTANCE, or central pith.

(2) A CORTICAL[6] SUBSTANCE, surrounding (1) and made up of horny scales.

(3) AN OUTER CUTICLE, composed of flat, horny plates, which overlap each other like tiles.

Each hair sac is furnished with two glands, which provide it with a kind of *natural pomade*, and are hence called *sebaceous*[7] *glands* (see Lesson 8).



Muscular fibres are connected with the hair sac, and when these contract, as they sometimes do, under the influence of cold or terror, "*horripilation*" takes place. The skin then assumes the appearance known as "*goose skin*,"[8] and the hair is then said to "*stand on end*."

II. Uses of Hair.

(1) The hair protects the part upon which it grows from exposure. "The brain is of so frail a texture, and of such exquisite organization, that it cannot bear great sudden changes of temperature with impunity; hence the skin that covers the bony case in which the organ is lodged, has an outer defence of long, thick hair placed nearly all over it, in such a way that the natural warmth must be slow in escaping from within, even when the head is exposed to great exterior cold, and that great heat must be equally

[3] The teacher may here refer to the practice of the wealthy Chinese of allowing the nails of the left hand to grow until they are as long as the talons of a bird of prey, and thus shew to what extremes of folly fashion may lead.

[4] L. *folliculus* = a little bag.

[5] L. *medulla* = marrow. Shew why it is so called.

[6] L. *cortex* = bark. So called because it stands to the hair as the bark to a tree.

[7] L. *sevum*=suet.

f—the hair bag or follicle.
c—masses of cuticle cells.
b—the cortex, or bark of the hair.
m—the medulla, or pith
s—outer sheath of the hair.
P—follicular bag or papillæ.

[8] Refer, by way of illustration, to the naked arm on a cold day, when its surface is covered, as it were, with small conical elevations, which cause the limb to present the appearance of a newly-plucked goose.

hindered from finding its way in."[9] (Mann's "Vegetable and Animal Life," page 388.)

(2) It imparts additional beauty to the human form.

REMARK. "Hair, like other parts of the body, is liable to disease. In some parts of Poland and Hungary, the peasants, who greatly neglect the virtue of cleanliness, are afflicted with a grievous disorder of the roots of the hair, by which the whole becomes matted and tangled together."[10] (Girtin's "The House I Live in," page 110.)

[9] Here refer to the wisdom of the Creator iu, as seen in this provision.

[10] Hence deduce the importance of cleanliness.

PART II.—PHYSICAL GEOGRAPHY.

LESSON XXV.

FORMATION AND USES OF MOUNTAINS.

MATTER.

I. Introduction.

At one time our earth was, in all probability, of an uniform level, that is, its surface was not then diversified as it now is, by mountains and hills, and plains and valleys. These have been formed, from time to time, by the various forces of nature, acting sometimes singly, at others in combination.

II. Formation.

(1) It has been ascertained that the temperature[1] of the earth increases, as we descend, about 1° for every 54 feet, and from this fact it is inferred that, could we descend to a depth of 30 miles from the surface, we should come upon "an immense seething cauldron of fire."

(2) We know, too, that a large proportion of the rain which falls upon the earth's surface penetrates to a considerable distance into the interior; so far sometimes as to be acted upon by the fire to which reference has just been made.

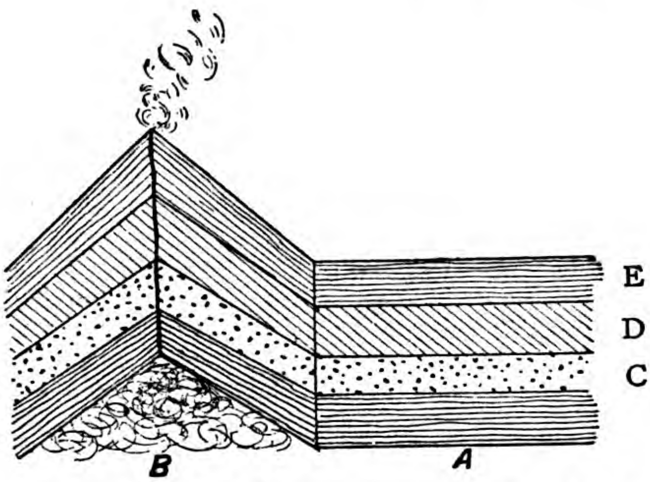
(3) The result of this action is that a large quantity of steam is constantly being generated,[2] and this process continues until the imprisoned steam finds vent by bursting the walls of its rocky house and suddenly upheaving the earth above it.

METHOD.

What name do we give to those portions of the earth's surface, which are raised considerably above its general level? **Mountains.**

[1] i.e. the degree of heat.

[2] Refer by way of illustration, to the boiling of water in a kettle.



(See the above diagram, in which A, C, D, E, are layers of the earth's crust and B the imprisoned steam.)[3]

III. Uses. Mountains

(1) Arrest the clouds, and thus cause rain, which fertilizes the soil.

(2) Give rise to springs, and hence the origin of brooks and rivers.

(3) Increase the earth's surface, thus rendering it less monotonous.[4]

(4) Protect countries from the cold north winds, and thus, by increasing their temperature, render them more fertile.[5]

(5) Reveal vast stores of mineral wealth, which probably would never otherwise have been discovered, and thus

(6) Create employment for thousands, and

(7) Increase our commerce.

(8) Determine the shape of the continents, and the courses of the rivers.[6]

(9) Form the boundaries of nations, and the strongholds of national freedom.[7]

[3] The teacher must take care to see that this diagram is understood.

The process of "upheaval" might well be illustrated by reference to "mole hills," the action of the steam being represented by the working of the whole.

[4] Explain: and derive the Gr. word *monos*=alone.

[5] Ask for instances:—The Alps (Plain of Lombardy, one of the most fertile districts in Europe).

[6] Show how and give examples, remarking that sometimes a mountain range extends almost in a direct line through the middle of a country, thus forming, as it were, its "backbone;" e.g., the Pennine chain, and the Apennines.

[7] Ask for instances of the former and illustrate the latter by reference to the Life of William Tell,—"Ye crags and peaks I'm with you once again."

LESSON XXVI.

EARTHQUAKES.

MATTER.

I. Kinds.

There are four principal kinds of earthquakes:—

(1) TREMULOUS. These are the least destruc-

METHOD.

Recapitulate the previous lesson, drawing attention to the fact that the pent-up steam (lesson 1, formation tive. They are common in Chili and the neighbourhood.[1]

(2) VERTICAL. Very destructive. They cause either an upheaval or subsidence of the land.[2]

(3) HORIZONTAL.[3] These rock the earth to and fro at the rate of 20 to 30 miles per minute.

(4) ROTATORY.[4] These are very rare, but most destructive. Isolated columns of statues have been found completely turned round by their action, so as to face a different quarter from that towards which they had previously turned.

Sometimes the agitation of the earth takes place in a direct line, in which case the earthquake is said to be *linear*, *e.g.*, the earthquake of Guadaloupe,[5] in 1842, which extended over an area 3,000 miles long, and from 60 to 70 broad.

Others again are *circular*, as the earthquake of Calabria,[6] in 1783, or *elliptical*, as that of Lisbon, in 1755.[7]

II. Distribution.

Earthquakes often take place in the same districts as volcanoes, but the most violent convulsions happen in localities remote from them.[8] The chief earthquake districts are :—

(1) The Mediterranean Basin.

(2) Central Asia.

These two are connected and extend from the Azores to Lake Baikal, thus forming the longest and most regular line of volcanic action in the world.

(3) Iceland.

(4) America. The earthquakes of this continent occur along the Andes, stretching into the North of S. America and the W. Indies.

III. Effects.

(1) They produce elevations and depressions of land, and often occasion violent movements in the ocean.

(2) They frequently cause great destruction of life and property, as will be seen by the following examples of

IV. Noted Earthquakes.

(1) LIMA.[9] In 1746. In this earthquake the port of Callao was destroyed.

(2) LISBON. In 1755. This earthquake was felt over an area four times the size of Europe. It shook the continent of Europe and rocked the

[3]) shakes the earth in making its escape, and hence **Earthquakes.** Illustrate by lid of a kettle rattling when the water boils.

1 Shew on the map.

2 Explain and shew the origin of the term. L. *vertex* = the top. They are so called because they have an up-and-down motion.

3, 4 Why so called?

5, 6, 7 Shew on the map, and draw attention to the fact that earthquakes may be classified :—

(*a*) According to the direction of the force, as, (1,) (2,) (3,) (4,) or,

(*b*) According to the *shape of the area of concussion.*

8 Why? Because the volcanoes act as a *vent* for the escape of the pent-up forces.

9 Refer to the situation of each of the places named under this head.

waters of L. Ontario in N. America, and the Atlantic Ocean was so agitated that many islands in the W. Indies were overflowed, and the waves rose 50 ft. at Lisbon above their usual level. The whole city, with 60,000 souls, was destroyed in six minutes.

(3) CUMANA. In 1797. In this earthquake 40,000 perished.

(4) CARACCAS. In 1812. In which 12,000 perished in 50 seconds.

(5) VALPARAISO. In 1822. In which the coast line of S. America was permanently raised for 50 miles to a height of 3 feet.

(6) S. AMERICA. In 1868. This was the most destructive earthquake of the present century. The Andes were shaken to the height of 13,000 feet. The convulsions were felt in New Zealand and the British Islands; and the ocean agitated over an area of 30 millions of miles.[10]

REMARK. Earthquakes sometimes happen without warning, but generally they are preceded by loud rumblings underground, resembling the roll of thunder or the rattling of heavy waggons over stone pavements.

[10] These facts should tend to inspire us with gratitude: show how.

LESSON XXVII.

VOLCANOES.

MATTER.

I. Introduction.

Volcanoes are portions of the earth's surface which occasionally throw out *fire*, together with various substances and liquids, such as *scoriæ*, (*i.e.*, cinders and ashes), *lava*, which is a mixed mass compounded of rocks and metals in a melted state; *hot-water*, *gases*, (chiefly carbonic acid and sulphuric acid), and *masses of rock and stone*, the latter known as pumice stone.

"Volcanoes *are not necessarily* mountains: the volcanic action may originate on level ground, either on the land or at the bottom of the sea;[1] but the ejected matter gradually increasing around the vent, in the course of time, forms a mountain. They are generally of large size, of a conical form,[2] with a cauldron-like hollow at the top, termed a *crater*."[3] (Collins's Elementary Physical Geography, p. 119.)

N.B. The volcanoes of the New World differ from those of the Old in ejecting no lava.[4]

METHOD.

You have heard of Etna and Vesuvius. What are they? **Volcanoes.** Shew the origin of the word as derived from *Vulcan*, the god of fire. hence "Vulcan-oes."

[1] Hence the origin of islands.

[2] Like a cone: illustrate by sugar loaves as seen in the windows of grocers' shops.

[3] Gr. *krater*=a cup or bowl.

[4] Why is this? Probably the lava cools before reaching the mouth of the crater, on account of the great height of the mountain.

II. Classification.

Volcanoes admit of a double classification :—

(1) ACCORDING TO THE FREQUENCY OF THEIR ERUPTION.

(*a*) *Continuously active*, *e.g.*, Stromboli, in the Lipari Islands, which is styled "The Lighthouse of the Mediterranean."[5]

(*b*) *Intermittent*, *i.e.*, those which occasionally break forth, *e.g.*, Vesuvius, Etna, Hecla, &c.

(*c*) *Extinct*, those of which no eruption is recorded, *e.g.*, the Auvergne Mts. in France.[6]

(2) ACCORDING TO THEIR SITUATION.

(*a*) *Central*, when their cones are *grouped*, *e.g.*, the Canary Islands, and the Peak of Teneriffe, the various groups of the Pacific.

(*b*) *Linear*, when the cones extend in a line, *e.g.*, the Andes, and those of Central America. These are by far the most numerous.

III. Distribution.

By far the greater number of Volcanoes are found on Islands or coasts, the only great exceptions are Pe-shan and Ho Chew in the Thian Shan range.[7] The most noted volcanic regions are the basins of

(1) THE PACIFIC, extending from Tierra del Fuego,[8] northwards through the Andes, and Central America to Aliaska; thence into the Aleutian Is., Kamschatka, Kurile Is., Japan, Loo Choo Is., Philippine Is., New Guinea, New Hebrides, Norfolk Is., and New Zealand to Mt. Erebus, in South Victoria Land.[9]

(2) THE ATLANTIC extends to the W. Indies on the West, to Iceland and Jan Mayen Is., on the North, and the basin of the Mediterranean on the South. (In this latter are included Vesuvius and Etna, the former in Italy, and the latter in Sicily.) The Greek Islands of Melos and Santorin, the Azores, and the cones of the Cameroon Mts. of Africa.[10]

IV. Effects.

(1) They reveal treasures of the earth which would otherwise remain unknown.

(2) They diversify the surface of the earth, causing either elevations or depressions.

V. Modifications of Volcanoes.

(1) SOLFATARAS, or Sulphur grounds, as the Peak of Teneriffe, and the cones of the Cameroon Mts.

[5] Ask why so called, to see that (*a*) is understood.

[6] Shew the situations of these volcanoes on the map.

[7] Shew on the map.

[8] i.e., The Land of Fire. (Shew why so called.)

[9], [10] Trace on the map of the world.

(2) FUMEROLES,[11] or Smoke vents.

(3) MUD VOLCANOES, as those of Java and Sicily.

(4) "FIELDS OF FIRE," or the burning springs of Naptha, near the Caspian Sea.

N.B. This spot was the place of pilgrimage of the ancient Guebres, or Fire-worshippers.

Similar to these are the Fire Springs, and Fire Hills of China.

(5) THE GEYSERS,[12] or hot-water springs of Iceland.

"The water at the edge of the basin has a temperature of 187° Fahr., but immediately before an eruption, that at the bottom of the deep tube or vent has been ascertained to be no less than 261,° or 49° higher than that of boiling water." (Collins's Elementary Physical Geography, page 125.)

N.B. For a full description of the Geysers, see page 100 of Nelson's "Royal Readers," No. 5.

VI. Noted Eruptions.

(1) VESUVIUS. A.D. 79, in which the towns of Herculaneum and Pompeii were destroyed; the former by lava, the latter by ashes.

(2) ETNA in 1669, in which the lava accumulated until it reached and ran over the walls of Catania, which were 50 ft. high.

(3) MT. JORULLO in Mexico. This mountain was formed in a single night, in 1759, the earth being upheaved to the height of 1,695 ft.

(4) TOMBORO in Sumbawa, one of the Sunda Is., in the E. Indian Archipelago. This occurred in 1815. The scoriæ was carried 300 miles in one direction and 200 in another, and was sufficient to cover the whole of Germany 2 ft. deep. The sound of the eruption was heard in Sumatra, a distance of 970 miles.

(5) HECLA in 1845, in which some of the ashes ejected, reached the Orkney Is., a distance of 700 miles.[13]

[11] L. *fumus*=smoke.

[12] An Icelandic word =roarers. Why?

[13] Shew all these localities on the map of the world.

LESSON XXVIII.

THE ATMOSPHERE.

MATTER.

I. Introduction.

The air is also called the Atmosphere.[1] It envelops land and water for a distance of upwards of 200 miles, though its density is not appreciated beyond a distance of 45 miles.

II. Properties.[2]

(1) IT HAS WEIGHT. Proofs :—

(*a*) Balloons, gas, clouds, and smoke, rise into the upper regions of the air, hence they must be *lighter* than the air.[3]

(*b*) A tumbler filled with water, having a piece of paper placed over it, and being inverted will retain its contents.[4]

(*c*) If a tube be placed in water and the mouth be applied to one end, the water may be made to rise in the tube.[5]

(2) IT IS ELASTIC.

(*a*) A bladder filled with air and pressed between the fingers, resumes its original shape when the pressure is removed.

(3) IT IS TRANSPARENT, *i.e.*, we can see clearly through it when *pure and dry*.[6]

(4) IT IS INVISIBLE. We cannot see *it*, though we can see its *effects*.[7]

III. Composition.

The atmosphere, when pure, is composed mainly of two gases, Nitrogen and Oxygen, combined in the proportion of 79 of the former, to 21 of the latter. It also contains small quantities of Carbonic Acid, (about 10 parts in every 10,000[8]) and Ammonia ; and more or less of watery vapour, according to the temperature.

IV. Air is the great medium for the transmission of Sound, Light, and Heat.

(1) SOUND. Air cannot be transmitted through a *vacuum*. This may be proved by ringing a bell under the receiver of an air pump, when it will be found, that, as the air becomes exhausted, the sound becomes fainter ; and, were it possible to produce a *perfect* vacuum, *no* sound would be heard.

METHOD.

In order to support life we must breathe. What do we breathe? **Air.**

[1] L. *atmos*=vapour, and Gr. *sphaira* = a sphere.

[2] Let as many as possible of these be given by the class.

[3] Illustrate by pressing a cork under the surface of a basin of water, when, on removing the finger, it rises. (Why?) Iron would sink. (Why?)

[4] Ask why; and shew that this is the principle of the boy's sucker.

[5] Why? Because the water is relieved from the pressure or *weight* of the air. Shew that this is the principle of the common pump.

(See lesson 95 of First Series.)

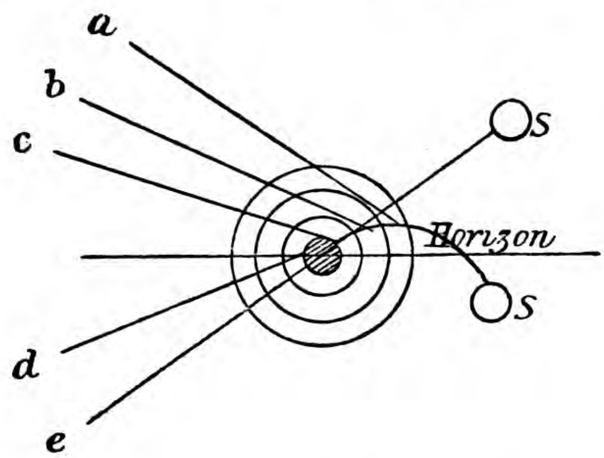
[6] Refer to the fact that when the air is overcharged with moisture this quality is, to a certain extent, destroyed.

[7] How? In the damage caused by wind, which is *air in motion*.

[8] Shew the wisdom of the Creator as exemplified in these proportions. Man and animals inhale oxygen and exhale carbonic acid; while, in the respiration of plants, the process is reversed. See p. 188 of Page's Adv. Text Book of Phys. Geog., pub. 1864.

(2) LIGHT. Out of 10,000 rays falling *vertically* towards the surface of the earth, 8000 reach it; but when the rays fall horizontally, only 5 out of 10,000 reach our eyes.[9]

The sun's rays are partly reflected, partly dispersed, and partly refracted[10] by their passage through the atmosphere, and the more so as they approach the earth's surface; hence, the sun is seen by us *before* he rises in the morning, and *after* he sets in the evening, i.e., we have, what is commonly known as, "*twilight.*"[11] The accompanying diagram will make this clear. S= the sun, E=the earth, the concentric rings,= the various strata of air, and the letters *a b c d*= the direction of the sun's rays.[12]



(3) HEAT. The rays of the sun are partly absorbed, and partly diffused over, the earth's surface, by the atmosphere. It is calculated that about $\frac{4}{10}$ of such rays are absorbed; but this proportion varies in different latitudes, and under different conditions of the air. "The direct heating effect of a vertical sun, at the sea level, is sufficient to melt half-an-inch of ice per hour; and thus it is one mode of expressing the influence of solar heat to say, that in one year it would liquefy[13] a shell of ice 100 feet thick, coating the earth."—(Ansted's Phys. Geog., p. 248.)

V. Uses.

(1) The atmosphere disperses light and heat over the surface of the earth, and enables us to hear sounds.

(2) Supplies to the lungs the oxygen which purifies the blood, and which is necessary to the support of flame; while, at the same time, it

[9] Hence the ease with which we can gaze upon the rising or setting sun.

[10] L. *re*=back, and *frango*=I break.

[11] See this graphically described on p. 187 of Page's Adv. Text Book.

[12] The teacher must be very careful to see that this is understood.

[13] i.e., turn to a liquid.

furnishes plants with the carbonic acid they require.

REMARKS. The pressure of the air, at the sea-level, is calculated at 15 lbs. to the square inch, i.e., an average pressure of 70 to 100 tons is resting upon every human being.[14] This has been ascertained by means of the barometer.[15] (See lesson on p. 94 of First Series.)

[14] Why does not this crush us? Because it is counterbalanced by the air within us.

[15] Gr. *baros*=weight, and *metron* = a measure.

LESSON XXIX.

WINDS.

MATTER.

N.B. This subject will furnish matter sufficient for two lessons; the teacher must choose for himself, where to make the division.

I. Causes of Winds.

(1) When any portion of the air becomes heated it expands and rises, and the colder air from the adjacent parts rushes in to supply its place. Hence there are established two aerial currents, the one, a hot, upper current, the other, a cold, under current.[1]

(2) The districts on each side of the Equator receive much more heat than those at the Poles, for in the former case the sun's rays fall *vertically*, while, in the latter, they reach the earth *obliquely*.

II. Classification.

Winds may be classified under four heads :—(1) Constant; (2) Periodical; (3) Variable; (4) Local.[2]

(1) CONSTANT WINDS.

(*a*) *The Trade Winds*. These are so called from their favourable influence upon trade or commerce. They prevail within the Torrid Zone and for a few degrees beyond it.

They are caused in the following manner :—The moist warm air of the Tropics rises and travels northwards; at the same time that the cold air from the Polar regions sets in towards the Equator to take its place. But, inasmuch as the earth, at the Equator, is revolving at the rate of 1000 miles per hour, the air from the Poles does not preserve its original direction, for it cannot, all at once, acquire this velocity, and hence it appears to *lag behind*, i.e., it becomes a

METHOD.

When air is in motion what do we call it? **Wind.** Let us consider how winds are produced.

[1] Show the analogy between these laws and the ventilation of a room, when it will be found, if the sashes of a window be opened a little at the top and bottom, the hot air escapes through the upper aperture, and the cold air rushes in by means of the lower. That the currents travel in these directions may be proved by noticing the effect produced upon a piece of lighted paper, when in the former case the flame will be bent *outwards*, and, in the latter, *inwards*.

[2] See that these terms are understood before proceeding to speak of each.

N.E. wind in the Northern hemisphere, and a S.E. wind in the Southern hemisphere.[3]

(*b*) *The Polar Winds*, are constantly blowing from the poles towards the Equator, but before they reach it, their direction becomes modified, and they merge into the Trade winds.

[3] Dwell upon this in order to impress it upon the minds of the class.

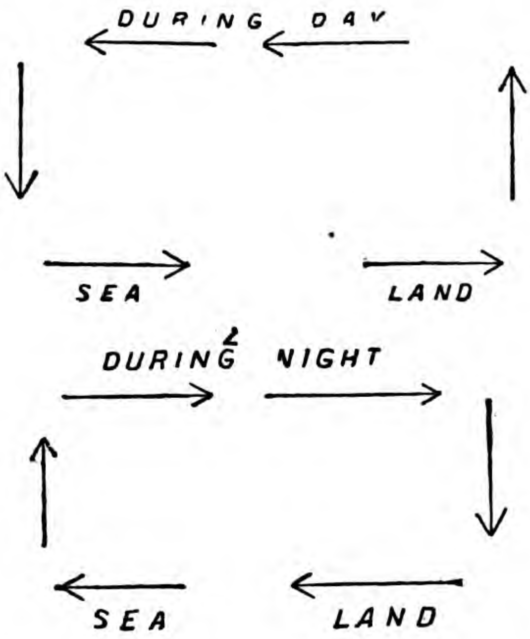
(2) PERIODICAL WINDS. The most important of these are—

(*a*) *The Monsoons.*[4] These, as their name implies, change their course with the seasons, blowing from one quarter for one-half of the year, and from the opposite quarter for the other half. They are met with chiefly in the Indian Ocean, and may be regarded as Trade winds, modified by the shape and positions of the regions over which they travel. The direction in which they blow are :—

[4] So named from a Malay word, *moussin* =a season.

North of the Equator—
The S.W. monsoons from April to October.
The N.E. „ „ October to April.
South of the Equator—
The N.W. monsoons from October to April.
The S.E. „ „ April to October.

The shifting of these winds, which is termed the "breaking up of the monsoons," is often attended by violent storms of thunder and lightning.



(*b*) *Land and Sea Breezes* are so called from the direction from which they blow. They are accounted for upon the principle already explained, viz., the unequal heating of the land and water surfaces. During the day the land becomes heated to a greater degree than the adjacent water; the hot air ascends, and the cold air from the ocean sets in as a *sea breeze* commencing generally about nine in the morning, gradually increasing till noon, and then diminishing towards sunset.[5]

"As evening approaches, the air over the surface of the land becomes more rapidly cooled by radiation than that of the water, and then a cool *land breeze* sets out towards the ocean, blows freshly during the night, and dies away towards morning, when the sea-breeze again commences." (Page's Adv. Text Book, p. 200.)

(3) VARIABLE WINDS, as their name implies, are those which are more or less changeable in their direction. Still they are obedient to fixed laws, though their movements are not so readily comprehended. The principal of these are:— The S.W. winds of the Northern hemisphere, and the N.W. winds of the Southern hemisphere, and these may be regarded as the prevailing winds of these regions.[6]

(4) LOCAL WINDS. These may be divided into two classes:—

(*a*) *Hot Winds.* The principal of these is the *Simoom*, which is an Arabic word for "hot" or "poisonous." It prevails chiefly in the Sahara, and is a suffocating blast, laden with extremely fine particles of sand. It is equally destructive to animal and vegetable life; sometimes a whole caravan[7] is overtaken by it, and many die of the thirst and fever it produces. The surest way to avoid its effects is to lie prostrate on the ground and bury the face in the hands."[8]

This wind is known by various names in different countries, e.g.,

In Turkey	it is called the		Samiel.
In Egypt	"	"	Khamsin.[9]
Guinea and Senegambia	"	"	Harmattan.
In Italy	"	"	Sirocco.
In Spain	"	"	Solano.

The Föhn is a hot wind which sometimes prevails in Switzerland.

(*b*) *Cold Winds.* The principal of these are:

The Puna, which sweeps over the plateau of Peru at an elevation of 12,000 feet above the sea level, and continues for four months in the year. It is so extremely dry as to prevent the

[5] Show how grateful this breeze must be to the inhabitants of hot climates, and explain the fact that ships generally make for port under its influence.

[6] Refer to a "Wind Chart," or shew the directions on a map of the world.

[7] Refer to desert travelling and explain the term.

[8] Refer to the instinct of camels which prompts them, on the approach of this wind, to bury their noses in the sand.

[9] A word which means 50, because it lasts 50 days.

putrefaction of animal remains; the body of a dead mule is converted, in a few days, into a mummy, even the entrails being free from decay. The bodies of dead Peruvians were preserved for ages by exposing them to the action of this wind. (Hughes' Phys. Geog., p 164.).[10]

The Pampero is a violent west wind, which blows from the Andes across the Pampas of Buenos Ayres, withering vegetation and obscuring the air with clouds of dust.

The Bora is a N.E. wind, prevailing in Istria and Dalmatia.[11] It sometimes blows with such force as to overturn men and horses at the plough.

The Mistrat is a N.W. wind blowing in the valley of the Rhone.

The Gallego is a N.W. wind, blowing in Spain.

The Vent de Bise is a N.E. wind blowing along the northern shores of the Mediterranean.

N.B. In addition to the above are the *Etesian winds*, which blow from the north across the Mediterranean to counteract the hot blasts from the Sahara.

REMARKS. "According to meteorological authorities, a velocity of 7 miles per hour is regarded as a gentle air; 14 miles an hour as light breeze; 21 miles per hour a good sailing breeze; 41 miles an hour a gale; 61 miles an hour a great storm; 82 miles an hour a tempest; 92 miles an hour a hurricane, producing universal devastation." (Page's Adv. Text Book, p. 194.)

N.B. For chapters on "Storms" and the "Region of Calms," the teacher is referred to Ansted's Phys. Geog., p. 258, and Hughes's ditto, p. 170 and 171.

[10] Here reflect upon the hardships to which many of our fellow-creatures are exposed, and contrast the circumstances under which they live with our own more favoured condition.

[11] Shew on the map.

LESSON XXX.

CLOUDS.

MATTER.

I. Formation.

As by far the greater portion of the earth's surface is covered with water and constantly exposed to the action of the air, a large quantity of moisture is continually being given off. This process is called "*evaporation*."[1] When the moisture thus formed hovers immediately above the surface of the earth, it is termed *fog or mist;* but it oftens happens that the aqueous vapour,

METHOD.

When we look up into the sky, what do we often see floating above our heads? **Clouds.**

[1] Illustrate this by reference to the *drying up* of pools of water on a summer's day, or by the disappearance of water which has been

acted upon by the force of aerial currents, rises into the higher regions of the atmosphere, where it remains suspended. In course of time this moist air is encountered by cold winds, which transform it into watery particles ; in other words, *clouds* are formed. Clouds have been defined as "visible capitals supported by invisible columns of vapour."

exposed to the air in a shallow vessel.

II. Classification.

Clouds are grouped into seven classes :—three primary forms and four compound.

The Primary clouds are :—The Cirrus, Cumulus, and Stratus.

The Compounds are : — The Cirro-Stratus, Cirro-Cumulus, the Cumulo-Stratus, and the Nimbus, or Rain-Cloud.

(1) PRIMARY CLOUDS.

(*a*) *Cirrus*[2] *or Curl Cloud.* This receives its name from its curly appearance. It is the highest of all clouds, being no less than three miles in height and sometimes five or six. As a consequence of the great height at which they float, they have been supposed by Kaemetz, a distinguished German meteorologist, to consist entirely of snow flakes, for the temperature of the atmosphere in which they are suspended must often be far below the freezing point.

From their several portions over-lapping each other, and being arranged in a somewhat regular manner, they form what are termed "*mackerel skies.*"[3]

(*b*) *Cumulus or Strachen Cloud.* This is so called because its several parts appear to be "piled on a heap."[4] It often assumes the appearance of a hemisphere resting upon a horizontal base. It generally prevails about midday and gradually disappears towards sunset. In the early morning it floats low, but its altitude increases with the ascending currents of air.[5]

The rounded figure of these clouds has been accounted for by the fact that, when one fluid flows through another at rest, the outline of the figure assumed by the first will be composed of curved lines.[6]

(*c*) *Stratus*[7] *or Fall Cloud.* Derives its name from the fact that it *falls* towards evening and rests as a layer near the horizon. It is the cloud of the night, as the Cumulus is the cloud of the day. It is formed in the same way as fogs and

[2] L. *cirrus*=a curl.

[3] Ask why?

[4] Refer by way of illustration to the word "accumulate."

[5] Proved thus :— Travellers when ascending a mountain have seen the cumulus *beneath* them in the morning ; it has *enveloped* them at noon ; and *soared above them* towards evening.

[6] Illustrate by reference to steam as it issues from the boiler of a locomotive.

[7] L. *stratus*=a covering.

mists, and, if not dissipated by the sun's rays, may condense into rain.

(2) COMPOUND CLOUDS.

(*a*) *Cirro-Stratus.* These are compounded of (*a*) and (*c*).

(*b*) *Cirro-Cumulus.* These are compounded of (*a*) and (*b*).

(*c*) *Cumulo-Stratus.* These are compounded of (*b*) and (*c*).

(*d*) *Nimbus.*[8] So called from its rainy appearance. It possesses no particular shape, but is known by its uniform grey tint and fringed edges. It is generally found floating at a low elevation.[9]

III. Uses. Clouds

(1) Are the reservoirs of the rains which dedescend to fertilize the earth.

(2) Serve as a screen to protect the earth from the intense heat of the sun's rays.

(3) "Add to the picturesque effects which the landscape painter, and the admirer of nature, love to study." (Ansted's Phys. Geog., p. 271)

REMARKS. Some clouds remain stationary, attached to a mountain summit. Such a phenomenon may be seen on Mount Pilate, in Switzerland, and at Table Mount, at the Cape of Good Hope. "This cloud, which may be almost always seen over the mountain, is called 'The Table-cloth.' It is constantly depositing the purest water at the mountain's foot, and forms the only source from which is obtained all the water for the supply of the 30,000 people living below it, as well as the ships which visit Cape Town. If the cloud is dense, so as to entirely cover the mountain top, it generally marks a coming storm; hence, when bad weather is expected, it is usual to say 'The Table-cloth is spread.'" (Hewitt's Brit. Col., p. 77.)

Why clouds remain permanent. The aqueous vapour of the atmosphere mixes with the gases therein contained, and is held up in the air, just as oxygen and carbonic acid, which are heavier than nitrogen, are suspended in it. "As sugar or salt mixed with water becomes, as it were fluid, by being mingled with fluids, so the vapour of water behaves as a gas when mingled with air in our atmosphere." (Ansted's Phys. Geog., p. 280.)

[8] L. *nimbus*=a raincloud.

[9] Refer to the fact that travellers are often enveloped in rainclouds when ascending hills.

LESSON XXXI.

THE OCEAN,

ITS DIVISIONS AND PHYSICAL FEATURES.

MATTER.

I. Divisions.

Although the waters which cover the surface of the earth form one continuous expanse, yet, for the sake of convenience, they have been divided into five great basins or oceans. Their names are :—

(1) ATLANTIC, extending between the eastern and western hemispheres, and so called from the Atlas mountains,[1] which formed a prominent landmark to the earliest navigators of the ocean, and seemed to preside, as it were, over its waters.

(2) PACIFIC, extending also between the eastern and western hemispheres, but having the latter for its eastern boundary, and the former on the west. Its name was given to it by Magellan, its first explorer, in 1520, from the calm weather he enjoyed on his voyage.[2]

(3) ARCTIC, is situated in the region of the N. Pole, and was so called in reference to the groups of stars, known as the Great and Little Bears, which point, as it were, to the N. Pole. The word is derived from the Gr. *arktos*=a bear.

(4) ANTARCTIC is opposite to the Arctic Ocean,[3] hence it surrounds the Southern Pole.

(5) INDIAN, receives its name from the fact that India is the principal country which is bathed by its waters. It extends from Africa on the W. to the E. Indies, and Australia on the East.

II. Physical Features.

(1) DEPTH. The bed of the ocean is diversified, like the surface of the land, and is not of one uniform level, as might be supposed : hence its depth varies from a few feet to several miles. As a general rule, low lands are bordered by shallow seas, and high lands by deep water, the character of the adjacent shores being continued underneath the waters which wash them. There are, however, exceptions to this general law :— e.g., the waters of the Bay of Biscay are 1000

METHOD.

The surface of the earth consists of land and water. Supposing it divided into four parts, three of them would be water. What name is given to this vast body of water? **The Ocean.**

[1] Shew on the map.

[2] Shew that this name is incorrect, and that it originated from the fact that its waters were found comparatively smooth after the rough passage Magellan had through the Straits bearing his name.

[3] Shew that it received its name on this account. Gr. *anti* = opposite. Illus. by antipodes.

feet deep, though they lave the shores of the Laudes. "The massive point of the S. of Africa ends with abrupt coasts, and yet it is necessary to go out to sea more than 100 miles, before a depth of 605 feet of water can be found."—(Guyot's Earth and Man, p. 51.)

The Atlantic (averaging from 3 to 5 miles) is deeper than the Pacific; the Indian and Southern oceans are from 4 to 6 miles, and the Arctic and Antarctic become shallower as they approach the Poles. The deepest sounding[4] ever taken was that by Sir James Ross in 15° 3′ S. Lat., and 23° 14′[5] W. Long., the ascertained depth being 27,600 ft. The *mean* depth of the ocean has been estimated at 21,000 ft., or about 4 miles.

(2) TEMPERATURE. Water being a slow conductor of heat, the ocean preserves a more equable temperature than the atmosphere, and hence its beneficial effects upon the countries in proximity to it, the severity of the northern regions being softened by it, and the intense heat of tropical climes rendered less oppressive. The temperature of the ocean at its surface is higher than that of the water below, varying from 80° near the equator, to 30° towards either Pole,[6] but at a depth of 100 fathoms,[7] the *mean* temperature of the ocean is 35½°.

(3) COLOUR. In small quantities sea-water is colourless, but in large quantities it assumes various shades. Certain colours are peculiar to particular seas, e.g.:—

(*a*) *The Yellow Sea*, off the coast of China: probably caused by the sediments of the rivers flowing into it.[8]

(*b*) *The Red Sea* owes its appearance to the presence of certain forms of animal life.

(*c*) *Off the Azores*, the sea is green (and is hence known as the *Sargasso Sea*,) owing to the abundance of sea-weed which floats upon its surface.[9]

(*d*) *Black Sea* } may receive their names from
(*e*) *White Sea* } the appearance their waters present, owing to the nature of their beds, or the presence of certain forms of animal or vegetable life.

(*f*) *Vermilion Sea* off California.

(4) SALTNESS. This is one of the most prominent features of the ocean. It has been calculated that, if all the salts of the sea were collected and spread equally over the land, they

[4] Refer to the mode in which "soundings" are taken.

[5] Let the pupils find out this spot on the map.

[6] Refer to the fact that this is below freezing point (32°).

[7] Reduce this to feet.

[8] Ask for their names.

[9] Brought together into this area by the combined actions of the Gulf Stream, and the Atlantic Equatorial Current. (See lessons 10 and 11.)

would cover a surface of seven millions square miles to a depth of one mile.

The component parts of this salt are : Common salt, sulphate of soda, chloride of lime, and magnesia, and it amounts to about 3½ per cent., or ½ oz. to the pound. All parts of the ocean, however, are not uniformly salt, e.g. :—

There is *less*—

(*a*) At the Poles than at the Equator.[10]

(*b*) Near the mouths of large rivers, e.g., the Amazon, the current of whose waters is felt 200 miles out at sea, and may be skimmed from the surface.[11]

(*c*) In inland seas, e.g., the Baltic, because it is not much exposed to the ocean, and has several rivers flowing into it.[12]

N.B. The Dead Sea forms an exception to this statement.

There is *more*—

(*a*) In the Mediterranean and Red Seas, for both have currents constantly flowing into them from the ocean, the former through the Straits of Gibraltar, the latter through the Straits of Bab-el-Mandeb,[13] and neither has any important river flowing into it, except the Nile.

Salt water freezes less readily than fresh, not being converted into ice, until the thermometer falls to 28½° Fahr.[14]

(5) LEVEL. The quantity of water in the ocean is uniformly the same, for that which is lost by evaporation is replaced by the rivers flowing into it, and thus the process of waste and renewal are nicely counterbalanced.[15] Hence we speak of the *level of the sea*, which we take as the standard for the measurement of heights.

It has been calculated that if the waters of the ocean were *increased* by a fourth, the whole surface of the land, with the exception of the highest mountains, would be covered ; and were its volume *diminished* by a fourth, the principal seas would be dried up.[16]

III. Uses. The Ocean

(1) Is the great storehouse of warmth and moisture, which are carried by the action of the winds, to fertilize the earth.

(2) Equalizes our comforts by enabling us to interchange our commodities for those of other nations.

(3) Exercises its influence on the destinies of

10 Why? Because of the melting of the ice.

11 Why? Because, being lighter than the waters of the ocean, it has not mixed with them.

12 Ask their names.

13 Show on the map.

14 Show what an advantage this is to commerce, and contrast with the character of the Arctic Seas.

15 Show that though this is true in regard to the ocean, some of its branches form an exception to the rule ; e.g., the Zuyder Zee, the surface of which is lower than that of the German Ocean ; the Red Sea is, at certain times, higher than the Mediterranean.

16 From this deduce the wisdom of the Creator, in maintaining the volume of the ocean constant.

nations :—those indented by its waters have ever been the most important : e.g.,

In ancient times, Greece and Rome.

In modern times, England, France, and United States.

(4) "Is the grand highway of the world. From the earliest ages, the civilized nations urged, by a secret instinct of their coming destinies, seem to have tended unconsciously to gather themselves near its shores. Commencing their national lives on the banks of the great rivers of the East, they clustered, afterwards, around the Mediterranean, under the sway of Greece and Rome. The modern world exchanged this theatre, henceforth too narrow, for the basins of the oceans, and our ships sail over the vast expanse of waters, with more ease and security than the triremes[17] of Greece and Rome crossed their inland seas." (Guyot's Earth and Man, p. 170).

[17] i.e., Three-decked galleys. (See Guyot's Earth and Man, 7th Ed., 1870.)

LESSON XXXII.

THE OCEAN.—WAVES.

MATTER.

I. Kinds and how formed.

We may divide waves into three kinds :—

(1) Wind waves; (2) Storm waves; and (3) Tide waves.

(1) WIND WAVES. The origin of these is easily explained. The currents of air drifting along the surface of the water raise it, at first, into small ripples, which are formed in parallel lines at right angles to the direction of the wind.[1] As the force of the wind increases, the agitation becomes greater, and is no longer confined to the surface, but extends downwards.

(2) STORM WAVES. Sometimes the wind blows in gusts, and frequently changes its direction suddenly, thus causing the various waves which it forms to become confused and broken. They rush onwards, and, at length, overtake each other, thus forming those sublime spectacles only met with in the open ocean.

N.B. These waves do not disturb the waters beyond a depth of 300 ft.; but they produce an after effect, known as the "*ground swell.*" This is a deep heaving of the water, often propagated to a great distance, and arrested only by the resistance of the land against which it strikes.

METHOD.

Let the teacher and his class take an imaginary trip to the seaside, and station themselves on the shore as the tide is coming in. Ask what name is given to the sheets of water as they appear to roll one over the other; many will be ready to answer, "**Waves.**"

[1] Illustrate by a diagram on the blk. bd.

(3) TIDE WAVES. These have an origin altogether independent of the wind, being produced by the action of the sun and moon. They also differ from (1) and (2) inasmuch as they are *regular*.[2] "The true tidal wave is not a stream. No doubt in confined channels it is converted into a wave of translation,[3] and the body of the water is driven forwards; but, in open seas it is only the *motion* that is transmitted, and *not* the water. Thus a ship or a bird floating on the water is not carried forward by the tide in open ocean. It is simply lifted up and let down. The water rises from beneath it, and bears it up, and then sinks again, and the ship or bird sinks with it."[4] (Ansted's Phys. Geog., p. 150.)

II. Characteristics.

(1) MAGNITUDE. The greatest waves are met with when the wind blows in a direction contrary to that of the current; hence those at the Cape of Good Hope often measure 40 feet in height, when a N.W. gale is blowing.[5] Only half the wave is visible. Its summit is called its *crest*, the bottom its *trough*.[6]

(2) VELOCITY. This depends upon three things:—

(*a*) The violence and duration of the wind.

(*b*) The angle at which the wind strikes the surface of the water.

(*c*) The area and depth of the water over which the wind travels.

In illustration of this latter statement, Professor Airy has calculated that a wave 100 ft. broad, in water of 100 ft. deep, travels at the rate of 15 miles per hour, and with ten times these proportions at a rate of 48 miles per hour.

(3) FORCE. This depends upon the bulk of the wave and its velocity. Experiments have been made on lighthouses and breakwaters, the result of which has proved that a pressure of 6000 lbs. to a square foot[7] is by no means uncommon. The pressure of the waves of the Atlantic, washing the W. coast of Scotland, corroborates this fact.[8]

Sometimes masses of rock, weighing 40 tons, have been dislodged. "It is thus that Nature sports with the works of man."

REMARKS. "The greatest waves known are those off the Cape of Good Hope (see above).

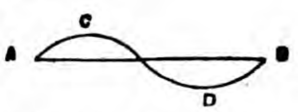
[2] Why? Because the causes producing them act in obedience to regular fixed laws.

[3] Explain this term.

[4] Illustrate by reference to the ears of corn in a field, which *appear* to advance, but, in reality, only oscillate to and fro, inasmuch as they are rooted in the ground.

[5] Why N.W. gale? Refer to the fact that a branch of the Equatorial current is flowing in an opposite direction.

[6] Explain the fact that waves are double the height which they appear, and illustrate by the following diagram:—



A B=surface of water.
C=the crest of the wave.
D=the trough of the wave.

[7] Let this be reduced to tons, the class assisting in the operation.

[8] Show that this statement is borne out by the indented character of the coast as compared with the opposite shores.

Off Cape Horn they have been measured at 32 feet from trough to crest, and, in the North Atlantic, waves from 20 to 25 feet are by no means uncommon. In our own seas, however, they rarely exceed 8 or 10 feet, and all accounts of their running 'mountains high' must be received as mere poetical exaggeration." (Page's Adv. Text Book, p. 130.)

LESSON XXXIII.

THE OCEAN.—TIDES.

MATTER.

I. Causes.

Tides are caused by the alternate rising and falling of the waters of the ocean, movements which are produced by the attraction of the sun and moon, but chiefly of the latter from its nearness to the earth. The whole body of the earth is attracted, but the waters are most affected.[1]

As the earth rotates on its axis, each portion of its waters is brought successively under these attractive influences, and thus the great tidal wave is drawn, as it were, around the globe.

The highest tides are called—

Spring Tides. They are the result of the *united* attractions of the sun and moon, while the lowest are termed *Neap Tides*, and are produced by the same influences differently exerted, the sun's attraction being at right angles to that of the moon, which, at such times, is in either her first, or last quarter.

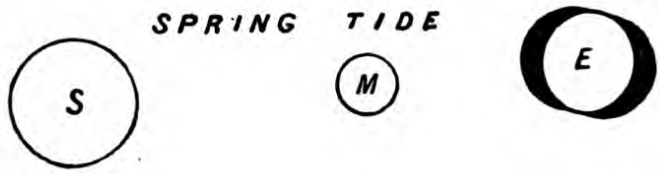
The annexed diagram will illustrate this explanation.[2]

I. May be regarded as the *sum* of the influences of the sun and moon.

II. May be regarded as the *difference* of the influences of the sun and moon.

Sun and moon in conjunction, producing spring tides.

I.



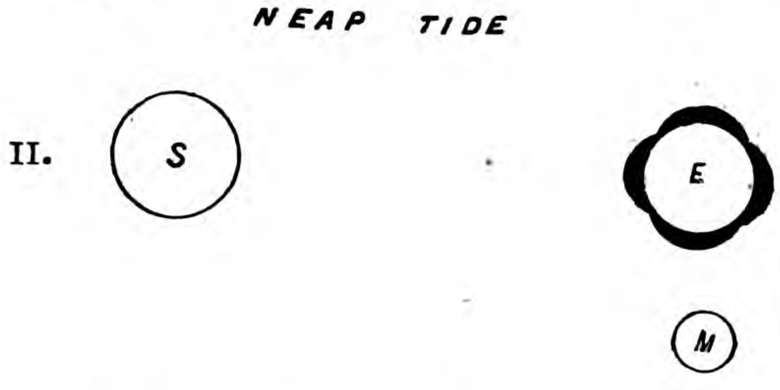
METHOD.

Let the teacher, as in the preceding lesson, take his class in imagination to the sea-side, and recall their attention to the gradual covering of the sands by the advancing waters. What do we say is taking place when this occurs? **The Tide is coming in.**

[1] Explain that this is a consequence of their liquid state.

[2] Let this diagram be drawn upon the blk. bd., upon an enlarged scale, and referred to as occasion requires.

The sun and moon in opposition, producing neap tides.



"The moon's attractive power compared with the sun's is as 100 : 38, and the difference between spring tide and neap tide as 7 : 3."

II. Explanation of the terms "High" and "Low" Water.

"The waters most directly under the moon being nearest, are most attracted and rise highest; at the same time the body of the earth also is drawn towards that luminary, so as to leave the mobile[3] waters, on the opposite side of the earth, behind; hence causing them to bulge out to an equal extent with those on the other side. There are thus two *high waters* at the same time on opposite sides of the globe, the one above, the other beneath the horizon; while the other two sides, having their waters drawn away from them, have *low water*.[4] Every place, therefore, owing to the earth's rotation, would have two high waters and two low waters every 24 hours; but as owing to the moon's revolution round the earth in a month, it requires 24 hours to bring the same meridians again beneath the moon, every successive tide is from 20 to 27 minutes later than the preceding, and the alternate tides about 50 minutes. The waters do not, however, *immediately* obey the moon, but, from the force of inertia,[5] require an interval of three hours at any given meridian, between the passage of the moon and high water." (Collins' Elem. Phys. Geog., p. 59).

When the sea continues to swell and enter the mouths of rivers, harbours, &c., it is called "*flood tide*," and it is then said to be "high water." This lasts about 12 minutes, the waters then ebb for about 6 hours, at the end of which time, they

[3] Why so called? Because they are easily moved.

[4] See diagrams.

[5] The inability of matter to change its own state of motion or rest. Illustrate by reference to a person alighting from a railway train before it has quite stopped.

remain stationary for another 12 minutes. This is known as "*low water.*"

III. Progress of the Tide-Wave.

This is very irregular, owing to the masses of land and their configuration. The Southern Ocean may be regarded as the area whence this great wave originates. Its course may be thus described :[6]—

Starting from Tasmania at midnight on Monday, the wave travels northwards and westwards, and reaches Ceylon, at noon, on Tuesday, and the Cape of Good Hope at one o'clock. It then enters the Atlantic, and, moving continually northwards, passes the western shores of Africa, and the eastern shores of America, reaching Newfoundland at midnight on Tuesday. Proceeding along the west of Ireland and round the north of Scotland, it reaches Aberdeen at noon on Wednesday. From this point it proceeds slowly, and arrives at the mouth of the Thames at midnight on Wednesday, and, it is only on the morning of the third day that it reaches London bridge.

REMARKS. Tides are scarcely perceptible in open seas, but they rise high in—

(1) *Straits and Channels*, e.g., in the English and Bristol Channels, where the height of 60 feet is sometimes reached.

(2) *Bays and Gulfs having their openings* TOWARDS *the tidal current;* e.g., in the Bay of Fundy,[7] the tide reaches the height of 120 feet, in the Ganges to 30 or 40 feet, and, in the Severn 10 to 30 feet. The tides of this latter river and also of the Hooghly and Amazon, are sometimes very destructive. They are termed "*Bores.*"

(3) *The Tropics*, because the surface of the earth is nearer the moon.

N.B. The *Velocity* of the tide-wave is greatest where the ocean is deepest. In the Southern Ocean it travels at the rate of 1000 miles per hour, while, in the North Sea it does not exceed 50.

[6] The teacher must take care to use the map of the world freely, at this stage of the lesson.

[7] Show on the map and explain.

LESSON XXXIV.

THE OCEAN.—CURRENTS.

MATTER.

I. Causes.

The principal causes of currents are the following :—

(1) The influence of tides and winds.

(2) The alternate expansion and contraction[1] of water by heat and cold.

The waters of the regions near the Equator, being greatly heated, rise to the surface and flow towards the Poles, at the same time that a considerable quantity passess off by evaporation. To maintain the equilibrium[2] of the ocean, the waters of the polar regious rush in to supply their place, and as they are colder, they form an *under* current.[3] Hence two sets of currents are established, two warm, upper currents, flowing from the Equator towards the Poles, and two cold under currents travelling in an opposite direction.[4]

(3) The revolution of the earth on its axis. (For an explanation of this, see under head III.)

II. Kinds.

Currents are divided into three principal kinds :—

(1) CONSTANT.[5] These are due, primarily, to cause (2), and, secondarily, to cause (3).

(2) PERIODICAL. Due mainly to cause (1). They are produced in a great measure, by the monsoons and land and sea breezes. (See lesson 5.)

(3) VARIABLE. Also result from cause (1), and also from the configuration of the land, and the melting of polar ice.

N.B. For *minor* varieties see under "*Remarks.*"

III. The Great Equatorial and Polar Currents.

From what has been said under cause (2), it will be readily seen that the waters of the Tropics and those of the Poles are in a constant state of circulation. But, inasmuch as the earth revolves more rapidly as we near the Equator[6] (its speed being 1000 miles per hour), the waters from the Poles should move at the same rate. But they cannot acquire this velocity all at once, they, therefore, as it were, *fall behind* the rest of the

METHOD.

To day we will have a lesson on **Currents.**

(Let the teacher derive the word. L. *curro* = I run, and thus deduce its meaning.)

[1] Explain: and ask for the names of substances which possess these properties.

[2] L. *equus* = equal, and *libra* = a balance.

[3] Show the analogy existing between these movements and those of the air. (See lesson 3.)

[4] Show that this is proved by the fact that icebergs are brought from the Arctic Ocean to the Azores, and from the Antarctic to the Cape of Good Hope.

[5] Show why these terms are applicable.

[6] Illustrate by reference to a coach wheel, the tire of which revolves very quickly, while the part near the axle-tree scarcely moves.

Equatorial surface, flowing *westwards*.[7] This is the explanation of the great Equatorial current, which extends for about 30° on each side of the Equator. It originates in the Antarctic Drift current. This flows N.E. to Peru,[8] where, in a belt 3,500 miles wide, it commences its tour of the Pacific. On reaching S.E. Asia, it divides into several currents, rendering the navigation among the Islands of the East Indian Archipelago extremely difficult. One portion, the Japanese current (Kuro Siwo, or Black Stream), flows N.E., and supplies the inhabitants of the Aleutian Islands with fishing tackle and wood, while the main stream forces itself into the Indian Ocean. Approaching E. Africa it again divides, one part flowing southwards, the other meeting it in the Mozambique Channel. It then doubles the Cape, when the main portion is turned back and forms the retrograde or counter current of the Indian Ocean. This has a velocity of 50 miles per day, and flowing directly towards the shores of Australia, renders a most important service to navigation.

The remainder of the stream enters the Atlantic, and, after skirting W. Africa, divides into two parts, off C. St. Roque, one portion, the Brazil current, bathing the shores of South America, and, being deflected eastwards becomes the south connecting current; the other flowing northwards, under the name of the Guiana current, and entering the Caribbean Sea and the Gulf of Mexico.

N.B. For the "Gulf Stream," which originates in this locality, see next lesson.

The Polar Currents set in from the Arctic and Antarctic oceans. The former skirts both shores of Greenland and trends southwards until it meets the Gulf Stream. Here it divides, one portion flowing into the Caribbean Sea, the other along the coast of the United States. As the waters of the Gulf Stream warm the shores of Europe, so those of the Arctic current cool those of America, at the same time that they furnish an excellent supply of fish, which are not to be met with in more southern latitudes.

"The Arctic current thus replaces the warm water sent through the Gulf stream, and modifies the climate of Central America, and the Gulf of Mexico, which, but for this beautiful and benign system of aqueous circulation, would be one of

7 See lesson 5. Head II. (1) *a*. Show how, recalling the fact that the earth is moving in the *opposite* direction. Here it will be necessary to impress upon the class the fact that currents are named after the direction *to* which they flow, while winds are called according to the direction *from* which they blow.

8 Constant reference must be made to the map.

the hottest and most pestilential in the world."—(Page's Adv. Text Book, p. 142.)

IV. Uses. Currents—

(1) Equalize differences and soften extremes.

(2) Maintain the purity and salubrity of the ocean.[9]

(3) Facilitate the course of the navigator.[10]

REMARKS. *Minor varieties* of currents are :—

(*a*) *Drift.* Due to the long-continued agency of the wind.

(*b*) *Counter.* Those which meet others flowing in an opposite direction.

Such a current is known to exist in the Caribbean Sea.[11]

N.B. Eddies and whirlpools belong to this latter class.

Examples:—The maelström off the coast of Norway, the roar of whose waters is sometimes heard for several leagues, and the whirlpool of Charybdis, outside the harbour of Messina.[12]

The mode of ascertaining the direction of currents is by means of *track bottles.* (For the manner in which they are employed, see Hughes' Phys. Geog., p. 126.)

[9] Contrast the health-giving influence of sea-water, with the diseases engendered by stagnant pools.

[10] See this graphically expressed in Guyot's "Earth and Man," p. 140.

[11] Proved thus :—a leaden weight suspended from the bow of a boat was so acted upon by *equal* and *contrary* currents that the boat remained stationary.

[12] Show on the map.

LESSON XXXV.

THE GULF STREAM.

MATTER.

I. Origin of Name.

The Guiana section of the Equatorial current pursuing a N.W. course, makes the circuit of the Caribbean Sea and the Gulf of Mexico, the temperature of its waters having increased 7° above that of the Atlantic. Henceforth this current is known as the Gulf Stream.

II. Course.

Emerging from this confined area, the Gulf Stream passes through the Straits of Florida[1] and travels in a N.E. direction, until it reaches the banks of Newfoundland. It then spreads across the Atlantic, a portion of its waters turning southwards towards the Azores,[2] while the main stream proceeds in a N.E. direction, bathing, on its way, the shores of the British Isles and Norway, and, finally disappearing in the Arctic Ocean.

METHOD.

Let the teacher briefly recapitulate the course of the Equatorial current of the Atlantic until it reaches the Gulf of Mexico.

[1] Let the pupils point out all places on the map.

[2] Draw attention to the fact that it was the wreck cast ashore on the Azores by this current, which led Columbus to conclude that there was land to the west.

III. Characteristics.

(1) EXTENT. The Gulf Stream is about 3000 miles in length, and 120 broad.

(2) SPEED. At first it flows at the rate of four miles per hour, but, as its waters by degrees cover a larger area, this speed gradually diminishes.

(3) COLOUR. Its waters are of an indigo blue, where the current is deepest and strongest, and they present so decided a contrast to those of the ocean around, that it is not difficult to draw the boundary line of the stream.

(4) TEMPERATURE. In the Straits of Florida this is 7° above that of the surrounding waters; off Newfoundland it is 25° or 30° higher than that of the Atlantic.[3] Two buckets let down, the one from the bow of a boat, the other from its stern, would contain water differing in temperature by 30.°

N.B. The waters of the Gulf Stream are salter than those of the surrounding ocean.

IV. Uses. The Gulf Stream—

(1) Dispenses heat and moisture in its course, and

(2) Tempers the climates of those countries, whose shores its washes.[4]

[3] Shew that the fogs of this region are mainly attributable to this fact.

[4] Ask for the names of these countries.

LESSON XXXVI.

SPRINGS.

MATTER.

I. General Formation.

The rain that falls upon the earth is partly carried off in streams to the ocean,[1] is partly evaporated,[2] and is partly absorbed or sucked into the soil. This latter portion of water continues to trickle downwards until it meets with some impervious[3] bed, which, on account of its nature, obstructs the progress of the stream. The waters are then forced to accumulate in some hollow, basin-like cavity, until they eventually overflow, and penetrating, in time, through rents and crevices, ultimately issue from the mountain side as springs.

II. Classification.

Springs may be divided into three classes :—

METHOD.

You have sometimes seen water issuing from a hill side. What name do we give to such streams? **Springs.**

[1] Shew that this is so by reference to lesson 7, under the head, "*Level.*"

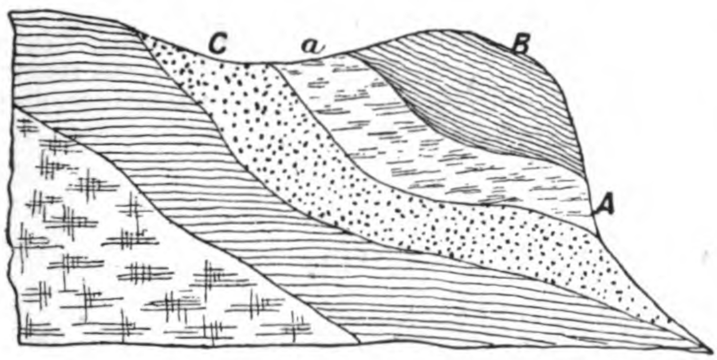
[2] See lesson 6, "*Formation.*"

[3] L. *im*, *per*, *via*, hence the meaning of the word will be "*impenetrable.*"

(1) SURFACE OR LAND SPRINGS. These are formed, as their name implies, near the surface, and are dependent for their supply of water, on the amount of rainfall. Hence they are frequently dry in summer, though they gush forth plentifully in winter.

N.B. These may also be termed "intermittent"[4] springs.

(2) TRANSTRATIC. These are springs which yield their waters at some distance from the spot where they enter the soil, such waters having penetrated *through a stratum* of a pervious nature, enclosed between two which are impervious.[5]



"The water has been received as rain at the surface *a*, lying between two impervious rocks, B and C: it makes its way through the stratum till it reappears at A, in the form of a spring.

"If the opening is sunk from B, through the water-bearing rock *a*A, the water will rise to the level of its source. Such is the principle of *Artesian Wells*."[6] (Collins's El. Phy. Geog., page 67.)

(3) DEEP-SEATED. These springs are by far the most numerous, and their waters are almost uniform in temperature and quantity. They derive their waters from great depths, and often containing carbonic acid and other gases, act chemically upon the rocks through which they pass: hence they form *mineral springs*, i.e., those which hold in solution more or less of mineral ingredients, possessing valuable medicinal properties, to partake of which invalids often undertake long railway journeys.[7] Some mineral springs are—

(*a*) *Saline*[8], as the brine springs of Cheshire. Others are—

(*b*) *Chalybeate*, as those of Tunbridge Wells.

[4] See that the meaning of this term is understood, and illustrate by reference to "intermittent fevers."

[5] Here draw attention to the meaning of the word "transtratic," deducing, if possible, its derivation from the the class.

[6] Why so called? Because they were first sunk at Artois, in France. (See "Artesian Wells," in the glossary of Page's Adv. Text Book, p. 299.)

[7] Ask where such springs are found:—Epsom, Cheltenham, &c.

[8] Let the derivation of each of these words be given, and thus the nature of the waters ascertained, e.g.,

(*a*) L. *sal*=salt.
(*b*) ,, *chalybs*—iron.
(*c*) ,, *silex*=flint.
(*d*) ,, *calx*=lime.

The teacher should see that the *locality* of each place is known.

(*c*) *Siliceous*, as the Geysers of Iceland.

(*d*) *Calcareous*, as the waters of the Anio, in Italy. Others again are—

(*e*) *Sulphurous*, as those of Harrogate, in Yorkshire, or

(*f*) *Carbonated*, as those of Auvergne, in France.

N.B. If such springs are *warm*, they are termed "*Thermal*:"[9] such are the Geysers of Iceland,[10] whose waters are often 261°, i.e., 49° above boiling point (212°). Bath, in Somersetshire, and Buxton and Matlock, in Derbyshire, are famous for their warm springs.[11]

Kinds (2) and (3) are termed "*perennial*."[12]

III. Uses.

(1) Springs are the fountain heads of our streams and rivers.

(2) They impart fertility to the adjacent soil.

(3) Their waters often contain valuable curative properties.

[9] Gr. *therme*=heat.

[10] For a description of these, see Nelson's "Royal Readers," No. 5, p. 100.

[11] See "Mineral Springs," in Hughes's Geog., p. 130.

[12] Why? Obtain, if possible, the meaning of the word from its derivation as given by the class.

LESSON XXXVII.

RIVERS.

MATTER.

N.B. This subject will be found to contain information sufficient for two lessons.

I. Classification.

Rivers may be divided into two classes:

(1) Oceanic. (2) Continental.

(1) OCEANIC RIVERS. To this class belong all those that flow into the ocean directly, or indirectly. Although the greatest number of important rivers of this kind are found in the Old World (440; while in the New World there are only 140), yet the New World has by far the largest rivers.[1]

The most important rivers have an easterly course.[2]

(2) CONTINENTAL. These are so called because they *do not* discharge their waters into the ocean; they either flow into some lake which has no outlet, or are lost by evaporation or in the sands of the desert. The areas occupied by such rivers are termed "Continental Basins." The chief of these are—

(*a*) *South Europe and Central Asia*, covering three millions of square miles,[3] and extending

METHOD.

In taking country walks we sometimes meet with streams of water, which can only be crossed by means of bridges; and, if we traced the course of such streams, we should, in all probability, come to some point of the sea shore. What are such streams called? **Rivers.**

[1] Ask for the names of some.

[2] Let the class give examples.

[3] Let the map of the world be freely used throughout the lesson.

from the Black Sea to the Yellow Sea. Rivers in this district are Volga and Oural, flowing into the Caspian Sea; Danube, Dnieper, Dniester, and Don, into the Black Sea; the Jordan into the Dead Sea; the Sir (or Sihoon) and Amoo[4] (or Oxus) into L. Aral, and the Yarkand, which disappears on the table-land of Thibet. Minor basins are—

(*b*) The Basin of the Dead Sea.

(*c*) The Basin of Utah, in North America.

(*d*) The Plateau of Bolivia.

(*e*) The Mexican Table-land, and, *perhaps*,

(*f*) The District around L. Tchad, in Central Africa.

II. Characteristics.

(1) SOURCES.[5] As a general law it may be stated that the higher the district in which a river rises the swifter will be its current, and vice-versa.[6]

Some rivers rise near each other, but discharge their waters into seas widely apart, e.g., Rhine, Rhone, and Po, all rise in the Alps, but their waters are received by seas separated from each other by many miles.[7]

When two rivers rise near each other, and pursue courses widely different, finally falling into the same sea, they are said to form a "*binary system*," e.g., the Hoang-Ho, with the Yang-tse-Kiang and the Euphrates with the Tigris, the latter enclosing Mesopotamia.[8]

(2) BASIN. By this term is meant the whole district which is drained by a river and its tributaries; such a district assumes, more or less, the aspect of a sunken valley. The extent of the river's basin is the true test of its magnitude. The largest river basin in the world is that of the Amazon, which has an area of two million square miles.[9] Next in order come the basins of the Obi, Mississippi, La Plata, and Yenesei, each embracing an area of about 1¼ million square miles.

The line or ridge of land which frequently separates one river basin from another, is termed the "*watershed*."[10]

(3) LENGTH. This will depend upon the country through which the river flows.[11]

In estimating the length of a river its windings must be accurately traced and taken into consideration, e.g., a river measured from source to mouth *in a straight line* may be only 200 miles

[4] Caution the class against confounding this river with the Amoor, flowing into the Pacific Ocean.

[5] Ask the meaning of this word.

[6] Ask for examples: Rhine, Rhone, Amazon, of the former; Volga, of the latter.

[7] Show how, and ask for the names of these seas.

[8] Gr. *mesos*=middle, *potamos*=a river. Shew the applicability of the the name.

[9] Compare with the area of England and Wales.

[10] German *watersched* =water parting. Ask for examples in England. Draw attention to the fact that a watershed does not necessarily run along a mt. ridge, and prove by reference to—

(*a*) The rivers flowing north into the Baltic, and those flowing south into the Black Sea, and

(*b*) The Casiquiare, a tributary of the Orinoco and the Rio Negro, a tributary of the Amazon. In both (*a*) and (*b*) there is an uninterrupted communication established, during times of flood.

[11] Compare South America on both sides of the Andes.

long, whereas, reckoning its windings it may be 1000.[12]

The whole course of a river thus carefully ascertained is termed its "*development*." (Page's Adv. Text Book Phys. Geog., p. 156.)

(4) VOLUME. By this term is understood the quantity of water which the channel of the river contains. This depends mainly on the character of the country through which the river flows, and, as a consequence of this, upon the number and size of its tributaries. Excessive rainfall, or melting of snow, would tend largely to increase the volume of a river,[13] which is, therefore, not always uniform. In some regions, such as Australia and South Africa, the rivers are *temporary*, i.e., during the rains they become torrents, while in seasons of drought their channels are dried up.

(5) DEPTH. The greater the volume of water the greater the depth of the river. But this is not uniform throughout its length, its upper portion being generally shallower than the middle and lower courses.[14]

(6) VELOCITY. The speed at which a river flows depends upon—

(*a*) The descent of its course, whether rapid or gentle.[15]

(*b*) The form of its channel, whether winding or comparatively straight.

(*c*) The volume of water contained in (*b*), and

(*d*) The nature of its bed.[16]

In proportion as the velocity of a river increases, its fitness for purposes of navigation diminishes. "Formerly a descent of more than one foot in 200 was considered unnavigable; and though the power of steam has enabled men to contend with higher velocities, it is still the velocity of current more than the depth of water that renders a river unavailable as a means of intercommunication." (Page's Adv. Text Book Phy. Geog., p. 158).

(7) MOUTHS. The nature of a river's mouth depends upon the character of the country; some rivers discharging their waters, at once, by a single mouth into the ocean;[17] others forming an estuary, and are consequently affected to a certain extent by the ebb and flow of the tides;[18] while others again creep slowly along, and divide into several branches forming *deltas*.[19]

N.B. For effects produced by rivers forming deltas, (see Collins's El. Phy. Geog. p. 75.)

[12] Illustrate by a sketch on the blk. bd.

[13] Ask for examples: The Nile, whose periodical floods are partly attributable to the latter cause.

[14] Draw attention to the threefold division of a river course here implied, and see that it is understood, asking for an instance as an illustration, e.g., Danube.

[15] See under *Sources*.

[16] Shew that if this be rough there will be more friction to overcome, and hence the velocity of the stream will be diminished.

(Illus. by the surface of roads, pavements, and ice.)

[17] Ask for examples.

[18] Let the class be required to give instances.

[19] Ask for the names of some. Shew the applicability of the term (Gr. Δ=delta.)

III. Uses. Rivers—

(1) Carry away superfluous moisture from the earth.

(2) Irrigate and thus fertilize lands which would otherwise be comparatively barren.[20]

(3) Facilitate commerce by affording a ready means of communication between the several parts of the same country.

(4) Have played an important part in the history of nations. The most renowned cities have always been *on* or near rivers : e.g.—

(*a*) *In ancient times*,	Babylon	on the	Euphrates.
„	Nineveh	„	Tigris.
„	Thebes	„	Nile.
(*b*) *In modern days*,	London	„	Thames.
„	Paris	„	Seine.
„	Vienna	„	Danube.
„	Calcutta	„	Ganges.

N.B. The subject of "*Floods of Rivers*," has been purposely omitted in order to avoid extending the lesson to an inconvenient length. For information upon this topic the teacher is referred to the standard works on Physical Geography, which have been quoted from time to time in these pages.

[20] Refer to Egypt as affected by the overflowing of the Nile.

LESSON XXXVIII.

LAKES.

MATTER.

I. Introduction.

The word "*Lake*" is a term applied to any considerable body of water surrounded by land, and not directly connected with the sea. Wherever there is a depression of the earth's surface, there water will continue to accumulate (unless it can be carried off by evaporation), until it ultimately overflows the margin of the basin in which it is enclosed. Thus lakes of all sizes are met with, some being mere pools, while others extend over areas of thousands of square miles.

II. Classification.

Lakes may be divided into four kinds :

(1) THOSE WHICH BOTH RECEIVE AND GIVE OUT WATERS. These are by far the most common, and may be regarded as the expansions of rivers ; examples of this kind are the North American

METHOD.

Many of you have seen in the country, sheets of water of various sizes, entirely surrounded by land. What name is given to such pieces of water? **Lakes.**

lakes,[1] and the Victoria and Albert N'Yanzas of the Nile, which, in all probability, are the receptacles of the head waters of that river.

(2) THOSE WHICH RECEIVE BUT DO NOT GIVE OUT WATER. How then is their supply of water drawn off as it were? In all probability by evaporation. Such lakes receive *continental rivers* (see Lesson XIII.), and their waters are almost always brackish.[2] Examples are—the Caspian, L. Aral, L. Baikal, and the Dead Sea.[3]

N.B. The saltest lake in the world is L. Elton, 70 miles E. of the Volga. Its waters contain 29 per cent. of saline matter; next to it is the Dead Sea, whose waters are impregnated with salt to the extent of 26¼ per cent., and are therefore extremely buoyant.[4]

(3) THOSE WHICH GIVE OUT BUT DO NOT RECEIVE WATERS. Here the question naturally arises, whence do such lakes derive their supply of water? Most likely they are fed by subterranean[5] springs, evaporation checking the tendency to overflow.

(4) THOSE WHICH NEITHER RECEIVE, NOR GIVE OUT WATERS. As in (3) the supply of water is furnished by subterranean springs and rain, while evaporation carries off the excess. Such lakes are generally of small dimensions, and are often found to occupy the craters of extinct volcanoes.

III. Distribution.

The largest lakes are found in high latitudes, because there, there is less evaporation: hence the number and magnitude of the N. American lakes, and of those of Scandinavia and Finland.

The lakes of North America extend along the course of the St. Lawrence, covering an area of 100,000 sq. miles. They are supposed to contain more than half the fresh water on the surface of the globe.

The largest body of fresh water in the world is L. Superior. Its area is 32,000 square miles.[6] The Victoria N'Yanza, when thoroughly explored, may prove to be of greater extent.

The largest fresh water lake in the Old World is L. Baikal, with an area of 14,800 sq. miles.

The largest salt water lake is the Caspian Sea, having an area of 130,000 sq. miles.

Sir-i-kol, the source of the R. Oxus, is the most elevated lake, being 15,600 feet above the sea level.

[1] Ask for the names of them, and shew their connection with the R. St. Lawrence.

[2] Take care to explain that L. Tchad, in Central Africa, is an exception to this rule.

[3] Let the class shew the situation of these on the map.

[4] Compare these percentages with that of the ocean (Lesson vii.), and thus shew the excessive saltness of these lakes. The fact that travellers, bathing in the Dead Sea, have found it difficult to dive, may be mentioned as proving this statement. (See Mc'Leod's "Palestine," p. 31.)

[5] Derive the word: L. *sub* = under, and *terra*=the earth.

[6] i.e., about the size of Ireland.

The Dead Sea exhibits the greatest depression, being 1312 ft. below the Mediterranean.

N.B. For a more detailed account of the distribution of lakes, see Ansted's Phy. Geog., pp. 176—191.

IV. Uses. Lakes—

(1) Regulate the discharge of rivers by acting as reservoirs for their waters.

(2) Purify rivers by allowing the sediments, which their waters receive, to settle in their depths.[7]

(3) Temper arid climates by exposing a larger surface of water to evaporation.[8]

[7] Shew that in this respect they act as filters.

[8] Explain this.

LESSON XXXIX.

CAUSES WHICH DETERMINE CLIMATE.

MATTER.

I. What is meant by "climate?"

"Climate is a very complex matter, and one dependent on a great variety of conditions. It includes the temperature of the air at various times and seasons; the direction and force of the winds that prevail; the liability to storm; the amount of humidity in the air at various seasons; the quantity of cloud, mist, and rain, the distribution of rain, and the varieties of electrical condition." (Ansted's Physical Geog., p. 288.)

II. Causes which determine it.

(1) THE LATITUDE OF A COUNTRY.[1] The countries within the Tropics experience the greatest amount of heat, because here the sun shines vertically, and its rays are therefore more powerful. Consequently, as we travel north or south, the heat diminishes, a greater number of the sun's rays being spread over a larger surface.[2]

(2) ELEVATION OR ALTITUDE. As a general rule it may be accepted that a decrease of 1° Fahr. takes place for every 350 ft. of ascent; but this is not uniformly the case, for the prevailing winds, slope of a country, and proximity to the sea, all act as modifying circumstances. This diminution of temperature is owing, partly to the rarefaction[3] of the air, and partly to the fact that the greater the elevation of a country the further is it removed from the heat reflected

METHOD.

By way of introduction the teacher may ask the class to mention countries having opposite climates, stating that a consideration of the causes producing these differences is to be the subject of his lesson.

[1] Shew that by this is meant the geographical position of any country with reference to the Equator.

[2] Illustrate by imagining a candle or some source of light, held in front of a globe.

[3] i.e., the air becomes rarer.

by the earth's surface.[4] Hence, a traveller in ascending the Andes, may pass from a region of equatorial heat to one of Arctic severity.

(3) PROXIMITY TO THE SEA. It was stated (Lesson VII.) that the ocean preserves a more equable temperature than the atmosphere. Hence it follows that the nearer a country is to the ocean the more is its softening influence felt, while, on the contrary, countries inland, though in the same latitude, experience a degree of cold much more intense. Hence we have two kinds of climate—*Insular and Continental.*[5] As illustrations of this statement it may be mentioned that London, though further north, enjoys a milder winter and cooler summer than Paris, and in proceeding from the West of Europe in an easterly direction, a greater degree of cold is felt.

(4) THE SLOPE OF A COUNTRY, i.e., the aspect it presents to the sun's course. Generally a north aspect is cold, while a south is warm, the reason being that the latter receives the heat of the morning and noon-day sun, while the former has the feebler rays of the afternoon and evening.

(5) THE DIRECTION OF MOUNTAIN CHAINS. This is a very important consideration in regard to climate, for the position of a mountain chain may affect a country in either of two ways, e.g., it may intercept and condense the vapours of the atmosphere, thus causing a rainfall on one side, while the side more remote is dry;[6] or, it may shelter from the winds; e.g., the Alps protect the plains of Lombardy from the cold north winds, and the Himalayas the plains of India from the winds blowing from Siberia.[7]

(6) THE PREVAILING WINDS. That these should influence climate will be obvious from the fact that the character of a wind depends upon the country whence it comes.[8] Great Britain would, to a great extent, lose its insular climate if its prevailing winds came across the continent, instead of from the Atlantic.

(7) THE NATURE OF THE SOIL. Different varieties of soil have their different powers of radiation and absorption.[9] One soil acquires heat more readily and keeps it longer than another; another allows the descending rain to penetrate into its depths, and thus it becomes saturated with moisture, from which exhalations arise, producing a humidity, or dampness in the surrounding atmosphere, and thus lowering the temperature. Clayey or marshy grounds have

[4] Shew that the elevation of countries near the Equator tempers the fierceness of the tropical heat, and ask for examples. (See Guyot's "Earth and Man," 7th ed., p. 39.

[5] Compare the interior of Russia with the British Islands, by way of illustration.

[6] The Ghauts of India may be mentioned as an illustration of this; also the Scandinavian range.

[7] Ask for other examples, and for examples of countries oppositely situated.

[8] Ask for illustrations in proof. In our own country a west wind brings rain (why?); an easterly one is dry (why?)

[9] Explain these qualities and ask for bodies possessing them.

this effect, while those which are light and stony tend to make the atmosphere salubrious.

(8) CULTIVATION OF THE SOIL. "In countries to which the labours of civilized man have never been extended, the rivers, spreading themselves over the low grounds, form pestilential marshes and forests; thickets and weeds are so numerous and impenetrable as to prevent the earth from receiving the beneficial influence of the sun's rays. The air, from these causes, is constantly filled with noxious exhalations.[10] But by degrees, the continuous and well-directed efforts of the colonist, have produced wonderful changes, and large territories have in this way been reclaimed and made subservient to man."

(9) THE ANNUAL QUANTITY OF RAINFALL. "In general, more rain falls in islands and on sea coasts than in inland districts, among mountains than in level districts, and within the tropics than in the other zones; the great heat which prevails in the equatorial regions, causes the amount of evaporation to be much greater than in higher latitudes, and hence the atmosphere becomes charged with a greater quantity of moisture." (Hughes's Phys. Geog., p. 207.)

REMARKS. Lines on the map connecting all places having the same *mean summer* temperature, are called "ISOTHERALS."[11]

Those connecting places having the same *mean winter* temperature, "ISOCHEIMONALS."[12]

Those connecting places having the same *mean annual* temperature, "ISOTHERMALS."[13]

N.B. For additional information on the above subject, the teacher is referred to Hughes's Phys. Geog., pages 200—211.

[10] Refer by way of illustration to the backwoods of Canada, and the forests of the Amazon.

[11] Gr. *isos* = equal, and *theros*=summer.

[12] Gr. *isos* = equal, add *chiemon*=winter.

[13] Gr. *isos* = equal, and *therme*=heat.

LESSON XL.

SNOW AND HAIL.

MATTER.

I. Formation.

We have already had occasion to remark (Lesson VI.) that the atmosphere contains a considerable quantity of moisture, which it sometimes retains in the form of clouds, and at others deposits as dew or rain. But when the temperature of the air is below freezing point (32° Fahr.), the particles of vapour, becoming gradually

METHOD.

The teacher may introduce his lesson by remarking that most of his pupils, if not all, have seen snow, but that very few, probably none, could explain its formation.

chilled, are at last *frozen*, and in this form they are heavier than the air, and hence fall as *snow*.

The structure of a snowflake presents a very beautiful appearance when examined under a microscope. It is then found to have crystallized[1] into hexagonal[2] stars. "From a central nucleus six spiculæ[3] of ice radiate with perfect regularity, and between each two spiculæ there is an angle of 60°. From each of these, six other spiculæ of smaller size, are thrown off, always at the same angle, and so again, others proceed in the same way. They are like the petals of a blossom, but exhibit the most marvellous variety, although all formed by a repetition of the same details." (Ansted's Phys. Geog., p. 196.)

If the flakes, on their descent, encounter a warm current of air, they become partially thawed, and form *sleet*.

II. Distribution.

At the sea level and within the Tropics snow is unknown. In most parts of the world it falls only during winter : the length of time it remains on the ground, varying according to local circumstances. In England and the West shores of Europe generally, there is very little snow, compared with countries more inland having the same latitude. Again, along the East coast of North America snow is almost permanent, and this too in latitudes where it is seldom seen in Europe.

The number of days on which snow falls during the year varies according to the climate. In Rome the average is only 1½ day, while at St. Petersburg it falls, more or less, on 171 days. In the polar regions and at extreme heights in all latitudes it becomes perennial,[4] and the limit at which it is but slightly affected by the heat of summer is termed the *snow line*. This varies very much in different latitudes, being modified by local circumstances, e.g., warm winds; but the distance from the sea and also from the Equator are important elements to be borne in mind. As a general law it will be found that the *lower the latitude*,[5] *the higher the snow line*, which descends gradually, but *not* regularly, as we near either pole.

N.B. For statistics on this point, see Ansted's Phys. Geog., p. 197.

III. Uses. Snow—

[1] Refer, by way of illustration, to crystallized sugar.

[2] Ask the meaning of this word; refer to geometry, and the cells of a honeycomb.

[3] L. *spica*=an ear of corn.

[4] L. *per* = through and *annus*=a year.
Illustrate by "*perennial* springs." Shew that the *whole* mass of snow is not *strictly* perennial, for
(*a*) A portion is melted (and much of the water thus formed, evaporated) by the heat of summer.
(*b*) Very large quantities are carried down into the valleys as glaciers and avalanches.
(See Ansted's Phys. Geog., p. 202.)

[5] Shew that by *low* latitudes are meant districts near the equator, and, consequently, that *high* latitudes are those far removed from it.

(1) Forms an admirable covering for the earth, protecting vegetation from the severity of frosts.[6] It has been found that the soil has a temperature 40° higher than that of the surface of the snow above it.

(2) Reflects the faint light that proceeds from the sky in northern regions, thus diminishing the darkness of the long winters.

N.B. Avalanches, glaciers, and icebergs owe their origin to the alternate thawing and compression of masses of snow.

IV. Formation of Hail.

Hail may be regarded as frozen rain. There is great diversity of opinion as to how it is produced. In all probability it is caused by excessive cold in the atmosphere, which results from a sudden change in its electrical condition.

A nucleus of snow is first formed in the higher regions of the atmosphere. This in its descent comes in contact with more moisture, which in freezing adds to its bulk, and under certain conditions falls to the ground as *hail*.

A microscopic examination of a hail-stone shews it to be composed of alternate layers of ice and snow, very much resembling the coats of an onion. Hail-stones vary in size, from small grains to a mass of four inches in diameter.

V. Distribution.

Hail-stones fall at all seasons, and in almost all latitudes, but they are most common in countries not far from mountains, and generally within the temperate zones. They are seldom met with within the Tropics or in northern latitudes.

REMARKS. At Roncesvalles, in August, 1813, a portion of the British army was overtaken by a hail storm, in which some of the stones were as large as a hen's egg; and, near the Cape of Good Hope, in 1860, during a thunder-storm, which lasted three minutes, blocks of ice were seen *as large as bricks*, but irregularly shaped.

In France, hail-stones often cause great destruction of property.

[6] Why? Because it is a bad conductor of heat. Explain: and shew the applicability of the term "*snow blanket.*" Prove this statement by the following:

(*a*) Travellers overtaken in a snow-storm, have saved their lives by enveloping themselves in a wreath of snow.

(*b*) Sheep, buried for some time in snow, have been dug out alive.

LESSON XLI.

GLACIERS AND ICEBERGS.

MATTER.

Glaciers.

I. Formation.

As the layers of snow rest one upon another, the lower portions become consolidated,[1] and when additional quantities fall, the masses underneath are by degrees squeezed together and carried downwards. Above the snow-line we always find snow on the surface and ice below, both in winter and summer. The lower portion forms the *glacier*, the upper is known as the *nèvè*, and may be termed the *feeder* of the glacier.

"The essential condition for a glacier is the existence of some ravine or valley, at sufficient height, on the mountain side, and at such a slope as to allow of the accumulation of nèvè to such an extent that its weight can force down the whole mass into the valleys below, where the ice brought will be melted." (Ansted's Phys. Geog., p. 203.)

II. Characteristics.

The motion of a glacier is peculiar. It is neither that of a solid, nor a fluid. (For a full account of this portion of the subject the teacher is referred to Ansted's Phys. Geog., pp. 205 and 206). Its rate of motion is very various, depending upon the condition to which it is exposed, such as temperature and moisture. The maximum speed may be taken as 30 inches per day in summer, and 16 in winter. All parts of the glacier do not move with the same velocity, the centre moving more rapidly than the sides.

Glaciers are often rent by numerous fissures, which alternately widen and close according to the season,[2] and thus are formed huge cracks, termed "*crevasses*."[3] As the glacier continues to move downwards, it becomes laden with loose stones and other debris, which are dragged into its course from the sides of the mountain. These streams of stones and gravel are called "*moraines*."

III. Distribution.

Glaciers are met with abundantly in the polar regions. They are also found—

METHOD.

In Lesson XVI. we said that sometimes large quantities of snow and ice become compacted together into one solid mass. When such masses are met with on the summits or sides of mountains they are termed "**Glaciers.**"

[1] Illustrate by reference to making snowballs.

[2] Here let the teacher put a question or two to see that this statement is understood.

[3] Recall to mind our English word "*crevice.*"

(*a*) *In the Alps.* The ice fields of these mountains cover an area of 1400 square miles; the number of glaciers being 400.

The principal are the Mer de Glace (Sea of Ice), which is 7½ miles long, and the glacier of Aletsch, 16 miles by 1¼. This glacier descends to nearly 4,000 ft. above the sea level.

(*b*) *In the Himalayas.* The principal are—The Baltoro glacier, 36 miles long, and between two and three wide. Biafo, 64 miles long, and the great Mustakh glacier, 36 miles long. This latter forms one of the sources of the Indus.

(*b*) *In Scandinavia.* This peninsular has glaciers on a large scale, that of Lodal is 5½ miles long, and descends to within 1900 feet of the sea.

(*c*) *In the Caucasus Mountains.* The glaciers of this range do not descend so low as those of the Alps. They give rise to several rivers of considerable size, but little known.

IV. Uses. Glaciers—

(1) Form the sources of some of our largest rivers, e.g., the Ganges and Indus in Asia, and the Rhine and Rhone in Europe.

(2) Affect the climate of the countries where they are found.[4]

Icebergs.

I. Formation.

When an icefield or glacier descends to the sea, and a portion becomes detached, it floats away into the sea and forms an *iceberg*[5] (ice mountain). They are often carried thousands of miles by marine currents.[6]

II. Characteristics.

(*a*) *Size.* Varies from a few yards to several miles in circumference. They are often seen to the height of 250 feet above the surface of the water, but their depth below is generally found to be eight or ten times greater.

(*b*) *Appearance.* "Icebergs, seen under favourable circumstances, and without mist, appear to have steep cliffs, with a glittering surface of an emerald green tint, and pools of water often lie on their surface, or are projected in cascades into the sea. They are constantly changing in form, melting generally with great rapidity both below and above the water-line, so that their centre of gravity is perpetually shifting. Occasionally they topple and fall over, and, if too near,

4 Shew how, and explain.

5 Refer to other words in which the termination "*berg*" occurs, e.g., mountains of Cape Colony, the Drakenberg, &c.

6 See Lesson X., note 4.

7 Illustrate the meaning of the word "displacement," by reference to the hand thrust into a basin of water.

8 Why do not the vessels steer clear of them? Because they are rendered almost

are likely to be dangerous to ships, owing to the enormous displacement of water that then takes place."[7]—(Ansted's Phys. Geog., p. 211),

N.B. Icebergs are very dangerous to navigation: many vessels have been wrecked by coming in contact with them.[8]

invisible by the fogs which encircle them. (i.e., the icebergs.)

Explain how such fogs are produced, and ask the class for instances as illustrations.

LESSON XLII.

CORAL FORMATIONS.

MATTER.

The islands of the Pacific and Indian Oceans are either of volcanic origin, or coralline formation. Of the latter there are three kinds.

I. Kinds and their Formation.

(1) LAGOON ISLANDS OR ATOLLS. These are the most numerous class of islands formed by the coral insect. They vary in shape, being sometimes circular, but more commonly oval,[1] or irregular. Atolls consist of a low ridge nearly surrounding a basin of sea-water, which is often very large in proportion to the island, and is open to the sea at one point. The portion of the ocean thus enclosed is termed a "*lagoon*."[2] It is very shallow, while the ocean beyond often deepens at once to several hundred fathoms.[3]

The coral insect ceases to exist beyond a depth of 25 or 30 fathoms, and "yet the coral wall descends precipitously to unfathomable depths, and although the whole of it is not the work of these animals, yet the perpendicular thickness of the coral is known to be very great, extending hundreds of feet below the depth at which these polypi cease to live."[4]—(Mrs. Somerville's Phys. Geog., p. 153.)

Some of the largest of these atolls are nearly 100 miles long, but the majority are very much smaller. The width of the coral reef varies from a quarter to half a mile.

(2) ENCIRCLING REEFS.[5] These differ from (1) only in having one or more islands within the enclosure.

(3) BARRIER REEFS.[6] These extend in a straight line in front of, and at some distance from the land, which is generally a continent or large island.

(4) FRINGING REEFS.[7] These are quite distinct from the preceding kinds. They form fringes of coral along the margin of a shore,

METHOD.

Let the teacher have before his class a map of the world, and let him require one of the pupils to point out the Pacific and Indian Oceans. He might then state that many of the groups of islands which are there marked, have been built up, almost entirely, by the united labours of a very small insect, called the coral insect.

1 Ask the meaning of the word "*oval*," and require the names of oval-shaped objects to be given.

2 Hence the name of the islands.

3 Shew that this is explained by the fact that coral insects build *vertically*, or nearly so.

4 Let the teacher here shew how these statements can be reconciled, by calling the attention of the class to the fact that certain portions of the bed of the ocean, as well as of tracts of land, are gradually *sinking*. (Ansted's Phys. Geog., p. 59.)

5, 6, 7 Shew the applicability of these terms from the nature of the several structures.

and, as they frequently surround shoals, are very dangerous.

N.B. "Atolls and barrier reefs are believed to be due to the growth of coral on *descending* land, while fringing reefs are those formed on land *rising* out of the sea." (Ansted's Phys. Geog., p. 71.)

II. Distribution.

(1) LAGOON ISLANDS OR ATOLLS are divided into three main groups :—

(*a*) The Low or Dangerous Archipelago, situated south of the Equator and to the east of the Society Islands; many of these are inhabited.

(*b*) The Caroline Archipelago. This is the largest of all, and lies north of the Equator. Many of these are of great size and are often washed by tempestuous seas, and visited by violent hurricanes.

(*c*) The Laccadives, Maldives, and Chagos Group in the Indian Ocean.

(2) ENCIRCLING REEFS. Instances of these are to be met with in the Caroline Archipelago, but the most noted is that of the Island of Tahiti, one of the Society group,[8] which is encompassed by a lagoon 30 fathoms deep, and hemmed in from the ocean by a band of coral, at a distance varying from half a mile to three miles.

(3) BARRIER REEFS. The principal of these is the great Australian Barrier, upwards of 1000 miles long, and from 20 to 30 miles from the coast.

"The reef is nearly 1200 miles long, because it stretches nearly across Torres Strait.[9] It is interrupted off the Southern coast of New Guinea, by muddy water (which destroys the coral animals), probably from some great river on that island."—(Mrs. Somerville's Phys. Geog. p., 152.)

(4) FRINGING REEFS are numerous on the shores of the islands of the Indian Archipelago. They are also met with around Madagascar, the east coast of Africa, and the West Indian islands.[10]

N.B. For an account of the manner in which coral reefs become converted into inhabited islands, together with much additional and interesting information on the subject, the teacher is referred to Hughes's Phys. Geog., pp. 87—89, and to Mrs. Somerville's Phys. Geog., pp. 149—154.

8, 9 Shew the situation of these, on the map.

10 Require the class to point out these places.

PART III. MANUFACTURES.

LESSON XLIII.

GLUE.

MATTER.

I. Materials employed.

These are such as contain gelatine.[1] They are obtained chiefly from the leather dresser and parchment maker, and consist of scrapings and cuttings of skins, together with the clippings of hides, hoofs, and horns, and the feet of calves, cows, pigs, and sheep.

II. Stages of Manufacture.

(1) SEPARATION OF WASTE MATTERS. On receiving the refuse material from the leather dresser, the first process is to make it clean and get rid of all matters which do not yield gelatine. In order to do this the pieces are placed in a lime pit, and, having been sufficiently steeped, are placed in baskets, rinsed in a stream of water,[2] and then hung on hurdles to dry.

(2) SEPARATION OF GELATINE. The next step is to separate the gelatine. This is done by boiling the pieces in a large cauldron, adding water and fresh pieces as necessary; the whole mass being repeatedly stirred, and pressed down with poles.[3] As the boiling proceeds, portions of the gelatine are taken out, and, if it is clear when cool, the boiling is finished.

The Gelatine thus obtained is placed in a bag and boiled a second, and even a third time, for making *size*, and when nothing more can be extracted, the refuse is sold to the manure dealer.[4]

(3) CLARIFYING AND CUTTING INTO SQUARES. The glue is now drawn off into a vessel called a "*setting back*," where it is clarified,[5] after which it is placed in long wooden coolers, each about 6 feet long,[6] and when sufficiently solid is cut into squares by a wire attached to a wooden bow.

(4) DRYING. The squares are then removed to the gluemaker's field, where they are placed in piles, with a space between each set.[7] Each pile is covered with a roof to protect it from the weather. The drying of the glue is the most

METHOD.

If a boy has broken one of his wooden toys how could we stick it together? By means of **glue.**

[1] In order to illustrate the nature of this substance, refer to the gelatine lozenges and jujubes of confectioners.

[2] Illustrate by reference to rinsing clothes.

[3] Refer to the "*pushing down*" of clothes in a copper.

[4] Ask what he will do with it.

[5] i.e., made clear.

[6] Ask the pupils to show this length upon the school-room floor, in order that they may have a clear idea of the dimensions of these vessels.

[7] Why this precaution? In order to give the air free access to them, and thus facilitate the process of drying.

anxious part of the manufacture.[8] A thunderstorm will sometimes prevent a whole field of glue from drying, and a fog would produce a mouldiness in the cakes.

(5) SOLIDIFYING. When the glue is about three parts dry, it is removed from the open air into lofts, where the process of solidifying is completed. This occupies several weeks and sometimes months, and should any mould appear on the surface of the cakes it is scrubbed off.

They are are then placed in a stove room of great heat, where they become hardened and fit for use.

[8] Shew why. Because of the fickleness of our climate. If the air be too warm, the cakes would be softened, if too cold, the glue would crack (owing to the freezing of the water in it), and would have to be remelted.

III. Use.

For sticking together articles of furniture, toys, &c.

REMARKS. Other kinds of glue are prepared for particular purposes. Isinglass (commonly known as *fish glue*) is made from portions of various fish, especially the sturgeon.[9] A strong compound of glue may be made by melting together for 24 hours, some pieces of common glue and isinglass, with spirits of wine; or, by adding a half-pound of common isinglass to two quarts of skimmed milk, and allowing the mixture to evaporate until it is of the proper consistence.

[9] Ask where these fish are found.

N.B. This kind of glue will resist the action of water.

Glue is made principally at Bermondsey, in the south of London.[10]

[10] Why in this particular locality? (See first head of the lesson.)

LESSON XLIV.

CARPETS.

MATTER.	METHOD.

I. Introduction.

In former times the floors of our houses were covered, in summer with rushes, and in winter with straw; but as civilization advanced, man began to look around him for materials which might be substituted for these. This gave rise to the manufacture of a rude kind of carpet of *one* colour, and, by degrees, as man's taste for the beautiful became more developed the experiment was tried of imitating the flowers of

What do we cover the floors of our rooms with? **Carpets.**

the field, and hence carpets were made containing various patterns.

II. Stages of Manufacture.

(1) Carpets are woven by machines which are formed of many pieces. The wool of which they are made is first prepared. After it is taken from the sheep's back, it is sorted or picked; then cleaned or scoured, and next combed.

(2) It is then laid straight, and drawn into regular threads which are spun or twisted into yarn, and then dyed of various colours.

(3) These threads are then woven by working them across each other. The long threads are called the "warp;" it is double: the short ones are termed the "woof."

(4) "In forming the figure on the carpet, the weaver copies a pattern which is drawn upon paper. Beside him, sorted in different colours and shades, are laid the woollen threads, which he takes up according to the figure to be woven, and nearly as a painter takes up his colours.

In working a rose, e.g., the weaver takes up different shades of green woollen thread, for the stalk and leaves, and shades of pink for the flower." (Vide the "*Instructor*," vol. ii., page 106.)

III. Varieties of Carpets.[1]

(1) KIDDERMINSTER carpets are made entirely of two woollen webs, worked together in such a manner as to produce certain figures. Such carpets are generally chosen for bedrooms, and are usually of small, neat patterns. Similar to these are Scotch carpets.

(2) AXMINSTER carpets are made in imitation of Turkey carpets.

(3) WILTON carpets were first made at the town of that name, in Wiltshire.[2]

(4) BRUSSELS carpets were originally made at Brussels, the capital of Belguim, but now the same kind of carpet is made in our own country.[3] In Brussels carpets the principal surface will be found to consist of woollen loops, which are made by drawing woollen threads over wires which are afterwards taken out.

N.B. In making "hearth rugs," the loops are made long and cut through the top.

(1) and (4) are made of different widths, but in pieces many yards long.

[1] Shew that these are named from the localities of their manufacture, and point out the places named on the map.

[2] Let the teacher draw attention to the fact that the foregoing kinds of carpets are made in England, while those which follow are of foreign manufacture.

[3] Hence the word "*Brussels*," as applied to these carpets would be a misnomer. (Explain.)

(5) TURKEY carpets have a longer woollen surface, are warmer than other kinds, and are softer to tread upon. They are generally of a dull pattern, and are made in *one* piece, with, not unfrequently, a handsome border of a different pattern from the rest of the carpet.

IV. Uses.

(1) Carpets form an article of furniture, and add to the appearance and comfort of our dwellings.

(2) Thousands of men, women, and children are engaged in the manufacture of carpets, and are thus enabled to earn their livelihood.

REMARKS. The earliest carpets were in the form of rugs,[4] and were the production of the Hindoo loom.

In selecting a carpet for a room, care should be taken that the colours of its patterns harmonize with those of the paper on the walls; hence, the distinction, in appearance, of the carpets of a dining room, and those of a drawing room.

[4] Let the teacher here refer to the recumbent posture so common among Orientals, and, as an illustration, he may recall to mind the Eastern schoolmaster, who, invariably sits on a small carpet or rug, with his scholars arranged around him in the form of a circle.

LESSON XLV.

CUTLERY.

MATTER.

N.B. Only the articles in *common* use have been selected as the subject-matter for this Lesson, e.g., Table-knives and forks, scissors, razors, and pen-knives.

I. Varieties of Steel.

All the above articles are, or ought to be manufactured of steel, which is made from the purest iron, after having been subjected to various processes. There are two kinds of steel:—

(1) BLISTERED STEEL, which is always more or less porous[1]. This is made by putting pure iron with charcoal into close pots, which are then placed in a strong coal fire in a covered furnace.

Here the pots are allowed to remain until the iron has become changed by the heat, and the charcoal into common steel.

N.B. Articles of a low price, and which do not require a fine polish, are made of this kind of steel.

METHOD.

What do we use to eat our dinners with? **Knives and Forks.**

[1] Ask the meaning of this word and illustrate by reference to a sponge or piece of cane.

(2) SHEAR STEEL is made by repeatedly hammering blistered steel until it becomes perfectly solid[2]. Articles of a better description are made of this kind of steel.

(3) CAST STEEL is the finest kind. It is made by melting (1) in a furnace, and pouring it into moulds to cool. It is then again gently heated, and carefully hammered into bars.

The most expensive articles are made of this kind of steel, as no other will bear a high polish.

II. Process of Manufacture.

(1) TABLE KNIVES AND FORKS. Table knives are mostly made of shear steel.[3] Each knife passes through 12 hands, or 144 stages of workmanship.[4]

(a) Hammering. The blade is first hammered out of a piece of steel. A piece of iron is then fastened on to the thicker end of the blade, and forms the shank, which is the part fitted into the handle.[5]

The blade is then hardened by plunging it when red hot into cold water.

(b) Tempering. But as it is now too hard, it is again heated, and then allowed to cool. This makes it less brittle[6]. This process is called "*tempering.*"

(c) Grinding. The blade is next carried to the grinding mill, where it is placed upon stone wheels of different finenesses, each wheel being worked by a treadle.[7]

(d) Polishing. The blade is then polished upon a wheel covered with leather, after which it is fixed into the handle.

Balance handles[8] are made by perforating the ivory, wood, or bone, as the case may be, to a greater depth than usual, and dropping in a small piece of lead; the knife then rests upon the handle, and the shoulder and the blade do not come into contact with the table cloth.[9]

N.B. Forks are shaped from steel at the anvil, and the prongs are stamped out, hardened, and tempered. Common forks are made of cast iron.

(2) SCISSORS. These occupy more time in making than any other article of cutlery.

A pair of scissors passes through 16 or 17 hands before it is ready for use.

A pair of scissors has three parts :—

(a) The blades, *(b)* the shank, *(c)* the bows,[10] each of which is made separately on an anvil.

[2] i.e., The various atoms of metal are so welded together as to get rid of the porosity above alluded to.

[3] How do we know this? By the stamp on the blade.

[4] Here notice the division of labour employed in this manufacture (See Lesson on Pins, page 85 of First Series.)

[5] The teacher would do well to provide himself with the articles named at the head of the lesson, so that he might refer to them when necessary.

[6] Ask for examples of other articles which possess this quality, and shew the danger of a brittle blade.

[7] Illustrate by reference to the knife grinder's barrow seen so often in the streets.

[8] Shew why so called.

[9] Explain and exhibit such a knife, if possible.

[10] Holding up a pair of scissors, the teacher should shew each of these parts.

They are then put into a fire to be softened, after which the shanks and bows are filed, and the hole bored for the screw which fastens the two blades together.

The blades are next ground, and the shanks and bows made bright, having first been hardened. The scissors are then finished with a polished steel instrument.

N.B. Snuffers are made much in the same manner as scissors.

(3) RAZORS are made of the finest steel. Each pair passes through a dozen hands. The blade, having been formed, is hardened and tempered by heating it to a straw colour.[11] It is then ground and polished, in order to make it hollow and give it a keen edge.

(4) PEN-KNIVES. The manufacture of these is divided into three parts :—

(a) The forming of the blade, the spring, and the iron-work of the handle.[12]

(b) The grinding and polishing of the blade.

(c) Fitting the several parts together, and finishing the knife.

N.B. The *uses* of the above article are too well known to require a separate head.

REMARKS. The finest cutlery is made at Sheffield and the neighbourhood ;[13] Birmingham also employs many hands in this manufacture.

English cutlery is superior to that made in any other part of the world, and large quantities are annually exported to the E. and W. Indies and America.

[11] Explain and illustrate by *red* hot, *white* hot, &c.

[12] Ask which is the spring.

[13] Shew on the map.

LESSON XLVI.

LEATHER.

MATTER.

I. Introduction.

Savages depend for their subsistence mainly upon the flesh of animals which they kill in the chase, adopting for their clothing the skins of the animals thus captured.[1] But such skins when dried, shrink, and become horny ;[2] in this condition they would be useless to us for manufacturing purposes, hence they are subjected to various processes to render them pliant, or as the old Saxon word expresses it, *lith*.[3]

METHOD.

Of what are boots and shoes made? **Leather.**

[1] Recall to mind by way of illustration the habits of the ancient Britons, the Picts, and Scots, &c.

[2] Illustrate by reference to dried rabbit skins.

[3] Hence "*lither*," from which we derive "*leather*."

II. Stages of Manufacture.

(1) The hide or skin of an animal consists of three layers :—

(a) The Epidermis, or Cuticle, which is covered with hair or wool.

(b) The net-like layer, called from its appearance, the rete mucosum ; and

(c) The Dermis, or Vera Cutis.[4]

(b) and *(c)* are useless in the manufacture of leather, and hence they must be separated from *(a)*.

In order to do this,

(2) The skins are placed in a mixture of lime and water, and allowed to stand for two or three weeks. This operation prepares them for

(3) The *unhairing* knife, which is an instrument used, as its name implies, for scraping off the hair. A *fleshing* knife is then used, which removes the flesh and fat.

(4) The skins are then placed in pits,[5] where they are left for some time until they become very soft, when they undergo the process of "*tanning*." This is done by steeping them in water, in which are placed portions of the bark of an oak tree, and a substance called *tannin*, which has been extracted from oak bark and gall nuts. At first the skins are white, but by degrees they are changed to a brown colour, and are then called *leather*.

N.B. This is the process adopted with the coarser kinds of leather, the black appearance being imparted to it either by laying on a mixture of oil, lamp black, and tallow, or by applying a solution of sulphate of iron.

This is called "*currying*."[6]

(5) Finer kinds of leather, (termed *white* leather,) are not tanned, but *tawed*, i.e., they are placed in a large cylindrical vessel,[7] where they are subjected to the influence of a mixture of alum and salt. Having been removed from this receptacle, and washed and dried, they are placed in a mixture of the finest wheat flour and the yolks of eggs. This produces the glossy finish and softness of white kid, which is further developed by working it upon a rounded iron resting upon a post.

III. Varieties of Leather.

(1) *Thick Leather*, such as is used in the manufacture of articles where strength and durability are required.[8]

[4] See Lesson VIII., Part I., "*The Skin.*"

[5] Called, because of the operation conducted in them, "tanpits."

[6] Draw attention to the fact that this process helps to render the leather waterproof, and illustrate by the practice of greasing or oiling boots in wet or snowy weather.

[7] i.e. A vessel having the shape of a cylinder. Illustrate by reference to a large gas pipe, or the body of a locomotive.

[8] Ask for the names of any articles which require leather of this kind.

(2) *Morocco* for coach linings, bookbinding, etc.[9] This kind of leather is made from goats' skins, which are brought from Morocco.[10]

(3) *Roan.* Used for slippers and bookbinding.

(4) *Skiver.* „ linings of hats.

(5) *Shamoy.* „ various purposes.[11]

N.B. This is also called "*wash leather*," because it will bear washing, even when dyed.

(6) *Russian.* Used extensively in bookbinding, the manufacture of purses, &c. The peculiar smell of this kind of leather is owing to its being dressed with the tar extracted from the birch tree.

(7) *Kid*, of which gloves and the uppers[12] of ladies' boots are made.

(8) *Calf*, also used for gloves and the more expensive kinds of boots.

IV. Locality of Manufacture.

Leather is manufactured principally at Bermondsey;[13] but there are many tan yards in various parts of the country. They are generally situated on the outskirts of towns.[14]

V. Uses.

Many of these have been already mentioned under head III.

The uses of leather may be thus briefly summed up:—it forms an important part of our clothing: furnishes harness to horses and other animals, linings to carriages, covers to books, and enters into the construction of various kinds of machines and articles of household furniture.[15]

[9] Ask for the names of other articles made of morocco.

[10] Shew on the map.

[11] Require the pupils to mention some of them, and inform them that this leather is made from the skin of the *chamois*, an animal found in Switzerland; the orthography of the word as here given being its anglicized form. (Comp. *crevice* and *crevasse*.)

[12] Ask which are the "uppers," and shew that this word is used in contradistinction to the sole.

[13] Where is this?

[14] Why? Because of the unpleasant odours arising from them.

[15] As an intellectual exercise calculated to call forth the powers of observation and reflection, the teacher might require the class to specify instances of leather being used for these various purposes.

LESSON XLVII.

NAILS.

MATTER.

I. Stages of Manufacture.

(1) By hand. (*a*) *Heating the iron.* Nails are forged by hand from rods of wrought iron of suitable size. The nailer's apparatus is very simple, consisting of a small forge, an anvil, a hammer, and one or two other tools. The nailer begins by putting the ends of three or four nail rods into the fire and working the bellows to bring them to a proper heat.

METHOD.

What do we drive into the wall to hang pictures upon? **Nails.**

(*b*) *Cutting off the nail.* He then takes one of the rods out of the fire, and resting it on the anvil, draws out the nail by a few skilful blows, and cuts it off from the rod by means of a *hack*-iron.[1]

(*c*) *Making the heads.* The next operation is to form the heads of the nails. This is done with a tool called a *bore*, which is a piece of iron furnished at each end with a steel knob perforated[2] to the size of the shank or hollow of the nail, and having another depression corresponding to the head. A nail, being taken up while hot, with a pair of tweezers, is inserted with its point downwards into the bottom: the nailer then strikes it with a hammer upon the projecting end, thus forcing it to take the shape of the perforation.[3]

(2) BY MACHINERY. (*a*) *Cutting the strips.* When nails are made by machinery, the sheets of iron, out of which they are formed, are first cut into strips by means of a *cutting press.*

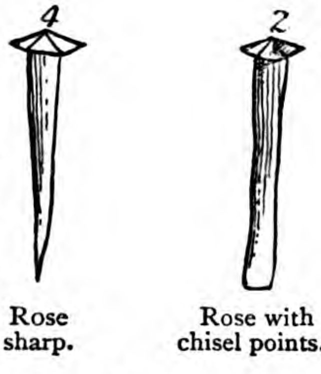
(*b*) *Cutting the nails.* Each of these strips is then mounted on a rod and held in the *nail-cutting* machine, the further end of the rod being supported on a forked rest to keep the strip in a proper position.[4]

(*c*) *Annealing.* But the nails thus cut off are very brittle, owing to the strong compression to which the iron has been subjected in rolling. In order to remove this brittleness they are *annealed*, i.e., they are placed in close iron boxes, heated in ovens, and allowed to cool gradually.

II. Principal varieties of Nails.

(1) *Clasp nail.* So called from the form of the head. Used for clasping work together. Much used by house carpenters.

(2) *Rose, with flat or chisel points.* These being driven with their edges across the grain, the wood is thus prevented from splitting.



Rose sharp. Rose with chisel points.

(3) } *Brads and tacks.*
(5) } Small, but very useful nails.

(4) *Rose sharp.* Used for coopering, fencing, and other coarse purposes where hard wood is employed.

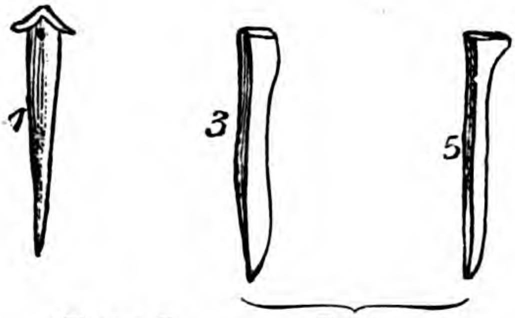
N.B. A finer kind of this variety, known as "fine rose," is used in pine and other soft woods, the broad head serving to hold down the work.

[1] Why so called? "To *hack*" is to cut.

[2] Ask the meaning of this word, and illustrate by reference to a sheet of perforated zinc.

[3] Let the teacher explain this clearly, in order that the class may understand the process.

[4] Let the teacher give the class some idea by diagrams on the blk. bd.



Clasp nail. Brads.

III. Locality of Manufacture.

Nails are made principally at Dudley,[5] and the neighbourhood.

N.B. The *uses* of nails are so well known as not to need a separate head.

REMARKS. Nails, like many other articles in common, every-day use, were formerly produced by individual efforts, i.e., they were made by hand, and hence the trade was called a *handicraft*.[6] It was originally confined to the male members of a family, and, for some years the trade continued steadily to increase; but as the religious and mental culture of the workman did not keep pace with his worldly prosperity, his gains were often squandered as soon as earned, and, in order to keep the home together, the husband's trade was acquired by the wife, who, not unfrequently, imparted it to her daughter. Hence the enquiry of Hutton, the Birmingham historian (when approaching that town from Walsall), on seeing numbers of women wielding a hammer, "Do these ladies shoe horses?" to which the answer was given, with a smile, "They are *nailers*."

For many years the trade was carried on in this manner; but, by degrees, machinery took the place of manual labour. This was owing to a combination of circumstances, the chief of which were :—

(*a*) The high price which the nailers charged for their produce.

(*b*) The inadequacy of the supply to meet the increasing demand.

For some time the nailer continued to struggle against the machine, but his trade rapidly declined, until, at last, it came to be one of the lowest and most despised.

[5] Ask the locality of this town.

[6] Shew why: and explain.

LESSON XLVIII.

BUTTONS.

MATTER.

I. Introduction.

The various materials of which buttons are now made are very numerous, the most common being metal, iron, ivory, bone, and glass.[1] But some years ago, the gilt button was almost universal, at any rate, as fastenings for coats and vests.[2] So important was its manufacture considered, that Acts of Parliament were passed protecting it. There is still a great demand for this kind of button, and, also for the *Florentine* button, or those with covers, and as these are the two principal varieties, the manufacture of the common kinds, i.e., those made of bone, horn, &c., is not here touched upon.

II. Process of Manufacture.

(1) A GILT BUTTON. (*a*) *Cutting out.* These are made of sheet copper with a small alloy[3] of zinc. Strips of this metal are furnished to the button maker, and by means of the *fly press* he cuts out circular pieces, termed "*blanks.*"

(*b*) *Shanking*, After smoothing the edges and faces of these blanks, they are ready for the "*shanks.*"[4] These are made by machinery and applied by hand, as follows :—The shank being placed in position is held there by a small spring clasp, and a little solder[5] and resin being heaped round the shank, the heat of an oven melts the solder and secures the shank.

(*c*) *Stamping.* If the button is to be ornamented with a crest or other device, it is passed through a stamping press, the lower die containing a hole for the reception of the shank during the stamping.

(*d*) *Cleansing and gilding.* The buttons are next cleansed by being stirred up in a weak solution of nitrate of mercury, in which from 2½ to 5 grains of gold are dissolved, this being the quantity allowed for the gilding of 144 one-inch buttons.[6] But as the buttons are now of a dull silvery hue, from the excess of mercury, they are placed in a wire cage, which is plunged into a furnace and kept revolving. This allows the

METHOD.

What have we on our coats and waistcoats to enable us to fasten them when we wish? **Buttons.**

[1] Let the class be called upon to name any others.

[2] Many of the class will, perhaps, call to mind the peculiarity (as it seems to us of the present day) of the style of dress worn by their grandfathers.

[3] Ask what the word "*alloy*" means: illustrate by reference to coins.

[4] Ask which part of the button is the shank. It would be well if the teacher provided himself with a button such as are worn on liveries.

[5] See that the class knows what this is, and ask for instances where solder is employed.

[6] i.e., Buttons whose diameter is one inch.

mercury to escape as vapour, leaving the gold equally diffused over the surface of the buttons.

(*e*) *Burnishing*. They are then burnished, an operation which imparts to them their beautiful lustre.

(2) A FLORENTINE, OR COVERED BUTTON. Although these appear simple, yet their manufacture is more complicated than that of a gilt button. The various parts of the button (which are cut out by fly presses) are :—

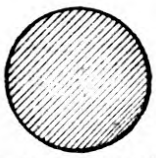
(*a*) A metal shell.

SHELL

COLLET

(*b*) A metal collet, containing an oblong hole for the shank of the button.

(*c*) A piece of silk or some other woven covering for the button.



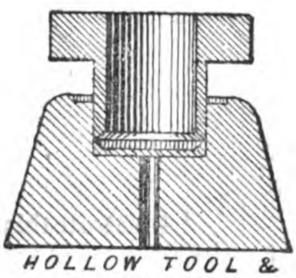
COVERING

7

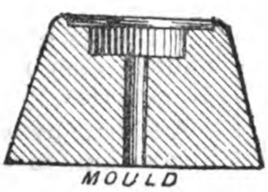
SHANK

7
8 { Let these be sketched on the blk. bd.

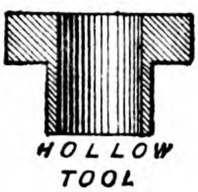
(*d*) The padding which lies underneath the collet. The various discs, (consisting of the silk



HOLLOW TOOL & MOULD



MOULD



HOLLOW TOOL

covering; a disc of paper to prevent the metal shell from cutting the silk,) and the shell, are placed in a mould to the bottom of which they are pressed by means of a punch, and, when this is removed, a hollow tool is forced into the mould, by which means the edges of the silk are made to overlap the shell. The collet, with the padding, is then dropped into the mould through a hollow tool, when a punch is brought down so as to force the padding, and the edges of the outer covering into the shell. The button is then removed from the mould, and having received its final pressure, is ready for use.

III. Locality of Manufacture.

Buttons are manufactured principally at Birmingham,[9] though other towns are also engaged in the trade.

N.B. The *use* of buttons is too well known to require a separate head.

[9] Ask for its locality.

LESSON XLIX.

A BEAVER HAT.

MATTER.	METHOD.

I. Introduction.

Hats were originally made from the fur of the beaver, an animal found in N. America. (See Lessson 6 in First Series). Of late years silk has taken the place of this fur, and, as the manufacture of this kind of hat is much more simple than that of the former, we shall not describe it in this lesson.

What is the covering called which gentlemen place upon their heads? **A hat.**

II. Stages of Manufacture.

(1) In making a beaver hat, a hat body, or foundation of wool is taken. This is in the form of a conical cap.[1]

(2) With one ounce of beaver fur the hatter mixes an ounce of *musquash*,[2] and the same quantity of cotton wool. These materials are so worked with the hands that they blend together, and, by degrees, form a sheet of cloth, called *felt*.[3]

(3) The operations are next transferred to the battery, which consists of a boiler, surrounded by sloping mahogany sides, and containing a mixture of water, sulphuric acid, and oatmeal. Here it is worked about until the fur is properly

[1] Illustrate this shape by reference to a sugar loaf, as seen in the windows of grocers' shops.

[2] The fur of another animal also found in N. America.

[3] Refer, by way of illustration, to hats of this kind.

combined with the body, which ultimately assumes a cylindrical shape.[4]

(4) The crown is then formed upon a block, and afterwards the brim.[5]

(5) The beaver hats are next combed, and the tips of the hairs cut off with a pair of shears, after which they are mounted on blocks and lowered into the dye copper;[6] they are then smoothed and finished by means of warm and damp hair brushes and hot irons.

(6) Trimming, binding, and lining, and lastly, blocking, (by which the particular shape is given to the hat) are the finishing operations.

N.B. The *use* of hats is too well known to require a separate head.

REMARKS. The finest hats, or those which are covered with beaver fur, are made in London. The cheaper kind are covered with *Nutria*, which is the fur of the coypou, an animal found in S. America.

Nearly a million of these animals are killed annually, and their skins sent to Great Britain.

[4] i.e., the shape of a cylinder. Ask for objects of this shape.

[5] Ask the class to say which parts of the hats these are.

[6] Call attention to the fact that most hats are black, and explain the reason that *drab* hats (commonly called white) are cooler for summer.

LESSON L.

BUTTER.

MATTER.

I. Introduction.

The machine used in making butter is termed a *churn*, and hence the process employed is called *churning*. There are two kinds of churns :—(many kinds of patent churns have been invented of late years.)

(*a*) *The common upright churn.* This is a wooden cask, diminishing in size towards the top, and having a movable round lid with a hole in the centre. Through this hole a stick passes, having at its lower end a round, flat board, with holes in it.

(*b*) *The barrel churn.* This is so called because of its shape. It is worked by a handle attached to a wheel, to which inside the barrel, are fastened cross boards pierced with holes.

Both (*a*) and (*b*) are made of wood.[1]

I. How made.

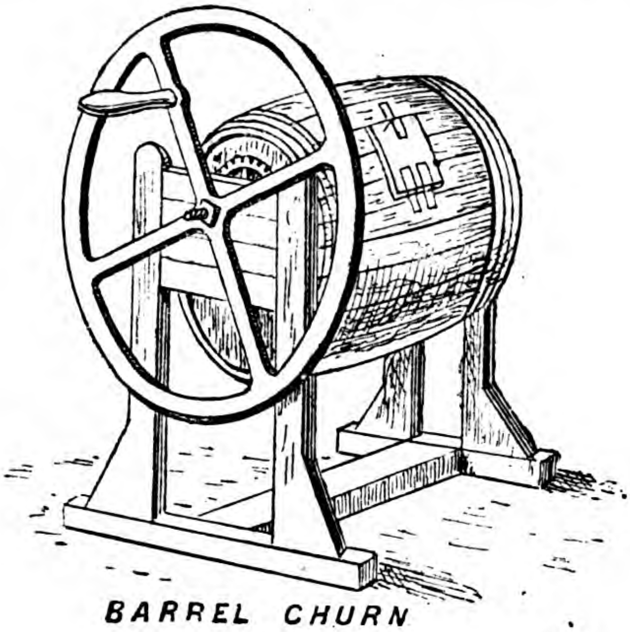
The cream is poured into the churn, which is then worked, (in the case of (*a*) by repeatedly raising and lowering the stick, or sometimes by

METHOD.

What do we commonly eat upon our bread at tea-time? **Butter.**

[1] Why? so that the flavour of the butter may not be affected by the machinery employed.

pushing it backwards and forwards, according to the construction of the churn; and, in the case of (*b*), by turning the handle above mentioned) until the heat[2] and the motion combined, change



BARREL CHURN

the cream from its liquid condition into small lumps of butter. These are collected and placed in a shallow tub, where they are worked by hand into a mass, and afterwards weighed off and stamped with various patterns, by means of carved wooden presses.[3]

The refuse of the churn is called *buttermilk*, and is not unfrequently bought for a trifle by the farm servants, who consider it a cool and palatable drink. That which is not sold is given to the pigs, and is said to improve their condition.

If the butter is to be used *fresh*, then but little salt is added;[4] but if it be intended for keeping, much more salt is added, and it is then packed into wooden tubs,[5] and called *salt butter*.

III. Where produced.

Butter is made all over England, but that which comes from Essex, Cambridgeshire, and Dorsetshire is most esteemed.[6]

Great quantities of salt butter are made in Ireland, and also in Holland, and many thousand tubs are imported into England annually. The latter of these two kinds is by far the best.

[2] What heat? That of the milk.

[3] Recall to mind the various patterns seen on butter in the dairyman's window.

[4] Explain the fact that *all* butter contains a little salt, otherwise it would soon turn sour and be unfit for food.

[5] Hence "*tub butter*."

[6] Ask for the situation of these counties, and refer to the placard so often seen in shop windows: "Prime Dorset butter."

IV. Uses.

(1) As an article of food.
(2) As an ingredient in cooking.

REMARKS. Butter can only be used as we use it, on bread, in cold or temperate countries :[7] in hot climates, as India, it is a liquid, and carried in skin bottles; when used in the countries of S. Europe,[8] is it sold in apothecaries' shops.

N.B. Olive oil is often used by the inhabitants of these countries as a substitute for butter.

[7] Recall to mind the effect of summer heat upon our butter.

[8] Ask for their names.

LESSON LI.

CHEESE.

MATTER.

I. Introduction.

Milk, if left to become sour, separates into two parts, called *curd and whey*.[1] The former of these is the substance used in making cheese; but as the cheese thus made is not of an agreeable flavour, another method of curdling the milk is adopted.

II. How made.

The milk is first warmed, and then some *rennet* is put into it. This is a liquid obtained by soaking the stomach of a calf in salt and water.

The curd is then removed with coarse cloths and placed in vats[2] with holes in them. These are fixed between boards and put into the cheese press. They are subjected to heavy pressure, which causes the remainder of the whey to run off through the holes above-mentioned. In the course of two or three days, during which the new cheese is taken out three or four times, wiped, turned, and replaced in the press, it is sufficiently solid to be placed in the salting tub, where it remains covered with brine[3] for several days. It is afterwards taken out and rubbed with salt daily, for another week or ten days. It is then taken to the cheese room, where repeated wipings, turnings, and airings, keep it from premature decay.

METHOD.

In our last lesson we spoke of butter as being made from cream. What becomes of the milk that is left? It is made into *Cheese*.

[1] Ask if any in the class have ever tasted this drink.

[2] What are these? Shallow wooden vessels. Refer, by way of illustration, to brewers' cooling vats.

[3] What is brine? A solution of salt and water. Recall the expression, "as salt as brine."

II. Where produced.

Cheese is made all over England, but the finest kinds are those made in Gloucestershire, Wiltshire, Somersetshire, and Cheshire;[4] hence we have "single" and "double" Glo'ster, (according to the *thickness* of the cheese) "Cheddar," made in Somersetshire, and "Cheshire" cheese, which takes its name from the county in which it is made.

Stilton cheese is a superior kind, and is made in Leicestershire.

N.B. Much of the cheese sold in England is made in America; it is known by its strong, biting flavour.

REMARKS. The quality of cheese varies according to the quality of the milk from which it is made.

This is ascertained by means of an instrument called a *lactometer*.[5] It consists of graduated tubes, into which the milk of different cows is poured. The amount of cream which settles at the top of each tube determines the richness of the respective milks.[6]

[4] Shew on the map.

[5] L. *lac, lactis* = milk. Gr. *metron* = a measure. Explain and illustrate by reference to thermometer, &c.

[6] Shew how.

LESSON LII.

BREWING.

MATTER.

N.B. This Lesson should be given next to that on "Malt and Hops," Lesson LIV., in Part IV. of the present Series.

It will be necessary at the outset of the Lesson to state, that inasmuch as the word "*beer*," in its widest acceptation, includes various kinds of beverages, (vide "Johnston's Chemistry of Common Life," Vol. 1, pages 302—309), the remarks which follow are applicable *only* to the brewing of *malt liquors*.

I. Introduction.

"Malt beers are so called because they are prepared either in whole, or in part, from infusions of malted barley. The manufacture of these drinks involves two distinct chemical processes:—

(*a*) "The change of the starch of the grain into sugar."

METHOD.

Enquire what are the common beverages of the English, and especially of the lower classes.

Beer will be mentioned as one of them. The teacher may then inform his class that the art of making beer is called **Brewing**.

(*b*) "The change of the sugar into spirit of wine or alcohol."

(See "Chemistry of Common Life," vol. 1, page 284.)

The first of these is accomplished by transforming the grain into malt: the second by fermenting the malt thus made.

The former of these we considered in our Lesson on "Malt and Hops;" we now proceed to speak of the latter process.

II. How made.

(1) MASHING. The malt is first crushed between iron rollers, or cut into pieces by a mill. It is then thrown into an immense tub, called a *mash tun*, where water heated to about 160° Fahr. is poured upon it. By this means the sugar is extracted from the malt, and if the process has been well conducted, very little but the husky grain is left undissolved.

The liquor thus made is termed "*wort*,"[1] and what remains of the malt is called "*grains*."[2] These are commonly used as food for horses, cows, and sheep.

(2) BOILING. The next process is to boil the wort with the hops. This imparts a bitter flavour to the liquid, and also helps to clarify it.[3] The length of time given to boiling, and also the quantity of hops added, depend upon the quality of the beer to be made.

(3) FERMENTATION. The liquor is now run off into shallow vessels, called "*coolers*,"[4] until its temperature is reduced to between 54° and 64° which is the most favourable to fermentation. It is then transferred to the fermenting tun, where a sufficient quantity of yeast is added:[5] here it remains for about six or eight days, during which time it produces a large quantity of yeast, which is skimmed off as fast as it appears.

The liquor is now beer, and is drawn off into smaller casks, and when it has ceased "*working*" is bunged down,[6] and stored away in cellars.

N.B. The *use* of beer as a beverage is known to all.

REMARKS. The taste and colour of beer depend greatly upon the malt being more or less dried in the kiln, e.g.,

Ale, or light-coloured beer, is brewed from *pale* malt.

1 Sometimes "*sweet wort*," from its being so sweet to the taste.

2 Ask if any of the class have ever seen waggons full of these grains, passing along the streets.

3 i.e., to make it clear.

4 Ask why so called, and why they are shallow. Illustrate by hot tea poured into a saucer.

5 Why? In order to make it *ferment* or "*work*," as it is called: i.e., produce a creamy froth upon its surface.

6 Ask what this expression means, in order to see that it is understood.

7 As an intellectual exercise for the class, the teacher might ask for the names of as many varieties of beer as could be given. By

Amber-coloured beer from malt which has been *lightly scorched*: and

Brown, or dark-coloured beer, (commonly called "*Stout*") from *burnt malt*.[7]

this means the localities famous for the brewing of beer would, to a certain extent, be ascertained.

PART IV. MISCELLANEOUS.

LESSON LIII.

TOBACCO.

MATTER.

I. Where Grown.

The Tobacco plant, which was originally a native of tropical America, will thrive without difficulty between the Equator and the 50th deg. of latitude, though it is most productive within 35° of the Line. The finest kinds are raised between the 15th deg. of N. Latitude and the 35th.[1]

Among narcotic[2] plants it occupies the same place as the potato among food plants, i.e., it is the most extensively used kind of the species to which it belongs.

II. Description of the Principal Varieties.

As many as 40 species of the tobacco plant have been enumerated by writers: the principal however are those known as :—

(1) Virginian[3] tobacco, (2) common green tobacco.

TOBACCO PLANT.

The Virginian tobacco is a plant averaging from 5 to 6 ft. in height, and having leaves about 1½ ft. long, and 6 in. broad. The blossoms of the plant are all at its summit,[4] and are pentagonal in shape,[5] each segment being pointed.

The common green tobacco is a smaller plant than the Virginian, being only from 3 to 5 ft. in height. It has shorter and

METHOD.

You have all seen men smoking: with what do they fill their pipes? **Tobacco.**

[1] By shewing these on the map of the world, the class will see that the first-mentioned latitude includes the Philippine Isands, the latter, the country around Latakia in Syria.

[2] Derive the meaning of this word from Gr. *narke* = torpor, shewing that it was applied to tobacco because of the effect it is said to produce upon those who indulge in its use.

Compare the opium of the Chinese and the betel-nut of the inhabitants of East Indian Archipelago.

[3] Why? Shew the situation of this state on the map, and recall the origin of its name. (*Vide* reign of Elizabeth.)

[4] What part of the plant is this? Ask for illustrations.

[5] i.e., of the shape of a pentagon: refer to geometry.

broader leaves and smaller flowers with rounded segments.[6]

III. Extensive Use.

The use of tobacco has become as extensive as its cultivation. Tea alone can compete with it, for, although it mây not be in use over so wide an area, yet it is probably consumed by as great a number of the human race.[7]

In America, tobacco is met with everywhere, and the consumption is enormous.

In Europe, from one end of the continent to the other, tobacco, in one or other of its various forms, is commonly used.

In the East, too, the use of tobacco is almost universal. "In Turkey the pipe is perpetually in the mouth. In India all classes and both sexes smoke. The Siamese chew moderately, but smoke perpetually. The Burmese of all ranks, of both sexes, and of all ages, down even to infants of three years old, smoke cigars. In China the practice is so universal, that every female, from the age of 8 or 9 years, wears, as an appendage to her dress, a small silken pocket, to hold tobacco and a pipe." (Johnston's "Chemistry of Common Life," vol. 2, page 9.)

Tobacco was first introduced into this country in 1586,[8] by Sir Francis Drake; and the colonists of Sir Walter Raleigh and though King James opposed it by his "Counterblast to Tobacco," yet such opposition only awakened curiosity respecting the plant, and tempted others to try its effects.

N.B. For information on statistics of consumption, the various forms in which tobacco is used, and the effects it produces, the teacher is referred to Vol. 2 of Johnston's "Chemistry of Common Life."

[6] Comp. the sketches (which the teacher should have ready.)

[7] Shew how this can be, and refer to the density of the population of China.

[8] Ask in whose reign this was.

LESSON LIV.

MALT AND HOPS.

MATTER.

I. Malt.

Malt is made from barley, which is grown in our fields like wheat. It is very easily distinguished from wheat, for it is thinner in the

METHOD.

Some of you can, perhaps, tell me of what beer is made? **Malt and Hops.**

ear,[1] and possessed of a beard;[2] it is sown later and reaped about the same time.

Before barley can be used in brewing it must be transformed into *Malt*. This is done as follows:—After having been steeped in water in a cistern it is taken out, and allowed for a short time[3] to sprout. It is then placed in a kiln, having a perforated floor,[4] under which is a coke fire. By the action of this heat, the starch of the barley is changed into sugar; hence the sweetness observable in a grain of malt. The malt is afterwards stored in malthouses, where it is kept until required for use.

II. Hops.

(1) WHERE GROWN. Hops are extensively grown in the following counties:—Kent, Surrey, Worcestershire, Sussex, and Hereford; but the finest varieties are those cultivated in the first three counties, the neighbourhood of Farnham, in Surrey,[5] being especially noted for the growth of hops.

(2) DESCRIPTION OF PLANT. There are several varieties, but the following remarks will apply equally to all of them. Hops are the flowers of a parasitical[6] plant, which, as it grows, entwines itself around a pole[7] to the height of 15 and sometimes 20 ft.[8] The growth of the hop-bine is worthy of notice. It always twines from left to right,[9] i.e., from E. to W., *with* the apparent course of the sun.

(3) HOW GATHERED. The flowers are the portions of the plant which are useful. They are gathered in September by women and children, who pick them off and put them into baskets.[10] Whole families of the poorer inhabitants of such of our large towns, as are in the vicinity of "hop gardens," migrate to them annually, living in the open-air[11] (if the weather be fine) for weeks.

After the flowers are gathered they are dried in the sun, and are then placed in sacks, called "*pockets*."[12] They are then fit for home use or for exportation.

(4) USES. (1) To impart a bitter flavour to beer, and (2) to keep it from turning sour. (3) They are sometimes used as "sleep producers," in cases of sickness.[13]

N.B. If the teacher is able, from his own observation, to describe the appearance of a "hop garden," and the operation of gathering, he will add much interest to the Lesson.

[1] The teacher would do well to *ask* for these differences. This would arouse the thinking powers of the class.

[2] Explain which part of the ear this is, and draw attention to the fact that *some* kinds of wheat resemble barley in this respect.

[3] Why a *short time*? Because its strength would diminish (compare the sprouting of potatoes, &c.)

[4] i.e., a floor full of holes (why?)

[5] Shew on the map.

[6] Why so called? Because they *climb*. Obtain derivation if possible.

[7] Why? That it may have support. Ask for examples as illus.

[8] See that the pupils have an idea of this height, by drawing their attention to some portion of the school-room.

[9] See that the class comprehends this, and impress upon their minds the fact that this direction is just the opposite to that in which our kidney beans and some other plants twine. By means of this comparison the advantages to be derived from a careful observation will be apparent.

[10] Ask how this can be done. Refer to the height of the poles.

[11] Shew what a boon is thus afforded to the dwellers in our courts and alleys.

[12] Hence the measure known as a "*pocket of hops*."

[13] Refer to the "hop pillow," which has often given sleep to the weary invalid, when every other means has failed.

LESSON LV.

THE VINE.

MATTER.

I. Where Grown.

In the southern countries of Europe,[1] S. France and Italy especially. The vine flourishes best between 20° and 50° of latitude; beyond these limits it does not attain to perfection. Vines are also cultivated, to a certain extent, in C. Colony.[2]

II. Cultivation and Gathering.

The vine grows best in a light soil. The first thing to be done is to choose a suitable spot; much care is exercised in this matter. The young plants are then placed in holes 18 inches deep, and a yard apart.[3] In some countries vines are trained upon short poles: in others they are cut down very low, and kept frequently hoed.[4] In some parts of Italy, vines are planted in corn fields, and thus, grapes for making wine, and corn for making bread, grow upon the same ground.

THE GATHERING (called "the Vintage") takes place late in September, or early in October. The fruit is picked by hand, or cut from the trees with a knife, or pair of scissors.

In order to prepare them for pressing, the grapes are generally picked off the stalks. In some countries, peasants, wearing wooden shoes, tread the grapes in baskets,[5] or in tubs with holes in them, through which the juice runs into a vat beneath.[6]

N.B. The *use* of the vine is so well known as not to need a separate head.

The names of various kinds of wine may be elicited from the class, and the localities of their production, (and hence their names) explained by the teacher.

METHOD.

Among the drinks used by the richer classes one is called "wine:" now wine is made from the juice of grapes, which are the fruit of the "**Vine.**"

1 Ask for the names of some others.

2 Hence the wines known as S. African port and sherry.

3 Ask the pupils to measure these distances in the school-room.

4 In order to afford support. Illustrate by the hoeing of potatoes, and refer to the frequency of violent hailstorms in South France.

5 Recall to mind as an illustration of this custom the care of Gideon (See Judges viii. 2).

6 What is a vat? A shallow wooden vessel. Refer to Lesson X., Part III., "Brewing."

LESSON LVI.

SPICES.

MATTER.

I. Description of the Various Kinds.[1]

(1) CINNAMON. This is the inner bark of a species of laurel, growing chiefly in Ceylon, which, from this fact is called the "Cinnamon country." In preparing Cinnamon the rough bark of the tree is first stripped off by means of sharp knives: the inner bark is then formed into quills or pipes.[2]

(2) NUTMEG. } (3) MACE. } These are the produce of the Moluccas or Spice Islands.[3] They grow upon the same tree, the Nutmeg being the kernel of the fruit, and the Mace one of its coverings. When the fruit ripens, it is dried in the sun, and afterwards by fire; the shell is then broken and the Nutmeg taken out. The Mace is then dried for a short time in the shade.

(4) CLOVES are the unexpanded flower of the Clove tree,[4] which is found abundantly, and sometimes wild, in the above islands. The word "*clove*" is a corruption of the French word "clou," signifying "a nail," which the buds very much resemble.

(5) GINGER is the root of a plant,[5] growing both in the E. and W. Indies, but the finest kind is brought from Jamaica. Young roots are sometimes scaled and peeled, and afterwards put into syrup, forming what is known as "preserved ginger."

(6) ALLSPICE,[6] or Pimento, is the berry of a handsome myrtle tree, growing plentifully in Jamaica. The berries are gathered when green, and dried on floors in the rays of the sun, until they become of a reddish brown colour.

(7) PEPPER is the berry of a twining plant very much like the vine. It hangs in bunches, each berry growing on a little stalk.[7] It is

METHOD.

You have all eaten plum-pudding. Tell me some of the things which your mother put into it.

(Among these **Spices** would probably be mentioned.)

[1] The teacher would do well to provide himself with a specimen of each kind of spice.

[2] Refer to the sticks of cinnamon as seen in the shop windows of grocers.

[3] Shew on the map, and draw attention to the suitability of the name.

[4] Let the teacher sketch one on the blk. bd., if he has not a specimen to shew.

[5] Let the teacher shew that the irregularity of its form would lead us to this conclusion.

[6] So called because it has the flavour of *many* spices.

[7] Illustrate by reference to our currants.

obtained chiefly from the higher parts of India. There are two kinds, black and white, both of which are produced by the same plant.[8]

N.B. Cayenne pepper is the ground pod of the red Capsicum. It is so called because it is the chief production of the island of the same name in the W. Indies.

II. Qualities.[9]

Spices are pungent (i.e., hot), and aromatic, or strongly scented and flavoured.

III. Use.

Spices are used to flavour and season our food, and thus render it more palatable.

N.B. Cinnamon is sometimes used in this country as an astringent,[10] and in S. America it is eaten by miners to preserve them from the effects of the foul air of the silver-mines.

[8] Explain this seeming contradiction, by stating that the berries are dried in the sun until they become *black*, and that, when stripped of their outer coat, they yield *white* pepper.

[9] Let these, if possible, be given by the class, the teacher asking for examples of other substances possessing the same properties.

[10] Let the teacher explain this word.

LESSON LVII.

A LOAF OF BREAD.

MATTER.

I. How Made.

(1) SETTING THE SPONGE. In making bread, the baker puts as much flour as he requires for the number of loaves he intends to make, into a deep trough, and mixes it with water and yeast,[1] thus forming a mass called "*dough*."[2] This process is known as "*kneading*." In a short time the dough swells up, or, as the baker terms it, "the sponge rises."[3] When the mixture has remained for some time in this state, it is cut and weighed into lumps. These are sometimes divided into two parts, the one being laid upon the other.[4]

(2) BAKING. The loaves are now conveyed to the oven,[5] in which they are baked by being placed upon its brick floor. The door of the oven is then shut and kept closed until the bread is baked, i.e., until the upper part becomes brown, or crusted. The under part (which rests upon the floor of the oven) is harder and browner than the upper, while the loaves are not crusted

METHOD.

You all know that corn is ground in a mill, and, is by this means reduced to a powder called "flour." What is made of flour? "**Bread.**"

[1] See Lesson X. Part III. of present series.

[2] Recall to mind the fact that some of the class have no doubt, now and then, carried dough to the bakehouse.

[3] The reason of this is that the sugar of the dough becomes decomposed by the yeast, and carbonic acid gas is set free from all points of the dough, and being imprisoned by heat, the gas makes it swell and become porous.

at all at their sides, except those next the oven walls.[6]

The bread is then taken out of the oven by means of a *peel*, an instrument resembling a shovel with a very long handle.[7]

WOODEN PEEL

II. Varieties of Bread.

Bread is named according to the ingredients of which it is composed. Thus we have :—

(1) WHEATEN BREAD, or that which is made from wheat. This is the daily food of all classes of persons in this country.

(2) RYE BREAD, or that which is made from rye.

(3) BARLEY BREAD, or that which is made from barley.

(4) OAT BREAD, or oat cakes, so called because made of oats.

N.B. The three latter kinds of bread were very common in England some years ago, and, even now many of the factory operatives of Lancashire and Yorkshire, much prefer oat cakes to wheaten bread.

REMARKS. Bread is deservedly called "the staff of life"[8]

[4] Recall to mind the loaves of this shape, as seen in the windows of the baker's shop.

[5] Let the teacher briefly describe a baker's oven, showing why it is so large.

[6] Let the teacher explain, shewing that loaves presenting this appearance are baked *in rows*, and hence their sides are in contact with each other.

[7] Why a long handle? To enable the baker to reach the further corners of the oven.

[8] Let the teacher explain this figurative expression, and shew its applicability.

LESSON LVIII.

BALLOONS.

MATTER.

I. Principle Explained.

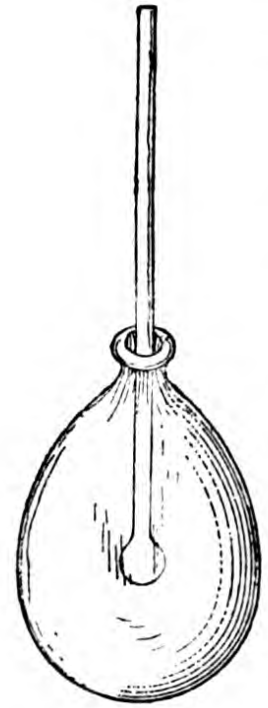
The principle upon which balloons ascend is that *that which is lighter than the air rises into it.*

"Place a well-closed bladder, nearly filled with air near the fire ; it will gradually expand, and at length burst. And yet the quantity of air it contains remains the same, because communication is not possible between the interior of the bladder and the atmosphere. At the same time the bladder becomes somewhat heated, and, if we

METHOD.

Sometimes people ascend into the higher regions of the atmosphere and are carried out of our sight. How is this done? By means of "**Balloons.**"

Ask for illustrations as examples: smoke, clouds, &c.



tie its neck round the tube of a thermometer, placing the bulb in the centre, we shall see that the temperature of the interior air rises. Remove the bladder from the fire; it will contract of itself, and growing cool, will resume its former condition. Thus, in absorbing heat, the air in the bladder has undergone two modifications, an elevation in temperature, and an augmentation in volume.[1] In losing heat, it, on the contrary, suffers a diminution both in temperature and volume. The bladder is pressed interiorly by the air it contains, and exteriorly by the atmosphere; and, as it is very flexible, and not elastic, we must admit that the two pressures are in equilibrium.[2] The air in the bladder is said to be heated under a constant pressure equal to the pressure of the atmosphere." (Cazin's "Phenomena and Laws of Heat," page 133).

From the foregoing, the following rule is deduced:—That, "Where a gas is heated whilst under a constant pressure, a part of the heat which it receives remains in the gas in a sensible[3] state, and serves to raise its temperature; another part is really consumed, loses its force as heat, and is transformed into mechanical work. (See above, page 134.)[4]

This is the principle of Fire Balloons, which were first constructed by Joseph and Stephen Montgolfier, at Avignon,[5] in France, in 1782.

II. Construction and Management.

Of late years, balloons have been constructed, fitted with either hydrogen gas, or coal gas; the latter, although heavier than the former, is generally preferred, because it is more easily obtained. It is passed into the balloon from the gas reservoir by means of a flexible pipe. A balloon "is made of long bands of silk sewed together and covered with varnish.[6] At the top there is a safety-valve closed by a spring, which the aeronaut[7] can open at pleasure by means of a

[1] **Explain these statements, and, if necessary, simplify the expressions.**

[2] **i.e., equally balanced.** Ask for the derivation of the word, and hence deduce its meaning.

[3] Explain this term, and shew that the ordinary meaning of the word is not here admissible.

[4] Here show that the balloon rises, because the air it contains is lighter than the surrounding atmosphere, and shew also that the balloon, ready to rise into the atmosphere, is like a cork held beneath the surface of a basin of water. (Explain the analogy.)

[5] Shew on the map.

[6] Why? To render it both waterproof and air-tight. Shew that these are very essential in the construction of a ballon.

[7] Gr. *aer*=air, and L. *naus*=a ship; **hence derive the meaning of the word.**

rod. A light wicker-work boat is suspended by means of rods to a net-work which entirely covers the balloon." (Ganot's "Physics," page 130.)

It is better not to fill the balloon quite full, inasmuch as the gas, by its expansive force, has a tendency to burst it. The aeronaut notes, by his barometer, whether he is ascending or descending.[8]

"When the aeronaut wishes to descend, he opens the valve at the top of the balloon, by means of the cord. This allows the gas to escape, and the balloon sinks. If he wants to descend more slowly, or to rise again, he empties out bags of sand, of which there is an ample supply in the car."

III. Uses.

(1) Meteorologists frequently have recourse to balloons as a means of travelling, when making their observations in the higher regions of the atmosphere.[9]

(2) Balloons prove very useful in time of war, as affording facilities for reconnoitring.[10]

(3) Balloon ascents often form part of the programme of a fête.

REMARKS. The following are the most remarkable balloon ascents :—

(1) In 1783, by the Marquis d'Arlandes, and Pilatre de Rozier, who rose to a considerable height above Paris.

(2) A second ascent was made by Pilatre de Rozier, in company with Romain. They attempted to cross the English Channel, but scarcely had they left Boulogne when their balloon caught fire, and was destroyed in an instant, the voyagers being thrown headlong on to the shore.

They were buried at Vimille, a village near Boulogne.

(3) In 1804, Gay Lussac attained the height of 23,000 feet[11] above the sea level.

(4) In 1861, Mr. Glaisher, accompanied by Mr. Coxwell, reached the height of 36,000 feet in about an hour."

[8] Shew how; and refer to the lesson on the "Barometer," p. 94 of First Series.

[9] Shew how.

[10] Shew how; and recall to mind the Franco-Prussian war.

[11] Let the class reduce these heights to miles.

LESSON LIX.

THE MECHANICAL POWERS.

THE LEVER, THE WHEEL, AND AXLE.

MATTER.

I. Introduction.

All machines are composed of one or more of the simple mechanical powers, so that, however complicated their structure, they may be resolved into various combinations of the following six principles :—the lever, the wheel and axle, the pulley, the inclined plane, the wedge, and the screw (the lever and its modification the wheel and axle are treated of in this lesson; the remaining four will be found in the two next lessons) : three of which are called

PRIMARY, viz., the lever, the pulley, and the inclined plane, and three

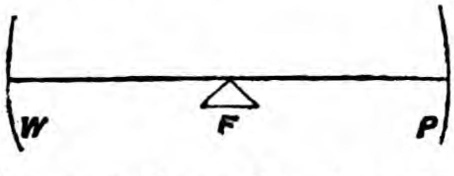
SECONDARY (because they are modifications of the others), viz., the wheel and axle, which is a modification of the lever; the wedge and the screw, both of which are modifications of the inclined plane.

II. The Lever[1]

Is defined as being a rigid[2] bar, resting on a fixed prop or support, termed a *fulcrum*.[3] It is used to raise heavy weights, and its operation depends upon the principle that, where two bodies perform complete revolutions round the same centre, within the same time, that which is more remote from the centre, has, proportionally, greater velocity than the other.

Levers are of three kinds, according to the position of the fulcrum, the weight to be lifted, and the power employed.

(1) FIRST KIND. Here the fulcrum is between W and the P, which describe arcs having their



concavities towards each other. Examples of this kind are :[4]

(*a*) A poker in raising the coal.

(*b*) A crow-bar in raising in a stone.

METHOD.

We shall begin to consider to-day, some of the powers which are employed in the construction of machinery. They are called **Mechanical powers.**

[1] L. *levis* = light; hence a lever is an instrument by means of which the lifting of a heavy weight is more easily accomplished, and hence, the weight made to *appear lighter.*

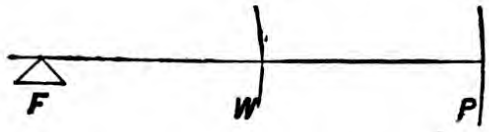
[2] i.e., inflexible.

[3] This is the Latin word for "a prop, or support."

[4] Let the examples of each kind be given, as far as possible, by the class, the teacher taking care to shew how each illustrates the principle laid down.

(*c*) A pair of scissors or shears. Levers of this order are the most simple and the most powerful.

(2) SECOND KIND. Here the fulcrum is at one end and the W and the P describe portions



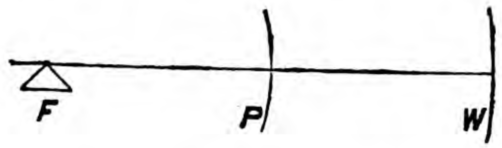
of concentric, circles[5] that described by the W being the smaller. Examples of this kind are :

(*a*) The oar of a boat in rowing.

(*b*) A pair of nut crackers.

(*c*) A door working on its hinges.

(3) THIRD KIND. Here the fulcrum is again at one end, and the W and the P describe portions of concentric circles as before, but that described by the P is the smaller. Examples of this kind are :



(*a*) Raising a ladder against a house.

(*b*) A pair of tongs.

(*c*) The treadle of a lathe.

N.B. The force of the lever increases as the distance of the power from the fulcrum increases, and diminishes in proportion as the distance of the weight from the fulcrum increases.

III. The Wheel and the Axle.

This is a modification of the lever. By means of this power, weights are raised to a far greater height than by the lever. The principle upon which the wheel and axle depends, is that, every part of a revolving body moves with a velocity proportionate to its distance from its axis : hence it must be plain that any point of the circumference, or outer rim of a wheel, moves with greater velocity than any point of its axle, and, consequently, that a force applied to the wheel has more power than the same force applied to its axle, in proportion as the circumference, or diameter of the wheel, is greater than that of the axle.[6]

[5] i.e., circles having the same centre. L. *con*=together, and *centum* = the centre. Illustrate by the circles made by throwing a stone into a pond.

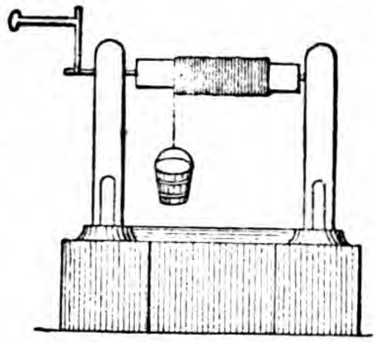
[6] This principle will be understood by reference to the revolution of an ordinary carriage wheel.

Examples of this power are :

(1) THE CAPSTAN, or windlass, on board ships. This is a large, upright axle, working on a pivot, round which a cable[7] is wound.

It is chiefly used for raising the anchor. The capstan is turned by men pushing at bars (inserted in the drumhead)[8] which may be considered as spokes of a wheel. The longer or further from the axle these bars can be used, the easier is the labour.[9]

(2) THE WINDLASS USED IN DRAWING WATER FROM A WELL. Here a bucket is fastened to a rope, which coils round a bar of wood or iron that is put in motion by force applied to a handle affixed to the extremity of it, like the handle of a hand-mill.



(3) A CRANE FOR RAISING WEIGHTS.[10]

(4) THE TREADMILL,[11] which is an instrument of punishment worked by criminals. The wheel is moved by a man (or several men) placed on the inside, who walks on bars as if going upstairs.[12]

[7] Ask what a cable is.

[8] Shew that this is an application of the principle laid down.

[9] A sketch of this might also be drawn on the blk. bd.

[10] Ask where chiefly employed.

[11] Ask why so called.

[12] Illustrate by a squirrel making the hoop inside its cage revolve.

LESSON LX.

THE MECHANICAL POWERS (*Continued.*)

THE PULLEY, THE INCLINED PLANE.

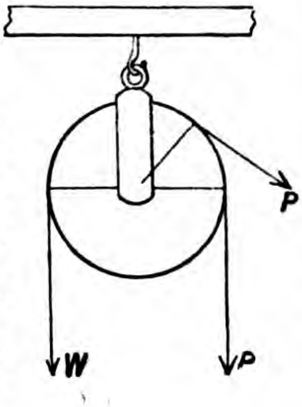
MATTER.

I. The Pulley.

There are two kinds of pulleys :

(1) The fixed. (2) The movable.

(1) THE FIXED PULLEY. This consists of a small wheel which turns on a pin in a block, and has a cord working in a groove,[1] on its outer edge. An illustration of the simplest use of the pulley is the rope by which a window sash is raised.[2] Fixed



METHOD.

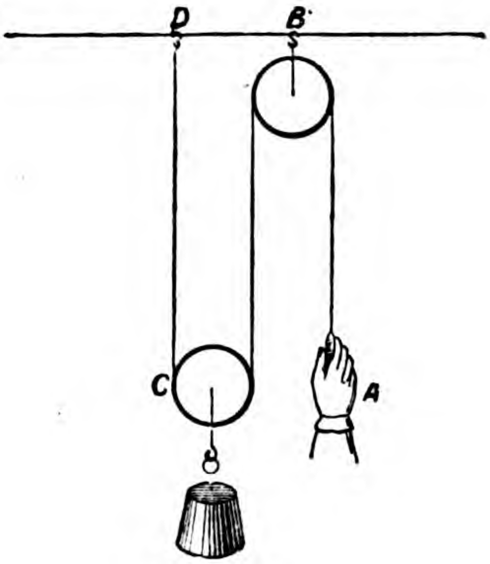
Let the teacher revise the previous lesson to ascertain that the principles therein laid down have been mastered.

[1] Ask what is a groove.

[2] Explain its action, and shew that the two weights must *together* be equal to the weight of the sash.

pulleys *do not* increase the power employed; they only change the direction in which it acts.

(2) THE MOVABLE PULLEY. The peculiarity of this pulley is, that besides the motion on its own axis, it has also a progressive one.



"Let C represent a movable pulley, and the line A B C D a rope, one end of which is fixed to a hook at D, and the other passes over the fixed pulley B, placed there merely for the purpose of altering the direction of the rope; a weight of one pound at A, will be sufficient to balance two pounds suspended from the movable pulley C. When the rope is set in motion, it will be found that the power at A moves with just *double* the velocity of the movable pulley and weight attached to it, because when the pulley has been raised one inch, the parts of the rope B C and C D will *both* have been shortened one inch."[3] (Vide National Society's "Standard VI. Reading Book," p. 190.)

A combination of several of these pulleys greatly increases the power; e.g., if two such pulleys be used, a power acting with a force of one pound, would support a weight of four pounds.[4]

II. The Inclined Plane.

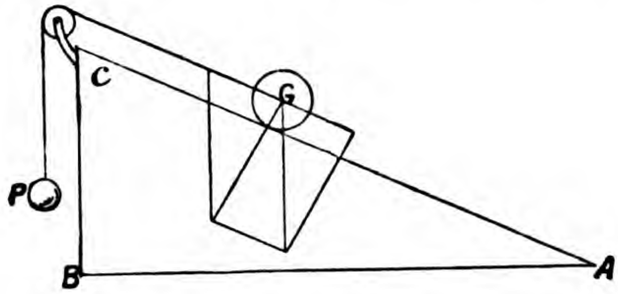
This is a slope or declivity employed in order to render the ascent of a body easier than it would have been in a perpendicular direction.[5] The principle upon which it depends is, that *the resistance to be surmounted is as the length*

[3] Shew that two inches of rope must therefore have passed over the fixed pulley, and that the power at A must have travelled *two inches* in the same time that the weight suspended at C, moved *one inch.*

[4] Shew the application of these principles by reference to the combinations of pulleys used in raising packages into warehouses.

[5] Why? Because the force of gravity is not so great. (Explain.)

of the plane to its height; i.e., if A C (see diagram) be twice the length of C B, one cwt.



at P, will sustain two cwts. at G.; hence, if a horse had to draw a load of one ton up A, a road which rose one foot in five, he would have to exert a force equal to that which would be required to draw 1 ton 4 cwts. along a *level* road, i.e., the load would be increased one-fifth.[6]

Illustrations of the application of the inclined plane are seen in hilly districts, where the roads made are winding or zig-zag. Examples of this mode of construction are to be found in the island of St. Helena, and in the Mont Cenis Railway;[7] and the Tower of Babel is said to have been built with a winding path round it, in order to facilitate the ascent to its lofty summit.

6 The teacher must be very careful to see that this is understood. He would do well to work out a few questions as illustrations.

7 Ask for the locality of this railway.

LESSON LXI.

THE MECHANICAL POWERS *(Continued.)*

THE WEDGE, THE SCREW.

MATTER.

I. The Wedge.

This is simply a movable, inclined plane, or rather, *two* inclined planes, placed base to base. The wedge is driven by percussion.[1] Let A B C represent the surface of this implement. "The less the breadth of the base A B in proportion to the length of the two sides A C, B C, the greater is the acquired power. It is calculated that if A C, and B C, taken together be four times the length of A B, or, which is the same thing, if A C be four times the length of A D, the half of A B, the power will be equal to four times the resistance."[2]

METHOD.

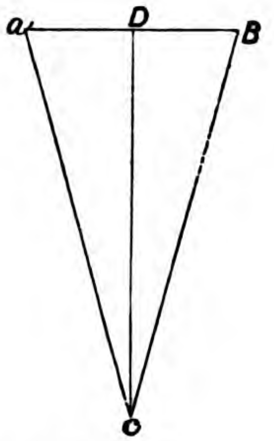
Let the teacher recapitulate the previous lesson, giving the class to understand that the powers of which he is about to speak are modifications of the inclined plane.

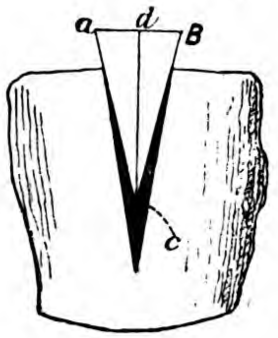
1 i.e., by repeated blows. Illustrate by reference to "percussion caps."

2 The teacher must impress upon the class that an allowance must be made for friction.

II. Applications of the Wedge.

(1) Carpenters' tools, such as chisels and hatchets, act upon the principle of the wedge.





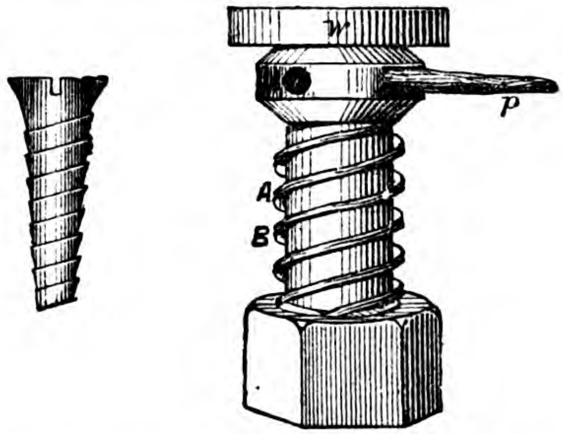
(2) Ships are raised in the dry dock by driving wedges under them.

(3) In oil mills the oil is pressed out of the seeds by wedges driven between pieces of wood placed on each side of the seed bags. The pressure employed is so great that the seeds are forced together (forming a mass called "*oil cake*,"[3]) while the oil runs through the bags.

(4) The beaks of many birds are formed in the shape of wedges.[4]

II. The Screw.

The screw consists of two parts:—the screw, properly so called, and the nut.

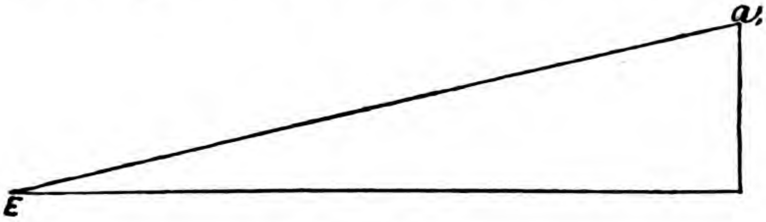


The turns, or spiral of the screw, are called its *threads*, and as they apparently coil round it as a serpent round a pole, they are also known as the *worm*. The nut, which is the weight to be

[3] Shew that this is not thrown away, inasmuch as it is used as food for cattle.

[4] Why? To enable them to penetrate various substances. (See Lesson on "Woodpecker," p. 25 of First Series.)

moved, is generally a heavy piece of iron with a hole in the centre. To the nut there is fastened a handle, the two, together, forming a *winch*. That the screw acts upon the principle of the inclined plane may be illustrated by the following: Let a piece of paper be cut in the form of a right-angled triangle with the side A E the same



length as an ordinary round ruler; then wrap the triangle round the ruler, placing the edge A E lengthwise against it, and it will be found to arrange itself as a spiral.[5]

So far the screw only has been considered, but practically it is never used without the lever.

" The power is applied to the end of the lever at P,[6] (see diagram above) and the weight or pressure W is sustained by the screw, as in the common screw-press. If the distance A B, between any two threads of the screw be half-an-inch, and the circle described by turning round the end of the lever P, be 5 feet, or 120 half-inches, then a force or pressure of one pound at P will sustain a weight of 120 lbs. at W. Hence the power exerted at the end of the lever, or, in other words, at the circumference of the circle made by the power, is to be multiplied by this circumference, and the result multiplied by the distance between two threads of the screw is equal to the weight or resistance that has to be overcome."[7] (Vide 6th Standard Reading Book of the Public School Series, page 48.)

APPLICATIONS OF THE SCREW. The screw is used very largely where great pressure is required, as in machines for stamping metals and coins: in book-binders' presses, and, in the presses used in the manufactures of cider and cheese.

[5] The teacher should perform this experiment before the class; they would then understand the principle much more readily.

[6] Let the teacher sketch the above diagram on the blk. bd., making reference to it as necessary.

[7] This portion of the lesson must be omitted or included according to the class for which the subject has been prepared.

LESSON LXII.

TIMBER, AND ITS USES.

MATTER.

I. Introduction.

The timber for building, for furniture, and for machinery, is supplied by forest trees.

Many of these grow in our own country, others are found only abroad. The timber of some trees is hard, while that of others is soft, hence the following

II. Classification of Woods.

(1) HARD WOODS.[1]

(*a*) *Oak.* Formerly very extensively used for building ships, including men-of-war.[2] Of late years, however, armour-plated vessels have, to a great extent, superseded those made of wood. This is partly on account of the great improvements which have been made in gunnery, and partly because our supply of oak has greatly diminished, owing to the increase of population, and the consequent building of towns.

Oak is also largely employed for making casks and tubs, because its close grain renders it almost impervious to moisture.[3]

N.B. A strong, and yet light kind of timber is furnished by the "teak tree," which is a native of India. It is sometimes called the "Indian Oak."

(*b*) *Elm* is much used in the construction of water wheels, pumps, pipes, and ship planks, because it is but little affected by the exchange of dryness for moisture, or vice versa. It is also employed for making coffins.

(*c*) *Beech* is much used by the turner for making bowls, trenchers,[4] and the legs of tables and chairs.

(*d*) *Birch*, largely employed for making bedroom furniture. It is light and cleanly in appearance.

(*e*) *Ash*, used for handles of agricultural implements, spokes of wheels, and hop-poles.

N.B. The hardest wood known is the *lignum vitæ*.[5] It grows in Jamaica, and is used principally for making pulleys.[6]

(2) SOFT WOODS. These are furnished chiefly by the class of trees termed *Coniferæ*.[7] They are the pine, fir, and cedar.

METHOD.

Of what are tables and chairs made? Wood Can any of you give me another name for wood. "**Timber.**"

[1] Draw attention to the fact that such woods are always employed where strength and durability are required. Ask for examples.

[2] Shew that oak was well adapted for this purpose. (Why?) Because it did not splinter when struck by a cannon ball.

[3] Explain; and ask for examples of woods which are more or less porous.

[4] What is a trencher? A wooden plate. Illustrate by reference to bread plates which are sometimes appropriately carved round their margins.

[5] Derive the word. L. *lignum*=wood, and *vita*=life; "the wood of life."

[6] Why is a *hard* wood so necessary here? (See Lesson on "*The Pulley*," and refer to the effects of friction.)

[7] L. *fero* = I bear. Ask what a *cone* is.

(*a*) *Pine* is a soft wood, durable, and easy to work. The best is furnished by the forests of Norway, the trees of which are especially fine.[8] Large quantities are also obtained from Canada and the shores of the Baltic. Pines are easily transported from the forests to the sea, by being floated down the rivers as rafts.[9] When cut into planks, it is called *deal*. It is largely used for building purposes, such as roofs, floors, doors, etc.,[10] and also for masts of vessels, and ladders.[11]

(*b*) *Cedar* is remarkable for its great durability. It is obtained from the mountains of Lebanon, and was largely used in the construction of Solomon's Temple.

(*c*) *Lime*, much used by turners and musical instrument makers.

(*d*) *Willow* is light and tough, and is made into cricket bats, clogs, hay-racks, etc. Its twigs are twisted to make baskets.

FANCY WOODS are such as are used for ornamental purposes. They are cut into thin plates called "*veneers*."[12] Such woods are :—

(*a*) *Mahogany* (See Lesson as above).[13]

(*b*) *Rosewood* derives its name from the fact than when first cut it emits an odour like that of the rose. It is extensively used in the manufacture of pianos and other articles of drawing-room furniture. The best kind comes from Brazil.

(*c*) *Ebony*, used for making the black keys of pianos. Its qualities are hardness, blackness, and weight. It is obtained chiefly from the W. coast of Africa. Another kind is found in the E. Indies and Ceylon.

(*d*) *Walnut*. Gun stocks are made of this wood.[14] It is much used also in the manufacture of pianos.

(*e*) *Maple* comes chiefly from Canada. It is the tree from which maple sugar is obtained. It is employed as a *veneer*. A particular kind is known as "*bird's eye*" maple.[15]

[8] Recall to mind the passage from Milton's "Paradise Lost," Book I., lines 292—294.

[9] See Lesson on "*Mahogany*," p. 41 of First Series.

[10] Ask for further examples of its use.

[11] Why? Ask what qualities are here necessary.

[12] Hence the word "*veneering*." Ask its meaning, and require the class to give examples of articles of furniture which are veneered.

[13] Draw attention to the fact that most of these woods are imported from foreign countries.

[14] Ask which part of the gun this is.

[15] Why? Because it is full of little knotty spots resembling birds' eyes.

LESSON LXIII.

LIGHTNING AND THUNDER.

MATTER.

N.B. This Lesson presupposes the teacher to have some acquaintance with the laws of electricity.

METHOD.

During the summer months we sometimes have very heavy storms, accompanied by peals of **Thunder** and flashes of **Lightning**. The teacher should first speak of Lightning, and, at the end of the lesson ask the class why he did so. If the subject has been understood the reason of his arranagement will be readily comprehended.

I. Lightning.

(1) How Produced.

The atmosphere has been proved to be charged with electricity, but how it is caused is a question which has given rise to much discussion among meteorologists, and no theory has hitherto been proposed which satisfactorily accounts for it. By some it was supposed to be generated in clouds of a dark and dense appearance, and hence they were termed "*thunder clouds*;" but recent investigations have proved that electricity is present in the air when the weather is *clear*. Among the principal causes which are supposed to produce electricity in the atmosphere are :—

(*a*) Evaporation from the earth's surface.

(*b*) Chemical changes which take place on the earth's surface, and

(*c*) The moisture, condensation, expansion, and variation of temperature in the air.[1]

When two clouds charged with opposite kinds of electricity meet, a discharge takes place between them, and the passage of the electricity across the sky is termed *lightning*. Franklin was the first to establish the identity of the lightning of the heavens, with the spark from an electrical machine.[2]

(2) Kinds. There are three kinds of lightning :—

(*a*) *Forked*, which appears in the form of lines of fire with sharp outlines, and is sometimes called *zig-zag*.[3] As it nears the earth, it is often seen to divide into two or three forks,[4] the extremities of which have been found to be several miles apart. This is the most dangerous kind of lightning.

(*b*) *Sheet*. This is much more frequent than (*a*) but is less destructive. It is so called because it has no definite shape, but appears as a mass of light, sometimes illumining a great part of the heavens.[5]

(*c*) *Ball*.[6] This may be more correctly described as a meteor, and may be considered rather as an accompaniment of the electrical discharge, than as a distinct kind of lightning. It is said to be produced as follows :—"After a violent explosion of lightning a ball is seen to proceed from the region of the explosion, and to make its way to the earth in a curved line like a bomb.[7] When it reaches the ground, it either splits up at once and disappears, or it rebounds like an

[1] Explain these terms

[2] For a detailed account of his famous kite experiment, see Ganot's "Physics," p. 793.

[3] Sketch its appearance on the blk. bd.

[4] Hence its name.

[5] Hence shew the applicability of its name.

[6] Called by the French "*globes de feu*." (Why?)

[7] What is a bomb? Refer to the siege of a town during war.

elastic ball several times before doing so." (See Ferguson's "Electricity," page 98.)

It frequently sets fire to buildings, and is more dangerous than *(a)* and *(b)*, inasmuch as the lightning conductor is no protection against it.

II. Thunder.

(1) HOW PRODUCED. Thunder is the violent report which succeeds lightning. It no doubt arises from a commotion in the air, brought about by the passage of electricity, but the precise mode of its production has not yet been clearly proved.

Lightning and thunder are always *simultaneous*, but an interval of several seconds is always observed between the flash and the report. This is because light travels much more quickly than sound.[8]

(2) HOW THE DISTANCE OF THE STORM IS DETERMINED. Sound travels at the rate of 1090 feet per second when the temperature of the air is 32° Fahr., or 0° centigrade: i.e., at freezing point, and it increases two feet for every degree of temperature thus, "An interval of 3½ secs. is observed to elapse between a flash of lightning and the peal of thunder. What is the distance of the electric cloud, the temperature of the air being 30° C.?" (Collins's Elementary Acoustics, etc., page 13.)

SOLUTION :—

Velocity of sound per sec. at 30° C =

1,090 + (30 × 2) = 1,150 ft.

1,150 × 3½ secs. = 4,025 ft.[9]

(3) EXPLANATION OF THE ROLLING OF THUNDER. Several attempts have been made to account for this, among which are the following :—

(a) The sound is reflected from the ground to the clouds and vice versa.[10]

(b) The lightning has been considered, not as a single discharge, but as a *series* of discharges, each of which gives rise to a particular sound.

[8] Ask for instances in proof of this; e.g.,
(*a*) The blows of a hammer at a distance are heard some seconds after it has struck the object.
(*b*) The report of a gun is heard after the flash is seen.

[9] Here let the teacher, aided by his class, work out several such problems, in order to familiarize his pupils with the method of calculating the velocity of sound, thus enabling them to determine the distance of the electric clouds.

[10] Illustrate by reference to echoes.

LESSON XLIV.

THE LIGHTNING CONDUCTOR.

MATTER.

I. Introduction.

II. Principle Explained.

"The principle of the lightning conductor is, that electricity of two conducting passages, selects the better, and that when it has got a sufficient conducting passage it is disarmed of all destructive energy." (Ferguson's "Electricity," page 102.)[1]

III. Construction.

The lightning conductor consists of three parts :—

(1) The rod, or part overtopping the building.

(2) The conductor, or part connecting the rod with the ground, and

(3) The part in the ground.

(1) THE ROD is made of a pyramidal or conical form,[2] the latter being preferable. It is from 8 to 30 ft. high, and should be securely fixed to the highest part of the building. The top of the conductor should be pointed,[3] and should extend 2 or 3 feet above the object on which it is placed. The best rods are made of copper, as this is a better conductor than iron.

(2) THE CONDUCTOR is generally a cylindrical rod of iron, galvanized iron being the best conductor. It should be securely soldered or riveted to the rod.[4]

As to its size, experiment has proved that it should not be less than half-an-inch in diameter, otherwise the heat of the electric fluid might cause it to melt. There should be no sharp turns in it, but each bend should be made as round as possible.

Lightning conductors should never be insulated,[5] but should communicate with all the metals used in the construction of the building ;[6] hence a conductor fixed between the four pinnacles of a tower would not guarantee the safety of all of them.

"In ships a rod is placed on every mast, and their connection with the sea is established by

METHOD.

Let the teacher allude to the danger of lightning, as shewn in the preceding lesson, and then proceed to state that we are enabled, to a certain extent, to provide against its disastrous effects by the adoption of a piece of scientific apparatus, called "**The Lightning Conductor**."

[1] The teacher should here bring his knowledge of electricity to bear upon the subject, shewing the analogy between the drawing off of the electricity from the electrical machine and the action of the lightning conductor.

[2] Explain these, shewing that the former has a pyramidal base, and the latter a circular one.

[3] Why? Because of the affinity which electricity has for points. It is thus prevented from leaving the conductor and striking the building to which it is attached.

(Here the teacher should again recall his knowledge of electricity: See the "power of points," explained in Ferguson's "Electricity," pp. 70 and 71.)

[4] Why? So that the communication may be uninterrupted. Ask what would be the consequence if this were not ensured.

[5] Explain this term, and from its derivation

strips of copper, inlaid in the masts, and attached below to the metal of or about the keel." (Ferguson's "Electricity," page 105.)

(3) THE PART IN THE GROUND. This is of as imuch mportance as (1) and (2). If the lower part of the conductor terminated in dry earth it would be worse than useless, for the lightning would find no passage through such a medium. Wherever it is practicable, a lightning conductor should end in a well, or large body of water. This being a good conductor, and having ramifications in the soil, proves a very efficacious means of dispersing the electricity, thus rendering it harmless. The rod, on reaching the ground, should lead downwards one or two feet, and then turn at right angles to the building, into a horizontal drain filled with charcoal.[7]

N.B. The ESSENTIAL CONDITIONS of a lightning conductor are :—

(a) A rod sufficiently large as not to be melted.

(b) It should terminate in a point in order the more readily to lead off the electricity.

(c) Continuous conduction must be ensured.

(d) All metallic arrangements of the building must be brought into connection with it.[8]

IV. Use.

Lightning conductors, when efficiently constructed, have proved, beyond doubt, a great protection against the ravages of lightning.

N.B. "The circle within which a lightning conductor is found to be efficacious is very limited. Its radius is generally assumed to be twice the height of the rod."[9] (Ferguson's "Electricity," page 105.)

deduce its meaning. Illustrate by reference to an island.

[6] This prevents "*lateral discharges,*" which might cause the destruction of the building. Derive the word "*lateral,*" and hence explain the expression.

[7] Why? For a double reason :—

(*a*) Charcoal prevents the rusting of the rod, and

(*b*) It facilitates the passage of the electricity.

[8] The teacher will observe that these have been alluded to in the course of the lesson, but they are here summarized in order that the class may commit them to memory.

[9] Here let the teacher take two or three examples of imaginary buildings, and ask the class to calculate the length of the rods required to protect them.

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