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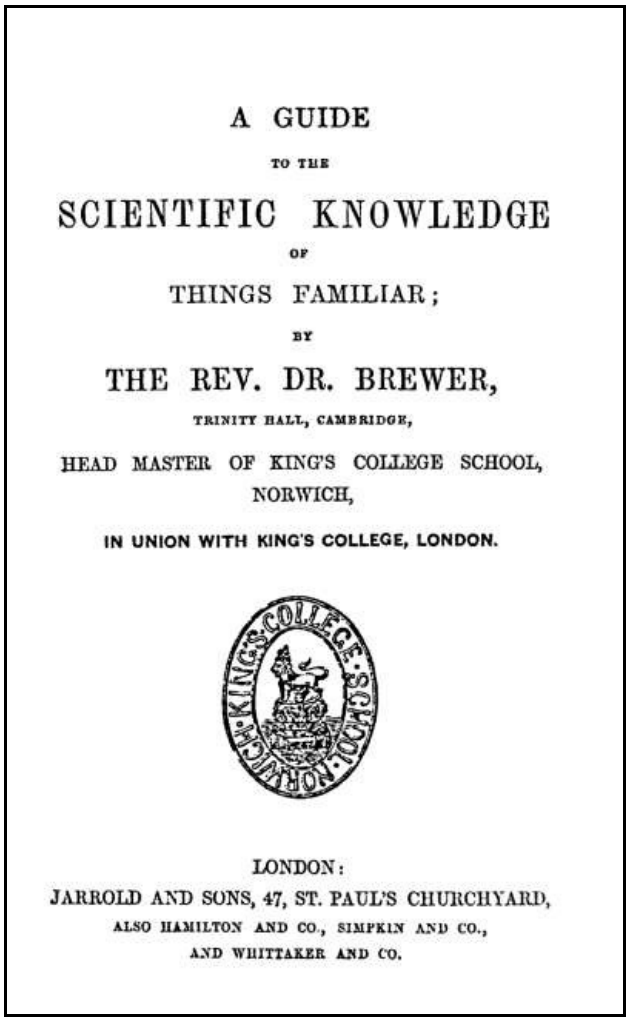
A GUIDE

TO THE

SCIENTIFIC KNOWLEDGE

OF

THINGS FAMILIAR;

BY

THE REV. DR. BREWER,

TRINITY HALL, CAMBRIDGE,

HEAD MASTER OF KING'S COLLEGE SCHOOL, NORWICH,

IN UNION WITH KING'S COLLEGE, LONDON.

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JARROLD AND SONS, 47, ST. PAUL'S CHURCHYARD,

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PREFACE.

Of all science, none is more generally interesting than that which explains the common phenomena of life. We see that salt and snow are both white, a rose red, leaves green, and the violet a deep purple; but how few persons ever ask the reason why! We know that a flute produces a musical sound, and a cracked bell a discordant one—that fire is hot, ice cold, and a candle luminous—that water boils when subjected to heat, and freezes from cold; but when a child looks up into our face and asks us "why,"—how many times is it silenced with a frown, or called "very foolish for asking such silly questions!" The object of the present book is to explain about 2000 of these "silly questions" (which are often more easily asked than answered) in language so simple that a child may understand it, yet not so childish as to offend the scientific; and in order that the answers may be strictly correct, not only the most approved modern authors have been consulted, but the manuscript has been submitted sheet by sheet to the revision of two gentlemen of acknowledged reputation for scientific attainments. To the Rev. A. Bath Power, M. A. especially, great obligation is due, for a careful revision of the whole manuscript, for many excellent hints, and useful additions. In conclusion, so much diligence has been bestowed upon this little work for nearly ten years, so much useful information has been supplied by scientific friends, and so minute a revision has been made of every answer, that it is no presumption to express a hope that this "Guide to the Scientific Knowledge of Things Familiar" will become generally useful and acceptable, not only to the young, but to those advanced to maturer life.

In this work some questions occur more than once, because they serve to illustrate different principles; and whenever cognate questions occur, the answers have been rendered as similar as possible, in order to assist the memory of the learner.

SUBJECTS OF THE CHAPTERS.

PART I.—HEAT.

PART II.—AIR.

PART I.

HEAT.

INTRODUCTION.

Q. *What is heat?*

A. The sensation of warmth.

Q. *How is this sensation produced?*

A. When we touch a substance of higher temperature than ourselves, the warmer substance keeps parting with its heat, till both are of equal temperature.

Q. *What is that "stream of heat" called, which flows thus, from one body, to another?*

A. Calo'ric. *Caloric*, therefore, is the *matter of heat*, which passes from body to body; but Heat is the *sensation, of warmth*, produced by the influx of Calo'ric.

Q. *What are the four principal* sources *of heat*?

A. 1.—The Sun. 2.—Electricity. 3.—Chemical Action: and 4.—Mechanical Action.

Q. *What are the principal* effects *of heat*?

A. Expansion, Liquefaction, Vaporization, and Ignition.

CHAPTER I.

Q. *What is the* principal *source of Heat*?

A. The Sun.

Q. *Why do* burning glasses *set fire to substances submitted to their power*?

A. The rays of the sun, collected by the Burning Glass, are all *bent to one point*, called the "focus;" thus the heat and light, (which should be diffused over the *whole* glass,) being gathered together into one point, are very greatly increased.

Q. *Why is there a* dark rim *round this focus*?

A. Because the rays of light, which should have fallen there, are *bent into the focus*, and the space around, (being deprived of these rays) is accordingly darkened.

Q. *Are* ALL *the rays bent into one point*?

A. No, not quite all: and, therefore, the rim round the focus is only *slightly* shadowed.

CHAPTER II.

Q. *What is the second chief source of heat?*

A. ELECTRICITY.

Q. *What is* LIGHTNING?

A. Lightning is only an *Electric Spark, taken from the clouds*.

Q. *What causes the discharge of an electric cloud?*

A. When a cloud, *overcharged* with electric fluid, approaches another which is *under-charged*, the fluid rushes from the former into the latter, till both have the same quantity.

Q. *Is there any* OTHER *cause of lightning, besides the one just mentioned?*

A. Yes; sometimes mountains, trees, and steeples, will discharge a lightning cloud floating near; and sometimes electric fluid rushes out of the *earth*, into the clouds.

Q. *What produces* ELECTRICITY *in the* CLOUDS*?*

A. 1st—The evaporation from the earth's surface.

2ndly—The chemical changes perpetually going on: and

3rdly—Currents of air of unequal temperature, excite electricity by *friction*, as they pass by each other.

Q. *How* HIGH *are the* LIGHTNING-CLOUDS *from the earth?*

A. Electrical clouds are the *lowest of all clouds*; they are rarely more than 700 yards above the ground; and sometimes, they actually *touch the earth* with one of their edges.

Q. *How high are the clouds generally?*

A. In a *fine* day, the clouds are often 4 or 5 miles above our head; but the average height of the

clouds is from 1-1/2 to 2 miles.

Q. *Why is lightning sometimes* FORKED?

A. When the lightning-cloud is a long way off, the *resistance of the air* is so great, that the electrical current is diverted into a zig-zag course.

Q. *Why does the resistance of the air make the lightning zig-zag?*

A. As the lightning *condenses* the air, in the immediate advance of its path; it keeps flying from side to side, in order to pass where there is the *least resistance*.

Q. *How does lightning* CONDENSE *the air in the immediate advance of its path*?

A. The air is condensed by the *rapidity* of the lightning-flash.

Q. *Why is* FORKED LIGHTNING *more* DANGEROUS *than a straight flash*?

A. Whatever *resists* the flash, *diverts its course*; and when *terrestrial* objects offer resistance to the current, they are in great danger of being destroyed.

Q. *Why are there sometimes* TWO *flashes of forked lightning at the same moment*?

A. Sometimes (in very severe storms) a flash of lightning will divide *into two or more parts*; and then each branch assumes the zig-zag form.

Q. *Why is the* FLASH *sometimes quite* STRAIGHT*?*

A. When the lightning-cloud hovers *near the earth*, as the flash meets with very little resistance, it is *not diverted*; or (in other words) the flash is straight.

Q. *What is the cause of* SHEET LIGHTNING?

A. It is only the *reflection of distant flashes*, not distinctly visible: and sometimes several flashes (from different clouds) intermingle, and form one vast blaze or sheet of lightning.

Q. *Which* FORM *of lightning is the most* DANGEROUS?

A. The *ball* of fire is by far the most dangerous; and the *zig-zag* lightning is next in danger. *Sheet* lightning is not often attended with danger.

Q. *Why are* BALLS OF FIRE *so very dangerous?*

A. Because (whenever they fall) much mischief is occasioned by their *bursting*, which they always do, with an explosion like that of a cannon.

Q. *Do these* BALLS OF LIGHTNING *ever run along the ground?*

A. Yes; they often run a considerable way along the ground, then *stop* for a little time, and *burst in numberless pieces*: sometimes *each of these pieces* will explode; and at other times, the *whole ball* will burst at once, producing most mischievous consequences.

Q. *What mischief will these balls of fire produce?*

A. They will set houses and barns on fire; and kill all cattle and human beings, which happen to be in their course.

Q. *Why does* LIGHTNING *sometimes* KILL *men and beasts?*

A. When the electric current passes through a man or beast, it produces so *violent an action upon the nerves*, that it destroys life.

Q. *When is a person struck dead by lightning?*

A. Only when his body forms a part of the lightning's path: i. e. when the electric fluid (in its way to the earth) actually passes *through his body*.

Q. *Why are* MEN *sometimes* MAIMED *by lightning?*

A. Because lightning strikes with amazing force, whatever opposes it: and if a man stand in the way, it strikes him such a blow, as to maim him.

Q. *What is* THUNDER*?*

A. Lightning *parts the air* through which it passes; and when the parted air *closes* again, the noise made by the concussion, is called Thunder.

Q. *Why does lightning* PART *the air through which it passes? It does not part a rod of iron.*

A. Iron is a *conductor*, and therefore allows the fluid to go freely through it: but air being a *non-conductor*, *resists* the lightning; which, therefore, rips it open, in order to pass through it.

Q. *Why is* THUNDER *sometimes* ONE VAST CRASH*?*

A. When the lightning-cloud is near the earth, as the flash is *straight*,—the whole volume of air (through which it passes) *collapses at once*; and produces one unbroken sudden *crash*.

Q. *What is meant by the air collapsing?*

A. When the rent air *closes again*, it is said to collapse.

Q. *Why is the* PEAL *sometimes an* IRREGULAR *mangling broken* ROAR*?*

A. When the lightning-cloud is a long way off, as the flash is zigzag, the air does not collapse *all at once*; and as we hear the concussion of one part after another, the peal is broken, protracted, and irregular.

Q. *Which part of the collapsing air do we hear first?*

A. That part *nearest* the *earth*; then the strata above; and last of all, *that* in the immediate vicinity of the cloud.

Q. *What is meant by* "STRATA *of air?*"

A. If a board were laid upon the earth, and several other boards were piled upon it, this pile would represent strata of wood.

Q. *How does this illustration apply to the air?*

A. A layer of air covers the earth; another layer rests upon *it*; and thus layer is piled upon layer, for 50 miles in height. Each layer is a "stratum" of air; and the *plural* of stratum is strata.

Q. *Why do we hear the collapsing of the air* NEAREST *the earth* FIRST*?*

A. Because sound takes a whole *second of time* to travel 380 yards; but the air is ripped from top to bottom instantaneously: if, therefore, the cloud were 1000 yards off, we should hear the collapsing of the lowest strata nearly *three seconds*, before we heard that in the immediate vicinity of the cloud.

Q. *Why is the* THUNDER *sometimes like a deep* GROWL*?*

A. When the storm is *far distant*, the thunder sounds like a deep growl.

Q. *Does not* SCENERY *affect the sound of thunder?*

A. Yes; the *flatter* the country, the more unbroken the peal: *Mountain* scenery *breaks* the peal, and makes it harsh and irregular.

Q. *What is the cause of* ROLLING THUNDER*?*

A. The rolling is produced by the *reverberation* of the thunder along the massive clouds.

Q. *What is meant by the reverberation?*

A. The echo.

Q. *Why is a flash of lightning generally followed by a* POURING RAIN*?*

A. The cloud *collapses*, as soon as the electric fluid has left it; and the water it contained is squeezed out.

Q. *Why is a flash of lightning generally followed by a* GUST *of* WIND*?*

A. The flash *rent the air asunder* through which it darted; and when the two parts collapse, a rapid motion is produced, which we call *wind*: the *vibration* of the thunder contributes also to agitate the air.

Q. *What is meant by the* "VIBRATION *of the thunder*?"

A. The quivering motion it gives to the air, by its loud sound.

Q. *Why is there* NO THUNDER *to what is called* SUMMER LIGHTNING*?*

A. Because the lightning-clouds are *so far off*, that the sound of the thunder is *lost*, before it reaches the earth.

Q. *Do* THUNDER-BOLTS *ever drop from the clouds?*

A. No; the notion of *thunder-bolts* falling from the clouds, arises from the *globular* form, that is sometimes assumed by a flash of lightning.

Q. *Why is the* THUNDER *often several moments* AFTER *the* FLASH*?*[1]

A. The flash travels nearly *a million* times faster than the thunder; if, therefore, the thunder has *far to come*, it will not reach the earth till a considerable time *after the flash*.

[1] The speed of lightning is so great, that it would go 480 times round the earth in one minute: whereas, thunder would go scarcely 13 miles in the same space of time.

Q. *Can we not tell the* DISTANCE *of a thunder-cloud, by observing the interval which elapses between the flash and the peal?*

A. Yes; the flash is *instantaneous*, but the thunder will take a whole *second of time* to travel 380 yards: hence, if the flash is 5 seconds before the thunder, the cloud is 1900 yards off.

(i. e. 380 × 5 = 1900 yards.)

Q. *What places are most dangerous to be in, during a storm?*

A. It is very dangerous to be near a tree, or lofty building; it is dangerous also, to be near a river, or any running water.

Q. *Why is it dangerous to be near a tree, or lofty building, during a thunder-storm?*

A. Because a tall pointed object, (like a tree or spire,) will frequently *discharge* a lightning-cloud; and then the electric fluid *will pass down it*, in its way to the earth.

Q. *How can a tree or spire discharge a lightning-cloud?*

A. A lightning-cloud (floating over a *plain*) may be *too far off* to be discharged by it; but as a tree, or spire, would *shorten* the distance between the cloud and its conductor, it might no longer be too far off a conductor to be discharged.

Q. *Is not air a conductor of lightning?*

A. No; dry air is *not* a conductor of lightning; and therefore, the flash *rends it in twain*, to get to some conductor.

Q. *Why would it be dangerous to stand near a tree or spire, while lightning is passing down it?*

A. Because the electric fluid (called lightning) always rushes down the *outside* of the tree or spire; and if any one were standing near, might pass through *him*, and kill or maim him.

Q. *Does lightning go through the inside or outside of a tree?*

A. It rolls down the *outside* of a *tree*; but passes through the *inside* of a *man*.

Q. *Why does lightning pass down the outside of a tree?*

A. Lightning always makes choice of the best conductors; and the *outside* of a tree is a better conductor than the inside.

Q. *Why does lightning pass through the inside of a man?*

A. As the *fluids* of the human body make a better conductor than the *skin*, therefore lightning passes *through* a man, and not down the skin.

Q. *Why is it dangerous to be near a deep river, or any other running water, during a thunder-storm?*

A. Because running water is a good conductor; and lightning always takes in its course the *best conductors*.

Q. *Why is it dangerous for a man to be near water, in a thunder-storm?*

A. Because the *height of a man* may be sufficient to discharge a cloud: and (if there were no *taller* object nigh) the lightning might make the *man* its conductor to the water.

Q. *Why is it* DANGEROUS *to* RING CHURCH-BELLS *during a thunder-storm?*

A. For two reasons: 1st—Because the steeple may *discharge* the lightning-cloud, in consequence of its mere *height*.

2ndly—The swinging of the bells causes *a current of air*, which collects electric fluid.

Q. *Why is it unsafe to* RUN *or* DRIVE FAST *during a thunder-storm?*

A. The rapid motion of running causes a *current of air*, which collects electric fluid, and is often fatal.

Q. *What* PARTS *of a* DWELLING *are most* DANGEROUS *during a thunder-storm?*

A. The fire-place, (especially if the fire be *lighted*); the attics and cellar. It is also dangerous to sit close by the walls; to ring the bell; or to bar the shutters, during a thunder-storm.

Q. *Why is it* DANGEROUS *to sit* BEFORE *a* FIRE, *during a thunder-storm?*

A. Because the heated air and soot are conductors of lightning; especially when connected with such excellent conductors as the stove, fender, and fire-irons.

Q. *Why are the* ATTICS *and* CELLAR DANGEROUS, *during a thunder-storm?*

A. Lightning sometimes passes *from the clouds* to the earth, and sometimes *from the earth* to the clouds; and therefore, the *middle story* of a house is always the safest to be in, during a thunder-storm.

Q. *When does lightning pass* FROM THE EARTH *to the* CLOUDS?

A. When the clouds are in a “negative” state of electricity.

Q. *When does lightning pass* FROM THE CLOUDS *to the* EARTH?

A. When the clouds are in a “positive” state of electricity.

Q. *What is meant by the clouds being in a “positive state of electricity?”*

A. When the clouds contain *more* electric fluid than they *generally* do, they are said to be in a *positive* state of electricity.

Q. *What is meant by the clouds being in a "negative state of electricity?"*

A. When the clouds contain *less* electric fluid than they *ought* to do, they are said to be in a *negative* state of electricity.

Q. *Does the flash proceed from a negative or positive body?*

A. Always from a *positive* body, or one over-burdened with electric fluid.

Q. *When lightning flashes from the earth to the clouds, what is the flash called?*

A. It is called the "returning stroke;" because the earth (being over-burdened with electric fluid) *returns* the surplus quantity to the clouds.

Q. *Why is it* DANGEROUS *to lean* BACK AGAINST A WALL *during a thunder-storm?*

A. Because the electric fluid sometimes runs down the *wall* of a house or room; and (as a man is a better conductor than a brick wall), would make *him* its path, and injure him.

Q. *Why is it dangerous to* RING *a* BELL *during a thunder-storm?*

A. Bell-wire is an *excellent conductor*; and (if a person were to touch the bell-handle), the electric fluid, passing down the wire, might run through his hand and injure it.

Q. *Why would the lightning run through a man touching a bell-handle?*

A. Because the human body is a better conductor than the *wall* (between the bell-handle and the floor); and as lightning always chooses the *best* conductors for its path, it would (in this case) pass through the *man*, and injure him.

Q. *Why is it* DANGEROUS *to* BAR *a* SHUTTER *during a thunder-storm?*

A. The iron shutter-bar is an *excellent conductor*; and (if a person were touching the bar), the electric fluid passing down it, might run from the bar *through the person touching it*, and injure him.

Q. *Why is it dangerous to be in a* CROWD *during a thunder-storm?*

A. For two reasons. 1st—Because a *mass* of people form a *better conductor* than an individual: and

2ndly—The *vapour* from a crowd *increases the danger* of such a place.

Q. *Why is a* MASS *of bodies a better conductor than a single body?*

A. *Each* living body is a *conductor of electricity*; and a connected *mass* of such conductors is more likely to be struck, than a *single individual*.

Q. *Why is the danger increased by the* VAPOUR *which rises from a crowd?*

A. *Vapour* is a conductor, and therefore, may determine the shock; especially when connected with so many living bodies.

Q. *Why is a* THEATRE *dangerous, during a thunder-storm?*

A. Because the *crowd assembled* there, and the *great vapour* arising from so many living bodies, render a theatre an *excellent conductor of lightning*.

Q. *Why is a* FLOCK *of sheep in greater danger than a smaller number?*

A. Because *each* sheep is a *conductor* of lightning, and the *greater the number*, the *better its conducting power*; besides, the *vapour* arising from a flock of sheep *increases its conducting power*, and its danger.

Q. *Why is a* HERD *of cattle in danger during a storm?*

A. 1st—The *number* of living bodies increases the conducting power of the *animal fluids*: and

2ndly—The *vapour* arising from a herd is also a good conductor.

Q. *If a person be* ABROAD *in a thunder-storm, what place is the* SAFEST*?*

A. Any spot about 20 or 30 feet from some tall tree or building; unless that spot be near to running water.

Q. *Why would it be safe to stand 20 or 30 feet from some tall tree, in a thunder-storm?*

A. Because the lightning would always choose the *tall tree* as a conductor, rather than the *shorter man*; and he would not be sufficiently near the tree, to be injured by the electric current passing down it.

Q. *If a person be in* A CARRIAGE *in a thunder-storm, in what way can he travel most* SAFELY*?*

A. He should not lean *against* the carriage; but sit upright, without touching any of the four sides.

Q. *Why should not a person lean* AGAINST *the carriage in a storm?*

A. Because the electric fluid might run down the sides of the carriage; and (if a person were

leaning against the sides), would make choice of *him* for a conductor, and perhaps destroy life.

Q. *If a person be in* A HOUSE *during a thunder storm, what place is* SAFEST*?*

A. Any room in the *middle story*. The *middle* of the room is best; especially if you place yourself on a mattrass, bed, or hearth-rug.

Q. *Why is the* MIDDLE STORY *of a house* SAFEST *in a thunder-storm?*

A. Because (even if the fluid *struck* the house), its strength would be exhausted before it reached the middle story.

Q. *Why is the* MIDDLE *of the* ROOM *more* SAFE*, than any other part of it, in a thunder-storm?*

A. Because, if the lightning came into the room at all, it would come down the *chimney* or *walls* of the room; and therefore, the further distant from these, the better.

Q. *Why is a* MATTRASS BED*, or* HEARTH-RUG *a good security against injury from lightning?*

A. Because they are all *non-conductors*; and, as lightning always takes in its course the *best* conductors, it would not select such things as these.

Q. *Is it better to be* WET *or dry during a storm?*

A. To be *wet*: if a person be in the open field, the best thing he can do, is to stand about 20 feet from some tree, and get *completely drenched to the skin*.

Q. *Why is it better to be* WET *than dry?*

A. Because the *wet clothes* would form a far *better conductor* than the *fluids of our body*; and, lightning would roll down the wet clothes, *without touching our body at all*.

Q. *What is the* SAFEST *thing a person can do to avoid injury from lightning?*

A. He should draw his bedstead into the middle of his room, commit himself to the care of God, and go to bed; remembering that our Lord has said, “The very hairs of your head are all numbered.”

Q. *What is a* LIGHTNING-CONDUCTOR*?*

A. A metal rod fixed in the earth, running up the whole height of a building, and rising in a point above it.

Q. *What metal is the best for this purpose?*

A. Stout copper wire.

Q. *Why is* COPPER *wire better than iron?*

A. 1st—Because copper is a better conductor than iron:

2ndly—It is not so easily fused or melted: and

3rdly—It is not so much injured by weather.

Q. *What is the* GOOD *of a lightning-conductor?*

A. Metal wire is a most excellent conductor; and as the lightning makes choice of the *best conductors*, it would run down the *metal wire*, rather than the *bricks* of the building.

Q. *How far will the beneficial influence of a lightning-conductor extend?*

A. It will protect a circumference all round, the diameter of which is (at least) 4 times as long as that part of the rod, which *rises above the building*.

Q. *Give me an example.*

A. If the rod rise 2 feet above the house, it will protect the building for (at least) 8 feet all round.

Q. *Why are not lightning-conductors more generally used?*

A. Because they are often productive of more harm than good.

Q. *How can lightning-conductors be productive of* HARM*?*

A. If the rod be *broken* by weather or accident, the electric fluid (being obstructed in its path) will rend the building into fragments.

Q. *Is there any* OTHER *evil to be apprehended from a lightning rod?*

A. Yes; if the rod be not big enough to conduct the *whole* current to the earth, the lightning will *fuse* the metal, and greatly injure the building.

Q. *How stout is it needful for the copper wire to be, that it may conduct the fluid safely to the earth?*

A. It should be (at least) *one inch* in diameter.

Q. *Why does* LIGHTNING *sometimes* KNOCK DOWN HOUSES *and churches?*

A. The steeple, or chimney is first struck; the lightning then darts to the iron bars and cramps employed in the building; and (as it darts from bar to bar) shatters to atoms the bricks and stones, which oppose its progress.

Q. *Can you tell me how St. Bride's Church (London) was nearly destroyed by lightning, about 100 years ago?*

A. The lightning first struck the metal vane, and ran down the rod; it then darted to the iron cramps, employed to support the building; and (as it flew from bar to bar) smashed the stones of the church, which lay between.

Q. *Why did the lightning fly about from place to place, and not pass down in a straight course?*

A. Because it always takes in its course the *best conductors*; and will fly both right and left, in order to reach them.

Q. *Why does* LIGHTNING *turn* MILK SOUR*?*

A. Lightning causes the gases of the air (through which it passes) to *combine*, and thus produces a poison, called *nitric acid*; some small portion of which, mixing with the milk, turns it sour.[2]

(N. B. Sometimes, the mere *heat* of the air, during the storm, turns milk sour.)

[2] The air is composed of two gases, called oxygen and hydrogen, *mixed* together, but *not combined*. If oxygen is *combined* with nitrogen, it produces five deadly poisons, viz.—nitrous oxide, nitric oxide, hyponitrous acid, nitrous acid, and nitric acid, according to the proportion of each gas in the combination.

Q. *What is the difference between* COMBINING *and* MIXING*?*

A. When different ingredients mingle *without undergoing any chemical change*, they are said to be *mixed*; but when the natural properties of each are *altered by the union*, then those ingredients are said to be *combined*.

Q. *Give me an example.*

A. If different coloured sands be shaken together in a bottle, the various grains will *mix* together, but not combine: but if water be poured on quick lime, the water will *combine* with the lime, and not mix with it.

Q. *Why are the different grains of sand said to be* MIXED*, when they are shaken together?*

A. Because they are mingled together, but the property of each grain remains the *same as it was before*.

Q. *Why is water poured on lime, said to* COMBINE *with it?*

A. Because the properties, both of the water and the lime, are *altered* by the mixture: the lime alters the character of the water, and the water alters the character of the lime.

Q. *Do oxygen and nitrogen* COMBINE, *or only* MIX *together, in common atmospheric air?*

A. They only *mix* together, as grains of sand would do, when shaken in a bottle. When oxygen and nitrogen *combine*, they do not constitute *air*, but acid *poisons*.

Q. *Why does* LIGHTNING *turn* BEER SOUR, *although contained in a close cask?*

A. If the beer be *new*, and the process of fermentation not complete, lightning will so *accelerate* the process, as to turn the liquor sour.

Q. *Why is* NOT *old beer and strong* PORTER *made* SOUR *by lightning?*

A. Because the *fermentation is complete* already; and, therefore, is not affected by electrical influence.

Q. *Why is* METAL *sometimes* FUSED *by lightning?*

A. Because the dimension of the metal is *too small*, to afford a path for the electric current.

Q. *Why does* LIGHTNING PURIFY *the* AIR*?*

A. For two reasons: 1st—Because the oxygen and nitrogen of the air *combine*,[3] and produce "nitric acid:"

2ndly—Because the agitation of the storm *stirs up the air*.

[3] The oxygen and hydrogen are not *combined*, but simply *mixed* in the ordinary air; but the lightning causes the mixed elements to *combine*.

Q. *How does the production of nitric acid purify the air?*

A. Nitric acid acts very powerfully in *destroying exhalations*, arising from putrid vegetable and animal matters.

Q. *Why is* LIGHTNING *more common in* SUMMER *and* AUTUMN, *than in spring and winter?*

A. The heat of summer and autumn produces *great evaporation*; and the conversion of *water to vapour*, always develops *electricity*.

Q. *Why does a* THUNDER-STORM *generally follow very* DRY *weather, and rarely succeeds continued* WET*?*

A. The clouds are *always* charged with electricity; but *dry air* (being a non-conductor), will not conduct the surplus fluid from the clouds to the earth: so it violently *rends the dry air* with a

flash, in order to relieve the cloud, and reach the earth.

Q. *What is the general* DIRECTION *of a* THUNDER-STORM*?*

A. Either from east to west; or else from north to south.

Q. *Why is* ELECTRICITY *excited by* FRICTION*?*

A. Electricity, like heat, exists in *all* matter; but is often in a *latent state*: friction *disturbs* it, and brings it into active operation. (see p. 31.)

Q. *Why is a* TREE *sometimes* SCORCHED *by lightning, as if it had been set on fire?*

A. Lightning scorches it by its own *positive heat*, just the same as fire would.

Q. *Why is the* BARK *of a* TREE *often ripped quite off by a flash of lightning?*

A. As the lightning runs down the tree, it develops the latent heat so *rapidly*, that it carries the bark of the tree along with it, while it seeks to escape.

Q. *Why are* BOUGHS *of* TREES *broken off by lightning?*

A. The *mechanical force* of lightning is very great; and when the flash strikes a tree, it will often break off the boughs by the *force* with which it strikes against it.

Q. *Why is an electric shock felt* MOST *at the* ELBOW JOINT*?*

A. Because the path of the fluid is *obstructed by the joint*: and the shock felt at the elbow is caused by the fluid *leaping from one bone to another*.

CHAPTER III.

Q. *What is the third chief source of heat?*

A. CHEMICAL ACTION.

Q. *What is meant by chemical action being the source of heat?*

A. Many things, when their chemical constitution is changed, (either by the abstraction of some of their gases, or by the combination of others not before united,) evolve *heat*, while the change is going on.

Q. *Explain by illustration what you mean.*

A. Water is cold, and sulphuric acid is cold; but if these two *cold* liquids be mixed together, they will produce *boiling heat*.

Q. *Why will* COLD WATER, *mixed with* SULPHURIC ACID, *produce heat?*

A. Because water (being *lighter* than sulphuric acid), is *condensed* by the heavier liquid; and its heat is *squeezed out*, as water from a sponge.

Q. *Why does* COLD WATER, *poured on* LIME, *make it intensely* HOT*?*

A. The heat is evolved by the chemical action, produced by the cold water combining with the lime.

Q. *Where does the heat come from?*

A. It was in the water and lime before; but was in a *latent state*.

Q. *Was there heat in the cold water and lime, before they were mixed together?*

A. Yes. *All* bodies contain heat; the coldest ice, as well as the hottest fire.

Q. *Is there* HEAT *even in* ICE*?*

A. Yes. But it is *latent*, (i. e. not perceptible to our senses).[4]

[4] Latent, from the Latin word, Lateo, (to lie hid.)

Q. *How do you know there is heat, if you cannot perceive it?*

A. Thus:—Ice is 32° by the thermometer; but if ice be *melted* over a fire, (though 140° of heat are thus absorbed,) it will feel no *hotter* than it was before. (*i. e. it will be only 32°, and not 172°*)[5].

[5] 32°, i. e. 32 degrees; 140°, i. e. 140 degrees, &c.

Q. *What becomes of the 140°, which went into the ice to melt it?*

A. It is hidden in the water; or (to speak more scientifically) it is stored up in a *latent state*.

Q. *How much heat may be thus secreted or made latent?*

A. *All* things contain a vast quantity of latent heat; but, as much as 1140° of heat may remain latent in *water*.

Q. *How can 1140° of heat be added to water, without being perceptible to our feelings?*

A. 1st—140° of heat are hidden in the water, when ice is melted by the sun or fire.

2ndly—1000° more of heat are secreted, when water is converted into steam. Thus, before ice is converted into steam, 1140° of heat become *latent*.[6]

[6] Thus, one pint of boiling water, (212° according to the thermometer,) will make 1800 pints of steam; but the steam is no hotter to the touch than boiling water, both are 212°: therefore, when water is converted into steam, 1000° of heat become latent. Hence, before ice is converted to steam, it must contain 1140° of latent heat.

Q. *Can we be made to* FEEL *the heat of* ICE *or snow?*

A. Yes. Into a pint of snow put half as much salt; then plunge your hand into the liquid; and it will feel so intensely cold, that the snow itself will seem quite *warm* in comparison to it.

Q. *Is* SALT *and* SNOW *really* COLDER *than snow?*

A. Yes, many degrees; and by dipping your hand into the mixture *first*, and into snow *afterwards*, the mere snow will seem to be comparatively warm.

Q. *What is* FIRE*?*

A. Combustion is another instance of heat, arising from chemical action.

Q. *What two things are essential to produce combustion?*

A. Fuel and air.

Q. *What are the elements of fuel?*

A. As bread is a compound of flour, yeast, and salt; so fuel is a compound of hydrogen and carbon.

Q. *What are the* ELEMENTS *of atmospheric* AIR*?*

A. The air is a compound of oxygen and nitrogen *mixed* together; in the proportion of five gallons of nitrogen, to one of oxygen.

Q. *What is* CARBON*?*

A. The solid part of fuel. It abounds also in all animal bodies, earths, and minerals.

Q. *Mention some different* SPECIES *of* CARBON.

A. Common charcoal, lamp-black, coke, black lead, and the diamond, are all varieties of carbon.

Q. *What is* HYDROGEN?

A. An inflammable gas. The gas used in our streets, is only the hydrogen gas *driven out of coals by heat*.

Q. *What are the peculiar characteristics of hydrogen gas?*

A. Though this gas *itself* will *burn*, yet a candle will *not* burn when immersed in it; nor can an animal live in it. Hydrogen gas is the lightest of all known substances.[7]

[7] Hydrogen gas may be made thus:—Put some pieces of zinc or iron filings into a glass: pour over them a little sulphuric acid (vitriol), diluted with twice the quantity of water; then cover the glass over for a few minutes, and hydrogen gas will be given off.

EXP. If a flame be put into the glass, an EXPLOSION will be made.

If the experiment be tried in a phial, which has a piece of tobacco-pipe run through the cork; and a light held a few moments to the top of the pipe, a FLAME will be made.

If a balloon be held over the phial, (so that the gas can inflate it,) the balloon will ascend in a very few minutes.

Q. *What is* OXYGEN?

A. A gas, much heavier than hydrogen; which gives brilliancy to flame, and is essential to animal life.[8]

[8] Oxygen gas is much more troublesome to make than hydrogen. The *cheapest* plan is to put a few ounces of manganese (called the black oxide of manganese) into an iron bottle, furnished with a bent tube; set the bottle on a fire till it becomes red hot, and put the end of the tube into a pan of water. In a few minutes, bubbles will rise through the water; these bubbles are oxygen gas.

These bubbles may be collected thus:—Fill a common bottle with water; hold it topsy-turvy over the bubbles which rise through the pan, but be sure the mouth of the bottle be held *in the water*. As the bubbles rise into the bottle, the water will run out; and when all the water has run out, the bottle is full of gas. Cork the bottle while the *mouth remains under water*; set the bottle on its base; cover the cork with lard or wax, and the gas will keep till it be wanted.

N. B. The *quickest* way of making oxygen gas, is to rub together in a mortar half an ounce of oxide of copper, and half an ounce of chlorate of potassa. Put the mixture into a common oil flask, furnished with a cork which has a bent tube thrust through it. Heat the bottom of the flask over a candle or lamp; and when the mixture is red hot, oxygen gas will be given off. Note—the tube must be immersed in a pan of water, and the gas collected as before.

(Chlorate of potassa may be bought at any chemist's; and oxide of copper may be procured by heating a sheet of copper red hot, and when cool, striking it with a hammer: the scales that peel off, are oxide of copper.)

EXP. Put a piece of red hot charcoal, (fixed to a bit of wire,) into your bottle of oxygen gas; and it will throw out most dazzling sparks of light.

Blow a candle out; and while the wick is still red, hold the candle (by a piece of wire,) in the bottle of oxygen gas; the wick will instantly ignite, and burn brilliantly.

(Burning sulphur emits a *blue* flame, when immersed in oxygen gas.)

Q. *What is* NITROGEN*?*

A. Nitrogen is another invisible gas. It *will not* burn, like hydrogen; and an animal cannot live in it: it abounds in animal and vegetable substances, and is the chief ingredient of the common air. [9]

> [9] Nitrogen gas may easily be obtained thus:—Put a piece of burning phosphorus on a little stand, in a plate of water; and cover a bell glass over. (Be sure the edge of the glass stands *in the water*.) In a few minutes the air will be decomposed, and nitrogen alone remain in the bell glass.
>
> (N.B. The white fume which will arise and be absorbed by the water in this experiment, is phosphoric acid; i. e. phosphorus combined with oxygen of the air.)

Q. *Why is there so much nitrogen in the air?*

A. In order to *dilute* the oxygen. If the oxygen were not thus diluted, fires would burn out, and life would be exhausted too quickly.

Q. *What three elements are necessary to produce* COMBUSTION*?*

A. Hydrogen gas, carbon, and oxygen gas; the two former in the *fuel*, and the last in the *air* which surrounds the fuel.

Q. *What causes the combustion of the fuel?*

A. The hydrogen gas of the fuel being set free, and excited by a piece of lighted paper, instantly *unites* with the *oxygen of the air*, and makes a yellow flame: this flame heats the *carbon of the fuel*, which also unites with the oxygen of the air, and produces *carbonic acid gas*.

Q. *What is carbonic acid gas?*

A. Only carbon (or charcoal) combined with oxygen gas.

Q. *Why does* FIRE *produce* HEAT*?*

A. 1st—By liberating *latent heat* from the air and fuel: and

2ndly—By throwing into *rapid motion* the *atoms of matter*.

Q. *How is latent* HEAT *liberated by* COMBUSTION*?*

A. When the *oxygen* of the air combines with the *hydrogen* of the fuel, the two gases *condense into water*; and latent heat is *squeezed out*, as water from a sponge.

Q. *How are the* ATOMS OF MATTER DISTURBED *by* COMBUSTION*?*

A. 1st—When *hydrogen* of fuel and *oxygen* of air *condense into water*, a *vacuum* is made; and the air is disturbed, as a *pond* would be, if a pail of water were taken out of it: and

2ndly—When the *carbon* of fuel and *oxygen* of air *expand into carbonic acid gas*, the air is *again* disturbed, as it would be by the explosion of *gunpowder*.

Q. *How does fire condense* HYDROGEN *and* OXYGEN *into* WATER*?*

A. The *hydrogen of fuel* and *oxygen of air* (liberated by combustion) combining together, *condense into water*.

Q. *How does fire expand* CARBON *into* CARBONIC ACID GAS*?*

A. The *carbon of fuel* and *oxygen of air* (combining together in combustion) expand into a gas, called *carbonic acid*.

Q. *Why is a* FIRE *(after it has been long burning)* RED HOT*?*

A. When coals are heated *throughout*, the carbon is so completely mixed with the oxygen of the air, that the *whole surface is in a state of combustion*, and therefore *red hot*.

Q. *In a* BLAZING *fire, why is the* UPPER *surface of the* COALS BLACK*, and the* LOWER *surface* RED*?*

A. Carbon (being very solid) requires a great degree of heat to make it unite with the oxygen of the air. When fresh coals are put on, their *under* surface is heated before the upper surface; and one is *red* (or in a state of combustion), while the other is *black*.

Q. *Which burns the quicker, a* BLAZING *fire, or a* RED HOT *one?*

A. A *blazing* fire burns out the fuel quickest.

Q. *Why do* BLAZING COALS BURN QUICKER *than red hot ones?*

A. In red hot coals, only the *mere surface* is in a state of combustion, because the carbon is *solid*; but in a *blazing* fire, (where the gases are escaping), the *whole volume of the coal throughout* is in a state of decomposition.

Q. *What is* SMOKE*?*

A. *Unconsumed* parts of fuel (principally carbon), separated from the solid mass, and carried up the chimney by the current of hot air.

Q. *Why is there* MORE SMOKE *when* COALS *are* FRESH *added, than when they are red hot?*

A. Carbon (being solid), requires a great degree of heat to make it unite with oxygen, (or, in other words, to bring it into a state of perfect combustion): when coals are fresh laid on, *more carbon is separated* than can be *reduced to combustion*; and so it flies off in smoke.

Q. *Why is there so* LITTLE SMOKE *with a* RED HOT FIRE*?*

A. When a fire is red hot, the *entire surface* of the coals is in a *state of combustion*; so a very little flies off unconsumed, as smoke.

Q. *Why are there* DARK *and* BRIGHT SPOTS *in a* CLEAR *cinder* FIRE*?*

A. Because the *intensity* of the combustion is *greater in some parts* of the fire, than it is in *others*.

Q. *Why is the intensity of the combustion so unequal?*

A. Because the air flies to the fire in various and unequal currents.

Q. *Why do we see all sorts of* GROTESQUE FIGURES *in hot* COALS*?*

A. Because the *intensity* of combustion is so *unequal*, (owing to the gusty manner in which the air flies to the fuel; and the various shades of red, yellow, and white heat mingling with the black of the unburnt coal), produce strange and fanciful resemblances.

Q. *Why does* PAPER BURN *more readily than wood?*

A. Merely because it is of a *more fragile texture*; and, therefore, its component parts are more easily heated.

Q. *Why does* WOOD BURN *more readily than coal?*

A. Because it is not so *solid*; and, therefore, its elemental parts are more easily separated, and made hot.

Q. *When a* FIRE *is* LIGHTED, *why is* PAPER *laid at the* BOTTOM, *against the grate?*

A. Because paper (in consequence of its fragile texture), so very readily catches fire.

Q. *Why is* WOOD *laid on the top of the paper?*

A. Because wood, (being more *substantial*), *burns longer* than paper; and, therefore, affords a *longer contact of flame* to heat the coals.

Q. *Why would not paper do without wood?*

A. Because paper burns out so *rapidly*, that it would not afford sufficient *contact of flame* to heat the coals to combustion.

Q. *Why would not* WOOD *do* WITHOUT *shavings, straw, or paper?*

A. Because wood is too *substantial* to be heated into combustion, by the flame issuing from a mere *match*.

Q. *Why would not the paper do as well, if placed on the* TOP *of the coals?*

A. As every blaze *tends upwards*, if the paper were placed on the *top* of the fire, its blaze would afford *no contact of flame* to fuel lying *below*.

Q. *Why should* COAL *be placed* ABOVE *the wood?*

A. As every flame tends *upwards*, if the wood were *above the coal*, the *flame* would not rise *through the coal* to heat it.

Q. *Why is a* FIRE KINDLED *at the* LOWEST BAR *of a grate?*

A. As every flame tends *upwards*; when a flame is made at the *bottom* of a fire, it *ascends through the fuel* and heats it: whereas, if the fire were lighted from the *top*, the flame would *not come into contact* with the fuel piled below.

Q. *Why does* COAL *make such* EXCELLENT FUEL*?*

A. Because it is so very *hard* and *compact*, that it burns away very slowly.

Q. *Why will* CINDERS *become* RED HOT*, quicker than* COALS*?*

A. Because they are *more porous* and *less solid*; and are, therefore, sooner reduced to a state of combustion.

Q. *Why will not* IRON CINDERS *burn?*

A. Iron cinders are *cinders saturated with oxygen*; they are unfit for fuel, because they can imbibe *no more oxygen*, being saturated already.

Q. *Why are* CINDERS *lighter than* COALS*?*

A. Because their vapour, gases, and volatile parts, have been driven off by *previous combustion*.

Q. *Why will not* STONES *do for fuel, as well as* COALS*?*

A. Because they contain no *hydrogen* (or inflammable gas) like coals.

Q. *Why will not* WET KINDLING *light a fire?*

A. 1st—Because the moisture of the wet kindling prevents the *oxygen of the air from getting to the fuel* to form it into carbonic acid gas: and

2ndly—The heat of the fire is perpetually *drawn off*, by the conversion of *water* into *steam*.

Q. *Why does* DRY *wood burn* BETTER *than* GREEN*?*

A. 1st—Because no heat is *carried away*, by the conversion of *water into steam*: and

2ndly—The pores of dry wood *are filled with air*, which supply the fire with oxygen.

Q. *Why do* TWO *pieces of* WOOD *burn* BETTER *than* ONE*?*

A. 1st—Because they help to entangle the *heat of the passing smoke*, and *throw it on the fuel*: and

2ndly—They help to *entangle the air* that passes over the fire, and create a kind of *eddy* or draught.

Q. *Why does* SALT CRACKLE *when thrown into a* FIRE*?*

A. Salt contains *water*; and the *cracking* of the salt is owing to the sudden *conversion of the water into steam*.

Q. *Why will not wood or paper burn, if they are steeped in a solution of* POTASH*, phosphate of* LIME*, or* AMMONIA *(hartshorn)?*

A. Because any "al'kali" (such as potash) will *arrest the hydrogen* (as it escapes from the fuel), and prevent its *combination* with the *oxygen of air*.

Q. *What is an al'kali?*

A. The con'verse of an *acid*; as *bitter* is the con'verse of *sweet*, or *insipid* the con'verse of *pungent*.

Q. *Why does a* JET *of* FLAME *sometimes burst into the room* THROUGH THE BARS OF A STOVE*?*

A. The iron bars conduct heat to the *interior of some lump of coal:* and its volatile gas (bursting through the weakest part) is kindled by the glowing coals over which it passes.

Q. *Why is this* JET *sometimes of a* GREENISH YELLOW *colour?*

A. When a lump of coals lies *over the hot bars*, or the coals below it are not *red hot*, the gas which bursts from the lump *escapes unburnt*, and is of a greenish colour.

Q. *Why does the gas escape UNBURNT?*

A. Because neither the *bars* nor *coals* (over which it passes) are *red-hot*.

Q. *Why does a BLUISH FLAME sometimes flicker on the surface of hot cinders?*

A. Gas from the hot coals *at the bottom of the grate* mixing with the *carbon of the coals above*, produces an inflammable gas (called carbonic oxide), which burns with a blue flame.

Q. *Why is the FLAME of a good fire YELLOW?*

A. Because both the hydrogen and carbon of the fuel are in a state of *perfect combustion*. It is the *white heat of the carbon*, which gives the pale yellow tinge to the flaming hydrogen.

Q. *What is LIGHT?*

A. Rapid *undulations* of a fluid called *ether*, striking on the eye.

Q. *How does COMBUSTION make these undulations of LIGHT?*

A. The atoms of matter (set in motion by heat) *striking against* this ether, produce *undulations* in it; as a *stone* thrown into a stream, would produce undulations in the *water*.

Q. *How can UNDULATIONS of ether produce LIGHT?*

A. As *sound* is produced by *undulations of air* striking on the *ear*; so *light* is produced by undulations of *ether* striking on the *eye*.

Q. *What is ETHER?*

A. A very subtile fluid, which pervades and surrounds *every thing we see*.

Q. *Mention a simple experiment to prove that LIGHT is produced by rapid MOTION.*

A. When a fiddle-string is *jerked* suddenly, its rapid vibration produces a grey *light*; and when a carriage wheel revolves very quickly, it sends forth a similar light.

Q. *Does HEAT ALWAYS produce LIGHT?*

A. No: the heat of a stack of hay, or reeking dunghill, though very *great*, is not sufficient to produce *light*.

Q. *Why is a* YELLOW FLAME *brighter than a* RED HOT COAL*?*

A. Because *yellow rays* always produce the greatest amount of *light*; though *red rays* produce the greatest amount of *heat*.

Q. *Why is the* LIGHT *of a fire* MORE INTENSE *sometimes than at others?*

A. The *intensity* of fire-light depends upon the *whiteness* to which the carbon is reduced, by combustion. If the carbon be *white hot*, its *combustion is perfect*, and the light intense; if not, the light is obscured by *smoke*.

Q. *Why will not* CINDERS BLAZE*, as well as* FRESH *coals?*

A. The *flame* of coals is made chiefly by *hydrogen gas*. As soon as this gas is consumed, the hot cinders produce only an *invisible* gas, called carbonic acid.

Q. *Where does the hydrogen gas of a fire come from?*

A. The *fuel is decomposed* (by combustion) into its simple elements, carbon and hydrogen gas. (see p. 33)

Q. *Why does not a* FIRE BLAZE *on a* FROSTY NIGHT*, so long as it does upon another night?*

A. The air (being very cold) *rushes to the fire so rapidly*, that the coals burn out *faster*, and the inflammable gas *is sooner consumed*.

Q. *Why does a* FIRE *burn* CLEAREST *on a* FROSTY *night?*

A. Because the volatile gases are quickly consumed; and the solid carbon *plentifully supplied with air*, to make it burn bright and intensely.

Q. *Why does a* FIRE *burn more intensely in* WINTER *than in* SUMMER *time?*

A. Because the air is *colder* in winter, than in summer-time.

Q. *How does the* COLDNESS *of the air increase the* HEAT *of a fire?*

A. For two reasons: 1st—Because cold air being more *condensed* than hot air, contains a greater *body*: and

2ndly—Cold air *rushes more quickly to the fire*, and supplies more *oxygen*.

Q. *Why does the* SUN*, shining on a* FIRE*, make it* DULL*, and often put it out?*

A. 1st—When the sun shines, the air is rarefied; and, therefore, *flows more slowly to the fire*.

2ndly—As the air is *rarefied*, even that which *reaches* the fire, *affords less nourishment*.

Q. *Why does the air flow to the fire more* TARDILY *for being* RAREFIED*?*

A. The greater the *contrast* (between the *external air*, and that *which has been heated by the fire*) the more *rapid* will be the current of air towards that fire.

Q. *Why does rarefied air afford* LESS NOURISHMENT *to fire, than cold air?*

A. Because it is *spread out*, (like a piece of gold *beaten into leaf*); and as a square inch of gold *leaf* will not contain so much gold as a square inch of *bullion*—so, a square inch of *rarefied* air has less *body*, than a square inch of *cold air*.

Q. *Why does a* FIRE *burn more fiercely in the* OPEN AIR*?*

A. 1st—Because the *air out-of-doors* is more *dense*, than the air in-doors: and

2ndly—Because air is *more freely supplied* to a fire out-of-doors.

Q. *Why is the air out-of-doors more* DENSE *than that in-doors?*

A. Because the circulation is more free; and as soon as any portion has been *rarefied*, it instantly escapes, and is supplied by *colder currents*.

Q. *Why does not a* FIRE *burn so freely in a* THAW*, as in a* FROST*?*

A. During a thaw, the air is filled with *vapour*; and, both *moves too slowly*, and is *too much diluted* to nourish the fire.

Q. *Why does a* FIRE *burn so fiercely in* WINDY *weather?*

A. In windy weather the *air is rapidly changed*, and affords plentiful nourishment to the fire.

Q. *Why do a pair of* BELLOWS *get a fire up?*

A. A pair of bellows, (like the wind), *drives the air more rapidly to the fire*; and the plentiful supply of oxygen soon makes the fire burn intensely.

Q. *Why is a* CANDLE BLOWN OUT *by the breath, and not made more intense, like a fire?*

A. As the flame of a candle is confined to a *very small wick*, it is *severed* from it by the breath; and (being unsupported) *must go out*.

Q. *Why is a* SMOULDERING WICK *sometimes* REKINDLED *by blowing it?*

A. The breath carries the air to it with *great rapidity*; and the oxygen of the air kindles the *red hot wick*, as it kindles charred wood.

Q. *Why is not the red hot wick kindled by the air* AROUND *it, without* BLOWING *it?*

A. Because oxygen is not supplied with sufficient freedom, unless it be *blown* to the wick.

Q. *When is this experiment most likely to succeed?*

A. In *frosty* weather; because the air contains more oxygen then, *being condensed by the cold*.

Q. *Why does a* POKER, LAID ACROSS *a dull* FIRE, *revive it?*

A. For two reasons. 1st—Because the poker *concentrates the heat*, and therefore increases it: and

2ndly—Because the poker *arrests the air* which passes over the fire, and *produces a draught*.

Q. *Why do* SEVERAL PIECES *of* WOOD *or coal burn* BETTER *than* ONE*?*

A. When there are two or three pieces of wood on a fire, the air *(circulating round them) produces an eddy* or draught, which draws up the fire.

Q. *Why are* STOVES *fixed on the* FLOOR *of a room?*

A. In order that the air, *on the lower part of the room*, may be heated by the fire.

Q. *Would not the air of the lower part of a room be heated equally well, if the stoves were fixed higher up?*

A. No; the heat of a fire has a very little effect upon the air *below the level of the grate*; and, therefore, every grate should be as *near to the floor* as possible.

Q. *Why are our* FEET *so* COLD *when we sit close by a good fire?*

A. As the fire consumes the air which passes over it, *cold air* rushes through the crevices of the doors and windows *along the bottom of the room* to supply the deficiency; and these currents of cold air, *rushing constantly over our feet*, deprive them of their warmth.

Q. *If a piece of* PAPER *be laid* FLAT *on a clear fire, it will* NOT BLAZE, *but* CHAR. *Why so?*

A. The carbon of a clear fire, being sufficiently hot to unite with the oxygen of the air, *produces carbonic acid gas*, which soon envelops the paper laid flat upon the cinders: but carbonic acid gas will not *blaze*.

Q. *If you* BLOW *the paper, it will* BLAZE *immediately. Why so?*

A. By blowing, or opening the door suddenly, *the carbonic acid is dissipated*, and the paper is instantly fanned into flame.

Q. *Why does* WATER EXTINGUISH *a* FIRE*?*

1st—Because the water *forms a coating* over the fuel, and keeps it from the air:

2ndly—The conversion of *water into steam*, draws off the *heat* of the burning fuel.

Q. *Why does a* LITTLE WATER *make a fire* FIERCER*, while a* LARGER *quantity of water puts it* OUT*?*

A. Water is composed of *oxygen and hydrogen*; when, therefore, the fire can decompose the water into its simple elements, it serves for *fuel* to the flame.

Q. *How can* WATER *serve for* FUEL *to fire?*

A. The *hydrogen* of the water will burn with a *flame*; and the *oxygen* of the water will increase the *intensity* of that flame.

Q. *If a house be on fire, is too* LITTLE *water worse than* NO *water at all?*

A. Certainly. Unless the water be supplied so plentifully as *to quench the fire*, it will increase the *intensity*, like fuel.

Q. *When will water* EXTINGUISH FIRE*?*

A. When the supply is so rapid and abundant, that the fire cannot *convert it into steam*.

Q. *Does not a very* LITTLE *water* SLACKEN *the heat of fire?*

A. Yes, *till it is converted into steam*; but then it increases the *intensity* of fire, and acts like fuel.

Q. *Why does the* WICK *of a candle (when the flame has been blown out)* CATCH FIRE *so readily?*

A. As the wick is already *very hot*, a little *extra* heat will throw it into flame.

Q. *Why does the* EXTRA *heat revive the flame?*

A. Because it again liberates the *hydrogen* of the tallow, and ignites it.

Q. *Cannot* WOOD *be made to* BLAZE *without actual contact with fire?*

A. Yes; if a piece of wood be held *near* the fire for a little time it will blaze, even though it does not *touch* the fire.

Q. *Why will* WOOD BLAZE, *even if it does not touch the fire?*

A. The heat of the fire *drives out the hydrogen gas* of the wood; which is inflamed by contact with the red-hot coals.

Q. *Why will a* NEIGHBOUR'S HOUSE *sometimes* CATCH FIRE, *though no flame of the burning house ever touches it?*

A. The heat of the burning house sets at liberty *the hydrogen gas* of the neighbouring wood-work, which is ignited by the flames or red-hot bricks of the house on fire.

Q. *What is* COKE*?*

A. Coal freed from its volatile gases, by the action of artificial heat.

Q. *Why do* ARNOTT'S STOVES *sometimes* SMELL *so strong of* SULPHUR*?*

A. The fire is made of coke, which contains sulphur; and, whenever the draught is not rapid enough *to drive the sulphur up the flue*, it is emitted into the room.

Q. *What is meant by* SPONTANEOUS COMBUSTION*?*

A. Ignition produced by the action of *one uninflamed* body on another.

Q. *Give an example of spontaneous combustion.*

A. Goods packed in a warehouse will often catch fire of *themselves*; especially such goods as cotton, flax, hemp, rags, &c.

Q. *Why do such* GOODS *sometimes* CATCH FIRE *of themselves?*

A. Because they are piled together in very *great masses* in a *damp* state or place.

Q. *Why does this produce spontaneous combustion?*

A. The damp produces *decay* or the decomposition of the goods, and the great heat of the piled-up mass makes the decaying goods *ferment*.

Q. *How does this* FERMENTATION *produce* COMBUSTION*?*

A. During fermentation, *carbonic acid gas* is given off by the goods,—a slow combustion ensues,—till at length the *whole pile* bursts into *flame*.

Q. *Why is the* HEAT *of a* LARGE MASS *of goods* GREATER *than that of a smaller quantity?*

A. Because compression *squeezes out* heat, as water is squeezed from a sponge; and as the goods of a large pile are greatly *compressed*, much of their latent heat is *squeezed out*.

Q. *Why do* HAY-STACKS *sometimes* CATCH FIRE *of themselves?*

A. Either because the hay was got up *damp*, or because rain has penetrated the stack.

Q. *Why will a* HAY-STACK CATCH FIRE *if the hay be damp?*

A. Damp hay soon *decays*, and undergoes a *state of fermentation*; during which, *carbonic acid gas* is given off, and the stack catches *fire*.

Q. *Why does roasted* COFFEE *sometimes* CATCH FIRE *spontaneously?*

A. The *heat* of coffee is greatly increased by being *roasted*; and the *carbon of the coffee* uniting with the *oxygen of the air*, produces *carbonic acid gas*, and bursts into *flame*.

Q. *Why do old* RAGS, *used for* CLEANING LAMPS *and* CANDLES, *sometimes set a* HOUSE *on FIRE?*

A. Because they very readily *ferment*, and (during fermentation) throw off exceedingly inflammable gases.

(N.B. Lamp-black mixed with linseed oil is more liable to spontaneous combustion, than anything that servants handle.)

CHAPTER IV.
SMOKE.

Q. *Why does* SMOKE ASCEND *the chimney?*

A. As the air of the room passes over the fire, it becomes *heated*; and (being thus made *lighter*,) ascends the chimney, carrying the smoke with it.

Q. *What is* SMOKE*?*

A. Small particles of carbon, separated by combustion from the fuel, but not *consumed*.

Q. *Why do* SMOKE *and steam* CURL*, as they ascend?*

A. Because they are moved in a *right line*, and then *pushed on all sides*; and this forces them into a *circular* motion.

Q. *What are* BLACKS*?*

A. When the hot air of the chimney has been cooled by the *external* air, it can no longer *buoy up* the solid smoke; so it falls to the earth in condensed flakes, called "blacks."

Q. *Why are there* NO BLACKS *in the smoke of a* RAILWAY *engine?*

A. The smoke of a railway engine consists chiefly of *watery vapour*, which dissolves in air, as sugar does in water; but the smoke of a common chimney consists of small fragments of *unburnt fuel*.

Q. *Why does a "COPPER HOLE" DRAW up more fiercely than an* OPEN *stove?*

A. As the air, which supplies the copper hole, must pass *through the furnace*, it becomes exceedingly *heated*, and rushes up the chimney with great violence.

Q. *What produces the* ROARING *noise made by a* COPPER-HOLE *fire?*

A. Air rushing rapidly through the crevices of the *iron door*, and up the *chimney flue*.

Q. *Why is the* ROAR LESS*, if the copper-hole* DOOR *be thrown* OPEN*?*

A. Because *fresh* air gets access to the fire *more easily*; and as the air is not so intensely heated, its motion is not so *violent*.

Q. *Why do some* CHIMNEYS SMOKE*?*

A. If fresh air is not admitted into a room, *as fast as it is consumed by the fire*, a current of air *will rush down the chimney* to *supply the deficiency*, and bring the smoke along with it.

Q. *What prevents air being supplied, as fast as it is consumed by the fire?*

A. Leather and curtains round the doors; sand-bags at the threshhold and on the window-frames; and other contrivances to keep out the draught.

Q. *Why is it needful for cold fresh air to be so constantly supplied?*

A. If water be taken with a pail out of a river, *other* water will rush towards the hole, as soon as the pail is lifted out; and if air be taken from a room, (as it is, when some of it goes up the chimney) *other air* will rush towards the void to fill it up.

Q. *Why will it come down the chimney?*

A. Because if doors and windows are all made *air-tight*, it can get to the room in no *other* way.

Q. *What is the best* REMEDY *in such a case?*

A. The *speediest* remedy is to open the door or window: but by far the *best* remedy is to carry a small tube from the hearth into the external air.

Q. *Why is that the* BEST *remedy?*

A. Because the fire will be plentifully supplied with air by the tube; the doors and windows may all remain air-tight; and we may enjoy a warm fireside, without the inconvenience of draughts and cold feet.

Q. *Why is a* CHIMNEY *raised so high above the* ROOF*?*

A. If it were not so, it would smoke; as all funnels do which are too short.

Q. *What is meant by the funnel, or flue of a chimney?*

A. That part of a chimney through which *the smoke passes*, is called the funnel, or flue.

Q. *Why does a* CHIMNEY SMOKE*, if the funnel be very short?*

A. Because the *draught* of a short flue *is too slack* to carry the smoke up the chimney.

Q. *Why is the* DRAUGHT *of a* SHORT FLUE *more* SLACK *that that of a long one?*

A. For many reasons. 1st—*The fire is always dull and sluggish* if the chimney be too short.

2ndly—The smoke rolls *out* of the chimney, before it has acquired its *full velocity*.

3rdly—The wind, rain, and air, have more influence over a *short* funnel, than over a *long* one.

Q. *Why is the* FIRE *always* DULL *and sluggish if the* CHIMNEY-FLUE *be very* SHORT*?*

A. Because the draught is so bad: and as the rarefied air *passes up the chimney very tardily*, *fresh air* flows as tardily *towards the fire*, to supply it with *oxygen*.

Q. *On what does the* INTENSITY *of fire depend?*

A. The *intensity* of fire is always in proportion to the *quantity of oxygen* with which it is supplied.

Q. *Why does not* SMOKE *acquire its full* VELOCITY *in a* SHORT *funnel?*

A. Because the *higher* smoke ascends in a flue, (provided it be clear and hot) the *faster* it goes; (as a stone falls faster and faster the lower it descends): if, therefore, a *funnel be very short*, the smoke never acquires its full velocity.

Q. *Does the* DRAUGHT *of a chimney depend on the* SPEED *of the* SMOKE *through the flue?*

A. Yes. The more quickly *hot* air flies *up the chimney*, the more quickly *cold* air will rush *towards the fire* to supply the place; and, therefore, the *longer the flue*, the *greater the draught*.

Q. *Why is the* DRAUGHT *of a* LONG FLUE *greater than that of a short one?*

A. Because the *higher* smoke ascends, the *faster* it goes; (as a stone falls faster and faster, the nearer it approaches to the earth): if, therefore, a funnel be *long*, the smoke acquires great *velocity*, and the *draught* is great.

Q. *If a* CHIMNEY *be* TOO SHORT, *and cannot be lengthened, what is the best* REMEDY *to prevent smoking?*

A. To *contract the opening of the chimney* contiguous to the stove.

Q. *Why will a* SMALLER OPENING *against the stove* PREVENT *the* SMOKING?

A. As all the air (which enters the chimney) *must pass near the fire*, it will become *greatly heated*, and *rise rapidly* through the funnel; and this *increase of heat* will compensate for the *shortness of the flue*.

Q. *Why will a* ROOM SMOKE, *if there be* TWO FIRES *in it?*

A. Because the *fiercer* fire will exhaust the most air; and draw from the *smaller* one, to supply its demand.

Q. *Why will a chimney* SMOKE *if there be a* FIRE *in* TWO ROOMS *communicating with each other?*

A. Whenever the *door* between the two rooms *is opened*, air will rush from the chimney of the *inferior* fire, to supply the *other*; and *both* rooms will be filled with smoke.

Q. *What is the* REMEDY *in this case?*

A. Let a tube be carried from the hearth of each stove, into the external air; and then *each* fire will be so *well* supplied, that neither will need to borrow from the other.

Q. *Why do* VESTRY CHIMNEYS *so often* SMOKE*?*

A. Because the wind (striking against the steeple) *is reflected back*; and tumbles down the vestry chimney, forcing the smoke *into the room*.

Q. *WHAT WINDS make vestry chimneys smoke?*

A. Those from the north-east or south-east; according to the position of the vestry.

Q. *Why will the* EASTERN *winds make* VESTRIES SMOKE*, more than those from the west?*

A. Because they *strike against the steeple*, and *bound back* to the vestry chimney: but *western* winds cannot rebound over the roof of a church.

(N. B. The *steeple* of a church is always due *west*, and the *other* end of the church due *east*; if, therefore, a *western* wind rebound, it would rebound to the *west*, or *away from the church*, and not towards it.)

Q. *Why does a* HOUSE *in a* VALLEY *very often* SMOKE*?*

A. Because the wind (striking against the surrounding hills) *rebounds back again upon the chimney*, and destroys its draught.

Q. *What is the common* REMEDY *in both these cases?*

A. To fix a *cowl* on the chimney top, to turn like a weather-cock, and present its back to the wind.

Q. *Why will not a* COWL *always* PREVENT *a chimney* SMOKING*?*

A. If the wind be *strong*, it will keep the *opening* of the cowl *towards the steeple or hill*; and then the reflected wind will *blow into the cowl*, and *down the chimney*.

Q. *As a cowl is such a poor remedy, can any* OTHER *be devised?*

A. If the chimney flue can be carried *higher* than the steeple or hills, no wind can enter the flue.

Q. *Why cannot the wind enter a chimney flue, if it be carried up* HIGHER *than the steeple or hills?*

A. Because the reflected wind would strike against the *sides* of the chimney-flue, and not pass over the *opening* at all.

Q. *In what* OTHER *cases will a* CHIMNEY SMOKE*?*

A. If both door and chimney be placed on *the same side of a room*, the chimney will often smoke.

Q. *Why will a* CHIMNEY SMOKE*, if the* DOOR *and* STOVE *are both on the* SAME SIDE*?*

A. Because when the door is opened, a current of air will *blow into the chimney-place*, and drive the smoke into the room.

Q. *What* REMEDY *can be applied to this evil?*

A. The door must be set *opposite* to the chimney, or nearly so; and then the draught from the door *will blow the smoke up the chimney*, and not into the room.

Q. *Why will a* CHIMNEY SMOKE *if it* NEEDS SWEEPING*?*

A. Because the obstruction in the chimney (presented by the loose soot, to the free passage of the smoke) *delays its current*, and prevents the draught.

Q. *Why will a* CHIMNEY SMOKE*, if* OUT OF REPAIR*?*

A. 1st—Because the *loose mortar and bricks* obstruct the smoke: and

2ndly—The *cold air* (oozing through the chinks) *chills the air in the chimney*, and prevents its ascent.

Q. *Why will an* ARNOTT'S STOVE SMOKE*, if the joints of the flue do not fit air-tight?*

A. Because the *cold air* (which gets through the joints) *chills the air in the flue*, and prevents its ascent.

Q. *Why does an old fashioned* FARM CHIMNEY-PLACE *so often smoke?*

A. Because the opening is so *very large*, that much of the air which goes up the chimney, *has never passed near the fire*; and this cold air mixing with the other, so *reduces its temperature*, that it ascends very slowly, and the draught is destroyed.

Q. *Why does a chimney smoke, if the* DRAUGHT *be* SLACK*?*

A. Because, unless the current of air up the chimney be very powerful, it cannot *buoy the smoke up* through the flue.

Q. *If the opening of a chimney be* TOO LARGE, *what* REMEDY *can be applied?*

A. The chimney-place must be contracted.

Q. *Why will* CONTRACTING *the chimney-place* PREVENT *its* SMOKING*?*

A. As the air will then pass *nearer the fire*, it will be *more heated*, and fly up the chimney *much faster*.

Q. *Why do almost all* CHIMNEYS SMOKE *in* GUSTY *weather?*

A. The gust (blowing the air *away* from the top of the chimney) *removes* (for a time) *all resistance to the smoke*: but when the wind *lulls* again, the *resistance of the air suddenly returns*—the *draught* is *checked*—and a puff of smoke rushes into the room.

Q. *What is the use of a* CHIMNEY-POT*?*

A. When the opening of a chimney is *large*, the top must be contracted by a chimney-pot, in order to increase the draught.

Q. *How does a* CHIMNEY-POT INCREASE *the* DRAUGHT *of a chimney?*

A. As the *same quantity* of hot air has to escape *through a much smaller opening*, it must pass through more quickly.

Q. *Why do tin* BLOWERS *help to get a fire up?*

A. Because they compel the air to go *through* the fire, and not *over* it; therefore the fire is well supplied with oxygen, and the draught greatly increased.

Q. *Why does a tin* BLOWER INCREASE *the* DRAUGHT*?*

A. As all the air which enters the chimney has to pass *through* the fire, it is much hotter, and ascends the chimney very fast; and the faster the air *flies up the chimney*, the faster it rushes *towards the fire* also.

Q. *Why does a parlour often* SMELL *disagreeably of* SOOT *in* SUMMER-TIME*?*

A. The air in the *chimney* (being *colder* than the air in the *parlour*) *descends into the room*, and leaves a disagreeable smell of soot behind.

Q. *Why are the* CEILINGS *of* PUBLIC OFFICES *so* BLACK *and filthy?*

A. The heated air ascending, carries the dust and fine soot to the ceiling; where the hot *air* escapes through the plaster, and *leaves the soot and dust* behind.

Q. *Why are some parts of the ceiling blacker and more filthy than others?*

A. As the air cannot penetrate the thick *joists* of the ceiling, *it passes by those parts*, and deposits its soot and dust on those which are more penetrable.

Q. *What is charcoal?*

A. Wood which has been exposed to a red heat, till it has been deprived of all its gases and volatile parts.

Q. *Why is a charcoal fire hotter than a wood fire?*

A. Because so large a quantity of *water* has been abstracted from the fuel, by the red heat to which it has been already exposed.

Q. *Why does charcoal remove the taint of meat?*

A. Because it absorbs all odoriferous effluvia, whether they arise from putrefying animal or vegetable matter.

Q. *Why is water purified by being filtered through charcoal?*

A. Charcoal absorbs the *impurities* of the water, and removes all disagreeable tastes and smells, whether they arise from animal or vegetable matter.

Q. *Why are water and wine casks charred inside?*

A. *Charring* the inside of the cask reduces it to a *kind of charcoal*; and charcoal (by absorbing animal and vegetable impurities) keeps the liquor sweet and good.

Q. *Why does a piece of burnt bread, steeped in impure water, make it fit to drink?*

A. The surface of the bread is reduced to *charcoal* by being burnt; and the charcoal surface of the bread *abstracts all the impurities of the water*, and makes it palatable.

Q. *Why should the toast and water, placed by the side of the sick, be made of burnt bread?*

A. The surface of the bread being *reduced to charcoal* by being burnt, prevents the water from being affected by the impurities of the sick room.

Q. *Why are timbers, which are to be exposed to damp, charred?*

A. *Charcoal undergoes no change* by exposure to air and water; therefore timber will resist weather *much longer*, after it has been charred.

CHAPTER V.
LAMPS AND CANDLES.

Q. *Of what are* OIL, TALLOW, *and* WAX *composed?*

A. Principally of carbon and hydrogen gas. The *solid* part is carbon, the *volatile* part is gas.

Q. *What is* CARBON*?*

A. A solid substance, generally of a black colour; well known under the forms of charcoal, lamp-black, coke, black-lead, &c.

Q. *What is* HYDROGEN GAS*?*

A. The principal ingredient of water. It is well known in the form of common *coal gas*: it burns so readily that it used to be called "inflammable air."[10]

[10] To make hydrogen gas, see p. 34>.

Q. *Why does a* CANDLE BURN *when lighted?*

A. The heat of the lighted wick *decomposes the tallow* into its elementary parts of carbon and hydrogen; and the *hydrogen of the tallow*, combining with the *oxygen of the air*, produces *flame*.

Q. *Why is the* FLAME *of a candle* HOT*?*

A. 1st—Because the flame liberates *latent heat* from the air and tallow: and

2ndly—It throws into *rapid motion* the *atoms of matter*.

Q. *How is* LATENT HEAT *liberated by the flame of a* CANDLE*?*

A. When the *hydrogen* of the tallow and *oxygen* of the air *combine*, they *condense into water*; and much of their latent heat is *squeezed out*.

Q. *How are the* ATOMS *of* MATTER *disturbed by the flame of a candle?*

A. 1st—When the *hydrogen* of the tallow and *oxygen* of the air *condense into water*, a *vacuum* is made; and the air is disturbed, as a *pond* would be, if a pail of *water* were taken out.

2ndly—When the *carbon* of tallow and *oxygen* of the air expand into *carbonic acid gas*, the air is *again* disturbed; in a similar way as by the explosion of *gunpowder*.

Q. *Why does the flame of a* CANDLE *produce* LIGHT*?*

A. The chemical changes made by combustion, excite *undulations of ether*, which (striking the eye) produce light. (see p. 46.)

Q. *Why is the* FLAME *of a* CANDLE YELLOW*?*

A. Only the *outer* coat of the flame is yellow; the *lower* part of the flame is *violet*; and the *inside* of the flame is *hollow*.

Q. *Why is the outside of the flame* YELLOW*?*

A. Because the *carbon of the tallow* (being in a state of *perfect combustion*) is made white-hot.

Q. *Why is the* BOTTOM *part* PURPLE *of the flame of a candle?*

A. The *bottom part* of the flame is *overladen with hydrogen*, raised from the tallow by the burning wick; and this *half-burnt gas* gives a *purple* tinge to the flame.

Q. *Why is the* INSIDE *of the flame of a candle* HOLLOW*?*

A. Because it is *filled with vapour*, raised from the candle by the *heat of the wick*.

Q. *Describe the different parts of the* FLAME *of a common* CANDLE*.*

A. The flame consists of *three cones*. The innermost cone is hollow; the intermediate cone of a dingy purple hue; and the outside cone is yellow.

Q. *Why is the intermediate cone of a flame* PURPLE*, as well as the* BOTTOM *of the flame.*

A. Because the gases are not in a state of *perfect combustion*; but contain an *excess of hydrogen*, which gives this cone a purple tinge.

Q. *Why is not the* MIDDLE *cone in a state of perfect combustion, as well as the* OUTER *cone?*

A. Because the outer cone *prevents the oxygen of the air* from getting freely to the *middle of the cone*; and without the free access of oxygen gas, there is no such thing as complete combustion.

Q. *Why does the* FLAME *of a candle point* UPWARDS*?*

A. The flame *heats the surrounding air*, which (being hot) *rapidly ascends*, and drives the flame upwards at the same time.

Q. *Why is the FLAME of a candle POINTED at the top, like a cone?*

A. The *upper* part of a flame is more *volatile* than the lower parts; and as it affords *less resistance to the air*, is reduced to a mere point.

Q. *Why is the UPPER part of a flame more VOLATILE than the lower parts?*

A. The *lower* parts of the flame are laden with unconsumed gas and watery vapour; which present considerable resistance to the air.

Q. *Why is the FLAME of a candle BLOWN OUT by a puff of breath?*

A. As the flame of a candle is attached to a *very small wick*, a puff of breath *severs the flame from the wick*; and it goes out for want of support.

Q. *Why does the FLAME of a candle make a GLASS DAMP, which is held over it?*

A. The *hydrogen of the tallow* combining with the *oxygen of the air*, produce a "watery vapour," which is condensed by the *cold glass* held above the flame.

Q. *Why does our hand, held ABOVE a candle, suffer from the heat of the flame so much more, than when it is placed BELOW the flame, or on ONE SIDE of it?*

A. Because the hot gases and air (in their ascent) *come in contact* with the hand placed *above* the flame: but when the hand is placed *below* the flame, or on *one side*, it only feels heat from *radiation*.

Q. *Why is a RUSH LIGHT extinguished so much more quickly than a cotton-wicked candle?*

A. As the *rush* wick is *smooth* and *hard*, the *mere motion of the air* (produced by carrying the candle from one place to another,) is sufficient to sever the flame from the rush.

Q. *Why is it more difficult to blow out a COTTON wick?*

A. The *cotton* wick is *quite full of small threads* or filaments, which help to *hold the flame on the wick*, like the roots of a tree.

Q. *Why does an EXTINGUISHER put a candle out?*

A. Because the air in the extinguisher *is soon exhausted of its oxygen* by the flame: and when there is no *oxygen to support it*, the flame goes out.

Q. *Why does not a candle set fire to a* PIECE OF PAPER *twisted into an extinguisher, and used as such?*

A. 1st—Because the flame very soon *exhausts the little oxygen* contained in the paper extinguisher: and

2ndly—The flame invests the *inside of the paper extinguisher* with *carbonic acid gas*, which prevents it from blazing.

Q. *Why is a* LONG WICK *never upright?*

A. Because it is bent by its own weight.

Q. *Why is a* LONG WICK *covered with an* EFFLORESCENCE *at the top?*

A. The knotty or flowery appearance of the top of a wick arises *from an accumulation of particles partly separated*, but still loosely hanging to the wick.

Q. *Why is not the* END *of a long wick* BURNT OFF, *as it hangs over the flames?*

A. Because the length of the wick so diminishes *the heat of the flame*, that it is not *hot* enough to burn it off.

Q. *Why do* PALMER'S METALLIC WICKS *never need* SNUFFING?

A. The wick is divided into two parts, each of which *bends outward* to the outside of the flame; where the *end is intensely heated*, and *separated* from the wick by the current of air up the candle.

Q. *Why do common* CANDLES *require to be* SNUFFED?

A. Because the heat of the flame is *not sufficient to consume the wick*; and the *longer* the wick grows, the *less heat* the flame produces.

Q. *Why do* WAX CANDLES NEVER *need* SNUFFING?

A. The wick of *wax* candles is made *of very fine thread*, which the heat of the flame is sufficient to consume: but the wick of *tallow* candles is made *of coarse cotton*, which is too substantial to be consumed by the heat of the flame, and must be cut off by *snuffers*.

Q. *Why does a* PIN, *stuck in a* RUSH-LIGHT, EXTINGUISH *it?*

A. Because a *pin* (being a good conductor), *carries away the heat of the flame from the wick*, and prevents the combustion of the tallow.

Q. *What is the* SMOKE *of a* CANDLE*?*

A. Solid particles of carbon separated from the wick and tallow, but not consumed.

Q. *Why are* SOME *particles consumed and not* OTHERS*?*

A. The *combustion of the carbon* depends upon its *combining with the oxygen of the air*: but as the outer surface of the flame *prevents the access of air to the interior parts*, therefore much of the carbon of those parts passes off in smoke.

Q. *Why do* LAMPS SMOKE*?*

A. Either because the *wick is cut unevenly*, or else because *it is turned up too high*.

Q. *Why does a* LAMP SMOKE *when the* WICK *is cut* UNEVENLY*?*

A. 1st—Because the *points of the jagged edge* (being very easily separated from the wick,) *load the flame with more carbon than it can consume*: and

2ndly—As the heat of the flame is *greatly diminished by these bits of wick*, it is unable to consume *even the usual quantity of smoke*.

Q. *Why does a* LAMP SMOKE *when the* WICK *is turned up too* HIGH*?*

A. Because more carbon is separated from the wick *than can be consumed by the flame*.

Q. *Why do not "Argand burners" smoke?*

A. Because a current of air passes through the *middle of the flame*; and therefore the carbon of the *interior* is consumed, as well as that *in the outer coating of the flame*.

Q. *Why does a* LAMP-GLASS DIMINISH *the* SMOKE *of a lamp?*

A. Because it both *concentrates and reflects the heat of the flame*; in consequence of which, the heat is so greatly increased, *that very little carbon escapes unconsumed*.

CHAPTER VI.
ANIMAL HEAT.

Q. *What is the cause of* ANIMAL HEAT*?*

A. Animal heat is produced *by the combustion of hydrogen and carbon* in the capillary veins.

Q. *What are* CAPILLARY VEINS*?*

A. Veins *as small as hairs* running *all over the body*; so called from the Latin word "capilla'ris" (*like a hair*).

Q. *Do these* CAPILLARY VEINS *run all over the human body?*

A. Yes. Whenever blood *flows from a wound*, some *vein* must be divided; and as you cannot insert a needle into *any part of the body without bringing blood*, therefore these little veins must run *through every part* of the human frame.

Q. *How do* HYDROGEN *gas and* CARBON *get into these very little veins?*

A. The food we eat is *converted into blood*, and blood contains both *hydrogen* and *carbon*.

Q. *How does* COMBUSTION *take place in the veins?*

A. The *carbon of the blood* combines with the *oxygen of the air we breathe*, and forms into *carbonic acid gas*.

Q. *What* BECOMES *of this* CARBONIC ACID GAS *formed in the human blood?*

A. Some of it is *thrown off by the breath*; and the rest of it is *absorbed by the blood*, to keep up the animal heat.

Q. *What is the cause of the* COMBUSTION *of* FIRE*?*

A. The *carbon of fuel* unites with the *oxygen of the air*, and forms *carbonic acid gas*.

Q. *What is the cause of the* COMBUSTION *of a* CANDLE *or* LAMP*?*

A. The *carbon of the oil or tallow* unites with the *oxygen of the air*, and forms *carbonic acid gas*.

Q. *What is the cause of* SPONTANEOUS COMBUSTION*?*

A. The piled-up goods *ferment from heat and damp*; and (during fermentation) *carbonic acid gas is formed*, as in the two former cases.

Q. *Does the* HEAT *of the* HUMAN BODY *arise from the* SAME CAUSE *as the heat of* FIRE*?*

A. Yes, precisely. The *carbon of the blood*, combining with the *oxygen of air inhaled*, produces *carbonic acid gas*, which is attended with combustion.

Q. *If animal heat is produced by* COMBUSTION, *why does not the human body* BURN UP *like a coal or candle?*

A. It actually does so. Every muscle, nerve, and organ of the body, actually *wastes away like a burning candle*; and (being reduced to air and ashes) is rejected from the system as useless.

Q. *If every bone, muscle, nerve, and organ, is thus consumed by combustion, why is not the* BODY *entirely* CONSUMED*?*

A. It would be so, unless the parts destroyed *were perpetually renewed*: but as a lamp will not go out, *so long as it is supplied with fresh oil*; neither will the *body* be consumed, *so long as it is supplied with sufficient food*.

Q. *When a man is* STARVED, *what parts of the body go first?*

A. First the *fat*, because it is the most combustible; then the *muscles*; last of all the *brain*; and then the man dies, like a *candle which is burnt out*.

Q. *Why does* WANT *of sufficient* NOURISHMENT *often produce* MADNESS*?*

A. After the *fat and muscles* of the body have been consumed by animal combustion, the *brain* is next attacked; and (unless the patient dies) *madness must ensue from starvation*.

Q. *Why does a man* SHRINK *when* STARVED*?*

A. A starved man shrinks *just as a fire does*, unless it be supplied with sufficient fuel.

Q. *What is the* FUEL *of the* BODY*?*

A. *Food is the fuel of the body*; and the *carbon of the food* mixing with the *oxygen of the air*, evolves heat in the same way that a fire or candle does.

Q. *Why is* EVERY *part of the* BODY WARM*?*

A. As the capillary veins run through every part of the human body, and the combustion of blood *takes place in the capillary veins*, therefore *every part of the body is warm*.

Q. *Why does* RUNNING *make us* WARM*?*

A. When we run, *we inhale air more rapidly*; and the rapidity with which we inhale air *fans the combustion of our body*, as a pair of *bellows* quickens the flame of a common fire.

Q. *How does* INHALING AIR RAPIDLY *make the body feel* WARM*?*

A. As the combustion of the blood is *more rapid*, (in consequence of the introduction *of more oxygen from theair*), therefore *the blood is more heated*, and every part of the body is warmer also.

Q. *Why does* HARD WORK *produce* HUNGER*?*

A. Because it produces *quicker respiration*; by which means a *larger amount of oxygen is introduced into the lungs*, and the *capillary combustion increased*. Hunger *is the notice* (given by our body) to remind us, *that our food-fuel must be replenished*.

Q. *Why does* SINGING *make us* HUNGRY*?*

A. Singing *increases respiration*; and as *more oxygen* is introduced into the lungs, *our food-fuel is more rapidly consumed*.

Q. *Why does* READING ALOUD *make us feel* HUNGRY*?*

A. Reading aloud *increases respiration*; and as *more oxygen* is introduced into the lungs, *our food-fuel is more rapidly consumed*.

Q. *Why do we feel* MORE HUNGRY *in the* DAY-TIME *than in the* NIGHT-TIME*?*

A. As we *breathe more slowly during sleep*, therefore, less *oxygen* is introduced into the lungs *to consume our food-fuel*.

Q. *Why do we need* WARMER CLOTHING *by* NIGHT *than by* DAY*?*

A. 1st—Because the *night is generally colder* than the day.

2ndly—As our *respiration is slower*, our *animal combustion is slower also*; in consequence of which, *our bodies are more cold*.

Q. *Why do we* PERSPIRE *when very* HOT*?*

A. The pores of the body are *like the safety valves of a steam-engine*; when the heat of the body is too great, the combustible gas and grease *flow out in perspiration*, instead of *burning in the blood*.

Q. *Why do persons feel* LAZY *and averse to exercise, when they are* HALF-STARVED *or* ILL-FED*?*

A. *Animal food* contains great nourishment, and produces a desire for *active occupations*; but when the body is not supplied with strong food, this desire for muscular action *ceases*, and the person grows slothful.

Q. *Why have persons, who follow* HARD OUT-OF-DOORS OCCUPATIONS, *more* APPETITE *than those who are engaged in* SEDENTARY *pursuits?*

A. Hard bodily labour in the open air *causes much oxygen to be conveyed into the lungs by inspiration*; the combustion of the food is carried on quickly; *animal heat increased*; and need for nutritious food more quickly indicated *by craving hunger*.

Q. *Why have persons who follow* SEDENTARY PURSUITS *less* APPETITE *than ploughmen and masons?*

A. 1st—The air they inhale *is not so pure*, because its oxygen is partly exhausted: and

2ndly—Their respiration is neither *so quick nor strong*, and therefore the combustion of their food is carried on more slowly.

Q. *Why do we like strong* MEAT *and* GREASY *food when the* WEATHER *is very* COLD*?*

A. Strong meat and grease contain large portions of *hydrogen*, which (when burned in the blood) produce a larger amount of heat than any other kind of food.

Q. *Why do persons* EAT MORE *food in* COLD *weather, than in hot?*

A. In *cold* weather the body requires more fuel *to keep up the same amount of animal heat*; and as we *put more coals on a fire on a cold day* to keep our *room warm*, so we *eat more food on a cold day* to keep our *body warm*.

Q. *Why does* COLD *produce* HUNGER*?*

A. 1st—The air contains more *oxygen* in cold weather; and as *fires burn fiercer*, so *animal combustion is more rapid*: and

2ndly—We are more *active* in cold weather; and increased respiration acts *like a pair of bellows* on the capillary combustion.

Q. *Why does rapid* DIGESTION *produce a craving* APPETITE*?*

A. This is a wise providence to *keep our bodies in health*; in order that the *body itself* may not be consumed, it gives notice (by hunger) that the *capillary fires need replenishing*.

Q. *Why do we feel a desire for* ACTIVITY *in cold weather?*

A. 1st—Because activity increases the warmth of the body, *by fanning the combustion of the blood*: and

2ndly—The *strong food* we eat creates a desire for muscular exertion.

Q. *Why are the Esquimeaux so passionately fond of* TRAIN OIL *and* WHALE BLUBBER*?*

A. Oil and blubber contain a very *large amount of hydrogen*, which is exceedingly combustible; and as these people live in climates of intense cold, the heat of their bodies is increased by the *greasy nature of their food*.

Q. *Why do we feel a dislike to strong meat and greasy foods in very hot weather?*

A. Strong meat and grease contain so much *hydrogen*, that they would make us *intensely hot*; and therefore we refuse them in hot weather.

Q. *Why do we like fruits and vegetables so very much in hot weather?*

A. Fruits and vegetables contain *less carbon* than meat, and therefore produce *less blood*: instead of blood, *they combine into water* as they are digested, and keep the body cool.

Q. *Why do people say that* FRUITS *and* VEGETABLES COOL *the* BLOOD*?*

A. 1st—Because they *deprive the blood of carbon*, which is the chief cause of animal heat: and

2ndly—These gases coalesce into *water*, which greatly tempers the animal heat.

Q. *Why do we feel* LAZY *and averse to activity in very* HOT WEATHER*?*

A. 1st—Because muscular activity would increase the heat of the body, by *quickening the respiration*: and

2ndly—The food we eat in hot weather, *not being greasy*, naturally abates our desire for bodily activity.

Q. *Why do the inhabitants of tropical countries live chiefly upon rice and fruit?*

A. Rice and fruit by digestion *are mainly converted into water*, and (by cooling the blood) prevent the tropical heat from feeling so oppressive.

Q. *Why are* POOR PEOPLE *generally* AVERSE *to* CLEANLINESS*?*

A. 1st—*Cleanliness increases hunger*; and as poor people are generally *ill-fed*, they are averse to cleanliness.

2ndly—*Dirt is warm*, (thus pigs who love *warmth*, are fond of *dirt*); and as poor people are generally *ill-clad*, they like the *warmth of dirt*.

Q. *Why are* POOR PEOPLE *generally* AVERSE *to* VENTILATION*?*

A. 1st—Because ventilation *increases the oxygen of the air*,—the *combustion of food*,—and the *cravings of appetite*: and

2ndly—Ventilation *cools the air of our rooms*: poor people, therefore, (who are generally ill-clad) love the *warmth* of an ill-ventilated apartment.

Q. *Why does* FLANNEL, &c. *make us* WARM*?*

A. Flannel and warm clothing do not *make* us warm, but merely *prevent the body from becoming cold*.

Q. *How does flannel, &c. prevent the body from becoming cold?*

A. Flannel (being a bad conductor) will *neither carry off the heat of the body into the cold air*, nor suffer the cold of the air *to come into contact with our warm bodies*; and thus it is that flannel clothing keeps us warm.

Q. *Why are* FROGS *and* FISHES COLD-BLOODED *animals?*

A. Because they consume *so little air*; and without a plentiful supply of air, combustion is so slow, that very little animal heat is evolved.

Q. *Why is a* DEAD BODY COLD*?*

A. Air is no longer conveyed to the lungs after respiration has ceased; and, therefore, animal heat *is no longer evolved by combustion*.

CHAPTER VII.

MECHANICAL ACTION.

1.—PERCUSSION.

Q. *How is heat produced by* MECHANICAL ACTION*?*

A. 1.—By Percussion. 2.—By Friction. 3.—By Condensation.

Q. *What is meant by* PERCUSSION*?*

A. *The act of striking*; as when a blacksmith strikes a piece of iron on his anvil with his hammer.

Q. *Why does* BEATING IRON *make it* RED-HOT*?*

A. *Beating* the iron *condenses the particles* of the metal; and squeezes out its latent heat, as water from a sponge.

Q. *Does* COLD *iron contain* HEAT*?*

A. Yes; *every thing* contains heat; but when a thing *feels cold*, its heat is LATENT.

Q. *What is meant by* LATENT HEAT*?*

A. Heat *not perceptible to our feeling*. When anything contains *heat* without *feeling* the hotter for it, that heat is called "*latent*." (See p. 31.)

Q. *Does* COLD *iron contain latent* HEAT*?*

A. Yes; and when a blacksmith *compresses the particles* of the iron by his hammer, he *squeezes out* this latent heat, and makes the iron red-hot.

Q. *How did blacksmiths use to* LIGHT THEIR MATCHES *before the general use of lucifers?*

A. They used to place a soft iron nail upon their anvil; strike it two or three times with a hammer; and the point became *sufficiently hot to light a brimstone match*.

Q. *How can a* NAIL *(beaten by a hammer)* IGNITE *a brimstone* MATCH*?*

A. As the particles of the nail are *compressed by the hammer*, it cannot contain *so much heat as it did before*; so some of it *flies out* (as water flows from a sponge when it is squeezed).

Q. *Why does* STRIKING *a* FLINT *against a piece of* STEEL *produce a* SPARK*?*

A. The blow *condenses* those parts of the flint and steel which strike *together*, and squeezes out their latent heat.

Q. *How does this development of* HEAT *produce a* SPARK*?*

A. A very small fragment (either of the steel or flint) *is knocked off red-hot,* and sets fire to the tinder on which it falls.

Q. *Why is it needful to keep* BLOWING *the* TINDER *with the breath?*

A. Because *blowing* the tinder, drives the *oxygen of the air* towards it.

Q. *Where does the* OXYGEN *of the air* COME FROM*, which is blown to the lighted tinder?*

A. The air itself is composed of two gases (*nitrogen and oxygen*) mixed together.

(Every 5 lbs. of common air contain 4 lbs. of nitrogen, and 1 lb. of oxygen.)

Q. *What is the good of* BLOWING OXYGEN GAS *to lighted tinder?*

A. Oxygen gas *supports combustion*; and lighted tinder is *quickened by the breath*, in the same way as a dull fire is revived by a *pair of bellows*.

Q. *Why do* HORSES *sometimes* STRIKE FIRE *with their* FEET*?*

A. When iron horse-shoes strike against the flint-stones of the road, *very small fragments* (either of the shoe or stones) are *knocked off red-hot*, and look like sparks.

Q. *What makes these fragments* RED-HOT*?*

A. The percussion *condenses* the part struck, *and squeezes out its latent heat*.

CHAPTER VIII.

2.—FRICTION.
3.—CONDENSATION.

Q. *What is meant by* FRICTION*?*

A. The act of *rubbing two things together*; as the Indians rub two pieces of *wood* together to produce fire.

Q. *How do the Indians produce* FIRE*, by merely* RUBBING TWO PIECES *of dry* WOOD TOGETHER*?*

A. They take a piece of dry wood (sharpened to a point), which they rub quickly up and down a *flat piece*, till a *groove* is made; and the *saw-dust* (collected in this groove) soon *catches fire*.

Q. *Why does the saw-dust of the* WOOD CATCH FIRE *by* RUBBING*?*

A. The *latent heat* of the wood is *developed by friction*; because the particles of the wood are *squeezed closer together*, and the heat pours out, as water from a sponge.

(The best woods for this purpose are *box-wood* against *mulberry*, or *laurel* against *poplar* or *ivy*.)

Q. *Do not* CARRIAGE WHEELS *sometimes* CATCH FIRE*?*

A. Yes; if the wheels be *dry*,—or *fit too tightly*,—or *revolve very rapidly*,—they often catch fire.

Q. *Why do wheels catch fire in such cases?*

A. The *friction* of the wheels against *the axle-tree* is so great, that their *latent heat is disturbed*, and produces ignition.

Q. *What is the use of* GREASING CART WHEELS*?*

A. The grease *lessens the friction*; and (by diminishing the *friction*) the latent heat is less disturbed.

Q. *Why is the* TOP *of a* MOUNTAIN COLDER *than the* VALLEY *beneath, although it be two or three miles nearer to the sun?*

A. 1st—Because the air on a mountain is *less compressed*, than the air in a valley.

2ndly—It is *more rarefied*: and

3rdly—It is *less heated by reflection*.

Q. *Why is air* COLDER *on a mountain "because it is* LESS COMPRESSED*?"*

A. As the air in a *valley* is more compressed (by the mass of air above) than that on the top of a *mountain*, therefore *more heat runs out*; just as more water runs from a sponge, the closer it is *squeezed together*.

Q. *Why is a mountain-top* COLDER *than a valley, "because the* AIR *there is* MORE RAREFIED*?"*

A. As the air is *more rarefied*, its heat is *diffused over a larger space* and is *less* intense; just as a candle would *show less light* in a *large* room, than in a *small* one.

Q. *Why is a mountain-top* COLDER *than a valley, "because the* AIR *there is* LESS HEATED *by* REFLECTION*?"*

A. Air is *not* heated by the *sun*, but by *reflection from the surface of the earth*; and as there is *no earth* round a *mountain-top* to reflect heat, therefore the air there is intensely cold.

Q. *Why does* RUBBING *our* HANDS *and* FACES *make them feel* WARM*?*

A. Chiefly because the friction *excites the latent heat* of our hands and faces, and makes it sensible to our feeling.

Q. *When a man has been almost* DROWNED*, why is suspended animation* RESTORED *by* RUBBING*?*

A. The vital heat of the body (which had become *latent* by the action of the water) is *again developed by friction*: and, as soon as this animal heat can be excited, the vital powers of the body are restored.

Q. *Why do two pieces of* ICE *(rubbed together)* MELT*?*

A. Ice contains 140 *degrees of latent heat,* and (when two pieces are *rubbed together)* their *particles are compressed,* and this *latent heat* rolls out and *melts the ice*.

Q. *Are not* FORESTS *sometimes* SET *on* FIRE *by friction?*

A. Yes; when two branches or trunks of trees (blown about by the wind) *rub violently against each other*, their *latent heat is developed,* and sets fire to the forest.

Q. *What is meant by* COMPRESSION*?*

A. The act of *bringing parts nearer together*; as a sponge is *compressed* by being *squeezed in the hand*.

Q. *Cannot* HEAT *be evolved from common air merely by* COMPRESSION*?*

A. Yes; if a piece of *German tinder* be placed at the *bottom of a glass tube,* and the air in the tube *compressed by a piston,*[11] the tinder will catch fire.

[11] In a common syringe or squirt, the *handle* part which *contains the sucker* (and is forced up and down), is called "The Piston."

Q. *Why will the tinder catch fire?*

A. Because the *air is compressed*; and its *latent heat being squeezed out,* sets fire to the tinder at the bottom of the tube.

CHAPTER IX.

EFFECTS OF HEAT.

1.—EXPANSION.

Q. *What are the principal* EFFECTS *of* HEAT*?*

A. 1.—Expansion. 2.—Liquefaction. 3.—Vaporization. 4.—Evaporation; and 5.—Ignition.

Q. *Does* HEAT EXPAND *the* AIR*?*

A. Yes; if a bladder (partially filled with air) be tied up at the neck, and *laid before the fire*, the air will *swell* till the bladder *bursts*.

Q. *Why will the* AIR SWELL, *if the bladder be laid before the fire?*

A. Because the heat of the fire *gets between the particles of air*, and drives them *further apart from each other*; which causes the bladder to expand.

Q. *Why do unslit* CHESTNUTS CRACK *with a loud noise, when* ROASTED*?*

A. Chestnuts contain a great deal of air, which is expanded by the heat of the fire; and, as the thick rind prevents the air from escaping, it violently *bursts through, slitting the rind*, and making a great noise.

Q. *What occasions the loud* CRACK *or report which we hear?*

A. 1st—The *sudden bursting of the rind* makes a report, in the same way as a piece of *wood* or *glass* would do, if *snapped in two*: and

2ndly—The *escape of hot air* from the chestnut makes a report also, in the same way as *gunpowder*, when it escapes from a *gun*.

Q. *Why does the sudden* BURSTING *of the rind, or* SNAPPING *of a piece of wood, make a* REPORT*?*

A. As the attraction of the parts is suddenly overcome, *a violent jerk* is given to the air; this jerk produces *rapid undulations* in the air, which (striking upon the ear) give the brain the sensation of *sound*.

Q. *Why does the* ESCAPE OF AIR *from the chestnut, or the* EXPLOSION *of* GUNPOWDER*, produce a* REPORT*?*

A. Because a quantity of air (suddenly let loose) *pushes against the air around*, in order to make *room for itself*; and as the *air of the chestnut* slaps against the *air of the room*, a *report* is made, (as when I *slap* a book or table).

Q. *If a* CHESTNUT *be* SLIT, *it will* NOT CRACK*; why is this?*

A. Because the *heated air* of the chestnut can *freely escape* through the *slit in the rind*.

Q. *Why does an* APPLE *spit and* SPURT *about, when roasted?*

A. An apple contains a vast quantity of *air*, which (being expanded by the heat of the fire) *bursts through the peel*, carrying the juice of the apple along with it.

Q. *Does an* APPLE *contain* MORE AIR*, in proportion, than a* CHESTNUT*?*

A. Yes, much more. There is as much condensed air in a common apple, as would fill a space 48 *times as big as the apple itself*.

Q. *Where is all this quantity of AIR stowed in the APPLE?*

A. The *inside* of an apple is *made up of little cells* (like a *honey-comb*), each of which contains a portion of the air.

Q. *When an APPLE is ROASTED, why is one part made SOFT, while all the rest remains hard?*

A. When an apple is roasted, the air in the *cells next to the fire* is expanded and flies out; the *cells are broken*, and their juices *mixed together*; so the apple *collapses* (from loss of air and juice), and feels *soft* in those parts.

Q. *What is meant by the "apple COLLAPSING?"*

A. The *plumpness* gives way, and the apple becomes *flabby* and *shrivelled*.

Q. *Why do SPARKS of fire start (with a crackling noise) from pieces of WOOD laid upon a FIRE?*

A. The *air* in the wood (expanded by the heat), *forces its way through the pores of the log*; and carries along with it the *covering of the pore*, which resisted its passage.

Q. *What is meant by the "PORES of the WOOD?"*

A. Very small *holes in the wood*, through which the *sap* circulates.

Q. *What are the SPARKS OF FIRE, which burst from the WOOD?*

A. Very small pieces of wood *red hot*, separated from the log by the *force of the air*, as it bursts from its confinement.

Q. *Why does DEAL make more snapping than any OTHER WOOD?*

A. The pores of deal are *very large*, and contain much *more air* than wood of a *closer grain*.

Q. *Why does DRY WOOD make more SNAPPING than GREEN WOOD?*

A. In *green wood* the pores are filled with *sap*, and therefore contain *very little air*; but in *dry* wood the sap is *dried up*, and the pores are filled with *air* instead.

Q. *Why does DRY wood BURN more easily than GREEN or wet wood?*

A. Because the pores of dry wood are *filled with air*, which supports combustion; but the pores of green or wet wood are filled with *vapour*, which extinguishes flame.

Q. *Why does* VAPOUR EXTINGUISH FLAME*?*

1st—Because the coat of water (which wraps the fuel round) prevents the *oxygen* of the air from getting to the *fuel*, to form into *carbonic acid gas*: and

2ndly—Heat is perpetually carried off, by the formation of the sap or water *into steam*.

(Carbonic acid gas is a compound of carbon and oxygen. The solid part of the fuel is *carbon*, and one of the gases of the air is oxygen.)

Q. *What has* CARBONIC ACID GAS *to do with* COMBUSTION*?*

A. Combustion is produced by the *chemical action* which takes place, while the *carbon* of fuel unites with the *oxygen* of air, and forms "*carbonic acid gas*." (See p. 36.)

Q. *Why do* STONES SNAP *and fly about, when heated in the* FIRE*?*

A. The air in the stones (expanded by the heat of the fire), *meets with great resistance* from the close texture of the stone; and, therefore, *bursts forth with great violence*, tearing the stone to atoms, and forcing the fragments into the room.

Q. *Must not* AIR *be very* STRONG, *to shatter into atoms a hard stone?*

A. Yes. All the dreadful effects of *gunpowder* are merely the results of the *sudden expansion of air*.

Q. *When bottled* ALE *and* PORTER *is set before a* FIRE, *why is the* CORK FORCED OUT *sometimes?*

A. If the bottle be *not quite full*, there will be *air* between the liquor and the cork; this *air* (expanded by the heat of the fire) *forces out the cork*.

Q. *Why does* ALE *or* PORTER FROTH *more, after it has been set before the fire?*

A. The *froth* of ale or porter *depends upon the pressure* to which it is subjected; and as the air (between the liquor and the cork) is *expanded* by the heat, *it presses against the liquor*, and increases the quantity of froth.

Q. *Why is the* FROTH *of ale and porter* INCREASED *by* PRESSURE*?*

A. Because the liquor absorbs *carbonic acid* so long as it is under *pressure*; and the moment that the pressure is *removed*, the carbonic acid *escapes* in foam or froth.

Q. *When a boy makes a* BALLOON, *and sets fire to the cotton or sponge (which has been steeped in spirits of wine), why is the balloon* INFLATED, *or blown out?*

A. The *air* inside the balloon is *expanded by the flame*, till the whole balloon is *blown out* without a crumple.

Q. *Why does the BALLOON RISE, after it has been inflated by the expanded air?*

A. The same quantity of air is expanded *to three or four times its original volume*; and is made so much *lighter than common air*, that even when all the paper, wire, and cotton are added, it is still lighter bulk for bulk.

Q. *What is meant by being lighter "bulk for bulk?"*

A. If the balloon be 3 square feet in size, it is *lighter* (when inflated) than 3 square feet of *common air*, and therefore *floats through it*; as a cork (at the bottom of a tub of water) would rise to the surface.

Q. *Why does SMOKE RUSH UP a CHIMNEY?*

A. The heat of the fire *expands the air in the chimney*; and (being thus made *lighter* than the air around), it *rises up the chimney*, and carries the smoke in its current.

Q. *Why has a LONG CHIMNEY a greater DRAUGHT than a short one?*

A. Because air rises faster and faster the *higher it ascends* in a chimney flue; the same as a stone falls faster and faster the *nearer it approaches to the ground*.

Q. *Why will a LONG chimney SMOKE, unless the FIRE be pretty FIERCE?*

A. If the fire be not pretty fierce, its heat will not be sufficient to *rarefy all the air in the chimney*; and then the chimney will *smoke*.

Q. *Why will the chimney smoke, if the fire be not BIG enough to heat ALL the air in the CHIMNEY FLUE?*

A. Because the *cold air* (condensed in the upper part of the flue), *will sink from its own weight*, and sweep the ascending smoke *back with it* into the room.

Q. *What is the use of a COWL upon a chimney-pot?*

A. The cowl acts as a *screen against the wind*, to prevent it from blowing into the chimney.

Q. *What HARM would the WIND do, if it were to BLOW into a CHIMNEY?*

A. 1st—It would prevent the smoke from getting out: and

2ndly—The *cold air* (introduced into the chimney by the wind) *would fall down the flue*, and drive the smoke with it *back into the room*.

Q. *Why does a SMOKE-JACK turn round in a chimney?*

A. The current of hot air up the chimney, striking against the *oblique vanes of the smoke-jack*, drives them round and round; in the same way as the sails of a *wind-mill* are driven round by the *wind*.

Q. *Why are some things SOLID, others LIQUID, and others GASEOUS?*

A. As *heat* enters any substance, *it drives its particles further asunder*; and a *solid* (like *ice*) becomes a *liquid*; and a *liquid* (like *water*) becomes a *gas*.

Q. *Why does WATER SIMMER before it boils?*

A. The particles of water *near the bottom of the kettle* (being formed into *steam* sooner than the rest) *shoot upwards*; but are *condensed* again (as they rise) *by the colder water*, and produce what is called “simmering.”

Q. *What is meant by SIMMERING?*

A. A gentle tremor or *undulation* on the surface of the water. When water *simmers*, the bubbles *collapse beneath the surface*, and the steam is condensed to *water again*: but when water *boils*, the bubbles *rise to the surface*, and *steam is thrown off*.

Q. *Why does a KETTLE SING when the water simmers?*

A. Because the *air* (entangled in the water) escapes by *fits and starts* through the *spout of the kettle*; which makes a noise like a wind instrument, when it is blown into.

Q. *Why does NOT a kettle SING, when the water BOILS?*

A. As *all* the water is *boiling hot*, the steam meets with no *impediment*, but freely escapes in a continuous stream.

Q. *When does a kettle sing most?*

A. When it is set on a *hob* to boil.

Q. *Why does a kettle SING MORE when it is set on the SIDE of a fire, than when it is set in the MIDST of the fire?*

A. When the kettle is set on the *hob* to boil, the heat is applied very *partially: one side is hotter than the other*, and therefore the steam is more *entangled*.

Q. *Why does a KETTLE sing, when the boiling water begins to COOL again?*

A. Because the *upper* surface cools *first*; and the steam (still rising from the lower parts of the kettle) is *again entangled*, and escapes fitfully.

Q. *Why does* BOILING WATER SWELL*?*

A. Water (like air) *expands by heat*. The heat of the fire drives the particles of water *further apart from each other*; and (as they are not *packed so closely together*) they take up *more room*; or (in other words) the water *swells*.

Q. *What is meant when it is said, "that* HEAT *drives the* PARTICLES *of water further* APART *from each other."*

A. Water is composed of little globules, like very small grains of sand; the heat *drives* these particles *away from each other*; and (as they then require more *room*) the water *swells*.

Q. *Why does* BOILING WATER BUBBLE*?*

A. Water contains *air*; and (as the water is heated) *the air is driven out*, and raises a *bubble* in that part of the water which resists its escape.

Q. *Why does a* KETTLE *sometimes* BOIL OVER*?*

A. Liquids *expand very much by heat*; if, therefore, a kettle be *filled with cold water*, some of it must *run over* as soon as it is *expanded by heat*.

Q. *But I have seen a* KETTLE BOIL OVER*, although it has not been filled* FULL *of* WATER*; how do you account for* THAT*?*

A. If a fire be *very fierce*, the air is expelled so *rapidly*, that the *bubbles are very numerous*; and (towering one above the other) *reach the top of the kettle, and fall over*.

Q. *Why is a pot, which is full to* OVERFLOWING *(while the water is boiling* HOT*),* NOTHING LIKE FULL*, when it has been taken off the fire for a short time?*

A. When the water was *swelled by boiling heat*, it filled the pot even to overflowing; but as soon as the water is *condensed by cold*, it *contracts* again, and occupies a much less space.

Q. *Why does the water of a* KETTLE *run out of the* SPOUT *when it* BOILS*?*

A. Because the steam cannot escape *so fast as it is formed*, and (being *confined in the kettle*) *presses on the water with great power*, and forces it out of the spout.

Q. *How can the* PRESSURE *of* STEAM *on the* SURFACE *of the water,* FORCE *the water through the* KETTLE-SPOUT*?*

A. In the same manner as *the pressure of air* on the *mercury of a barometer*, forces the *quicksilver up the glass tube*.

Q. *What causes the* RATTLING NOISE *so often made by the* LID *of a saucepan or boiler?*

A. The steam (seeking to escape) *forces up the lid* of the boiler, and the *weight* of the lid causes it to *fall back again*: this being done *frequently*, produces a rattling noise.

Q. *If the steam* COULD NOT LIFT UP THE LID *of the boiler, how would it escape?*

A. If the lid fitted so tightly, that the steam could not raise it up, the boiler would *burst into fragments*, and the consequences might be fatal.

Q. *When steam pours out from the spout of a kettle, the* STREAM *begins apparently* HALF AN INCH *off the* SPOUT*; why does it not begin* CLOSE *to the spout?*

A. Steam is really *invisible*; and the half-inch (between the spout and the "*stream of mist*") is the *real steam*, before it has been condensed by air.

Q. *Why is not* ALL *the stream* INVISIBLE*, as well as that half-inch?*

A. As the steam *comes in contact with the colder air*, the invisible particles (being *condensed*), roll one into another, and look like a thick mist.

Q. *What* BECOMES OF *the* STEAM*? for it soon vanishes.*

A. After it is condensed into mist, it is *dissolved by the air*, and dispersed abroad as *invisible vapour*.

Q. *And what* BECOMES *of the* INVISIBLE VAPOUR*?*

A. Being *lighter than air*, it *ascends* to the upper regions, where (being again *condensed*) it contributes to form *clouds*.

Q. *Why does a* METAL SPOON*, left in a saucepan,* RETARD *the process of* BOILING*?*

A. The metal spoon (being an excellent *conductor*) *carries off the heat from the water*; and (as heat is carried off by the spoon) the water takes a longer time to boil.

Q. *Why will a* POT *(filled with water)* NEVER BOIL*, when immersed in* ANOTHER *vessel full of water also?*

A. Because water can *never be heated above the boiling point*: all the heat absorbed by the water after it *boils*, is employed in *converting the water into steam*.

Q. *How does the conversion of water into steam prevent the* INNER POT *from* BOILING*?*

A. The moment the water in the larger pot is *boiling hot* (or 212°), *steam is formed*, and *carries*

off some of its heat; therefore, 212 *deg*$^{s.}$ of heat can never *pass through it*, to raise the *inner* vessel to the *same heat*.

Q. *Why do* SUGAR, SALT, &c. RETARD *the process of* BOILING*?*

A. Because they have a tendency to *fix* water by chemical attraction; and therefore retard its *conversion into steam*.

Q. *If you want water to boil, without* COMING IN CONTACT *with the* SAUCEPAN, *what plan must you adopt?*

A. *Immerse the pot* (containing the water you want to boil) in a saucepan containing *strong brine*, or sugar.

Q. *Why would the* INNER *vessel boil, if the* OUTER *vessel contained strong* BRINE*?*

A. Though *water* boils at 212 *deg*$^{s.}$ of heat, yet *brine* will not boil till raised to 218 or 220 *deg*$^{s.}$ Therefore, 212 *deg*$^{s.}$ of heat may easily pass through brine *to raise the vessel immersed in it to boiling heat*, before any of it is *carried off by steam*.

Q. *Why will brine impart to another vessel* MORE *than 212°, and water* NOT SO MUCH*?*

A. Because both liquids will *impart heat* till they *boil*, and then *they can impart heat no longer*.

Q. *Why can they impart no extra heat after they boil?*

A. Because all *extra* heat is spent *in making steam*. Hence water will *not* boil a vessel of water immersed in it, because it cannot impart to it 212 *deg*$^{s.}$ of heat: but *brine* will, because it can impart *more than* 212 *deg*$^{s.}$ *of heat*, without being converted itself into steam.

Ether boils at	104 *deg*$^{s.}$
Alcohol boils at	173-1/2 *deg*$^{s.}$
Water boils at	212 *deg*$^{s.}$
Water with one-fifth salt at	219 *deg*$^{s.}$
Syrup boils at	221 *deg*$^{s.}$
Oil of turpentine at	304 *deg*$^{s.}$
Sulphuric acid at	472 *deg*$^{s.}$
Linseed oil at	640 *deg*$^{s.}$
&c. &c.	

Any liquid which boils at a *lower* degree can be made to boil if immersed in a liquid which boils at a higher degree. Thus a *cup of ether* can be made to boil in a saucepan of *water*. A *cup of water* in a saucepan of *brine or syrup*. But a *cup of water* will *not* boil if immersed in *ether*; nor a *cup of syrup* in *water*.

Q. *Why are* CLOUDS HIGHER *on a* FINE DAY*?*

A. 1st—Because the *air* (expanded by heat) *drives them higher up*: and

2ndly—The *clouds themselves are lighter*, and therefore *more buoyant*.

Q. *Why are the* CLOUDS LIGHTER *on a* FINE DAY*?*

A. Because their mists are either *absorbed by the dry air*, or *vapourized* by the hot sun.

Q. *Why is a* CUP PUT *topsy-turvy into a* FRUIT-PIE*?*

A. Its principal use is to *hold the crust up*, and *prevent it from sinking*, when the cooked fruit gives away under it.

Q. *Does not the cup* PREVENT *the* FRUIT *of the pie from* BOILING OVER*?*

A. No, by no means; it would rather tend to *make it boil over*, than otherwise.

Q. *Why would the cup tend rather to* MAKE *the* FRUIT BOIL OVER*?*

A. As soon as the pie is put into the oven, the *air* in the cup will *begin to expand*, and drive every particle of juice from under it; the pie dish, therefore, will have a cup-full *less room* to hold its fruit, than if the cup were *taken out*.

Q. *If the juice is driven* OUT *of the cup, why is the* CUP *always* FULL *of* JUICE*, when the pie is cut up?*

A. Immediately the pie is drawn, the *air* in the cup begins to *condense again*, and *occupy a smaller space*; in consequence of which, there is no longer *enough air to fill the cup*, and so *juice* rushes in *to fill up the deficiency*.

Q. *Why does* JUICE *rush into the cup, because the cup is* NOT FULL *of* AIR*?*

A. As the external air *presses upon the surface of the juice*, it rushes into the cup *unobstructed*; as mercury rises through the tube of a barometer through similar pressure.

CHAPTER X.
EXPANSION FROM HEAT.
(Continued.)

Q. *Does heat expand every thing* ELSE BESIDES *air and water?*

A. Yes; *every* thing (that man is acquainted with) is expanded by heat.

Q. *Why does a* COOPER *make his* HOOPS RED-HOT, *when he puts them on a tub?*

A. 1st—As *iron expands by heat*, the hoops will be *larger* when they are red-hot; and will, therefore, *fit more easily on the tub*: and

2ndly—As *iron contracts by cold*, the hoops will *shrink* as they cool down, and *girt the tub with a tighter grasp*.

Q. *Why does a* WHEELWRIGHT *make his hoops* RED-HOT, *which he fixes on the* NAVE *of a* WHEEL*?*

A. 1st—That they may *fit on more easily*: and

2ndly—That they may *girt the nave more tightly*.

Q. *Why will the wheelwright's* HOOP FIT *the nave* MORE EASILY, *because they are made* RED-HOT*?*

A. As *iron expands by heat*, the hoops will be *larger* when they are hot; and (being larger) will go on the nave more *easily*.

Q. *Why will the* HOOPS, *which have been* PUT ON HOT, *girt the nave more* FIRMLY*?*

A. As *iron contracts by cold*, the hoops will *shrink as they cool down*; and, therefore, *girt the nave with a tighter grasp*.

Q. *Why does a farrier put the* HORSE-SHOE *on* HOT*?*

A. That it may *stick the closer*, when it has contracted by cold.

Q. *Why does a* STOVE *make a* CRACKING NOISE, *when a fire is very hot?*

A. The iron stove *expands by heat*, and (as it swells) the parts rub both *against each other*, and *against the bricks around*, driving them further off; and this produces a *cracking* noise.

Q. *Why does a* STOVE *make a similar* CRACKING NOISE, *when a large* FIRE *is* TAKEN DOWN*?*

A. The iron stove *contracts again*, as soon as the fire is removed; and (as it shrinks into a smaller space) the parts *rub against each other again*, and the *bricks are again disturbed*; and this produces a cracking noise.

Q. *Why does the* PLASTER *round a* STOVE CRACK *and fall away?*

A. When the fire is lighted, *the iron-work* (which expands more than the brick-work and plaster) *pushes away the bricks and plaster*: but when the fire is put out, the metal *shrinks* again, and *leaves the "setting" behind*.

Q. *Why does the* PLASTER FALL AWAY*?*

A. As a *chink* is left (between the “setting” and the stove), the plaster will frequently fall away *from its own weight*.

Q. *What* OTHER *cause contributes to* BRING *the* PLASTER DOWN*?*

A. As the *heat of the fire* varies, the *size of the iron stove* varies also; and this swelling and perpetually contracting, keeps up such a *constant disturbance about the plaster*, that it *cracks and falls off*, leaving the fire-place very unsightly.

Q. *Why does the* MERCURY *of a* THERMOMETER RISE *in hot weather?*

A. Heat *expands the metal*; and as the metal is *increased in bulk*, it occupies a *larger space*, (or, in other words, rises higher in the tube.)

Q. *Why is a* GLASS BROKEN, *when* HOT WATER *is poured into it?*

A. Because the *inside of the glass* is expanded by the hot water, and *not the outside*; so the glass *snaps* for want of *flexibility*.

Q. *Why is not the* OUTSIDE *of the* GLASS *expanded by the hot water, as well as the* INSIDE*?*

A. Glass is a *non-conductor of heat*; and, therefore, *breaks* before the heat of the *inner surface* is *conducted to the outside*.

Q. *Why does a* GLASS *snap, because the* INNER *surface is* HOTTER *than the* OUTER*?*

A. *Glass is expanded by heat*; and as the inner surface expands, *it stretches the outer surface till it snaps*.

Q. *Why is a* CHINA CUP *broken, if* HOT WATER *be poured over it, or into it?*

A. China is a *non-conductor*; and, as the *inner surface expands by the heat*, before the *outer one*, *it forms an arch*, and pulls the parts of the cup asunder.

Q. *Why does the* BOTTOM COME OFF, *if a* GLASS BEAKER *be set on a warm* HOB*?*

A. Glass is a *non-conductor*; and, as the *bottom of the glass* (from the warmth of the hot stove) *expands, before the sides are heated*, the two parts *separate* the one from the other.

CHAPTER XI.

2.—LIQUEFACTION.
3.—VAPORIZATION.

Q. *What is meant by* LIQUEFACTION*?*

A. The *state of being melted*; as ice is melted by the heat of the sun.

Q. *Why is* ICE MELTED *by the* HEAT *of the* SUN*?*

A. The *heat of the sun* (entering the solid ice) *forces its particles asunder*, till their attraction of cohesion is sufficiently overcome, to *convert the solid ice into liquid*. (See p. 112.)

Q. *Why are* METALS MELTED *by the heat of* FIRE*?*

A. The *heat of the fire* (entering the solid metal) *forces its particles asunder*, till their attraction of cohesion is sufficiently overcome, to *convert the solid metal to a liquid*.

Q. *Why is* WATER *converted to* STEAM *by the heat of* FIRE*?*

A. The *heat of the fire* (entering the water) *divides its globules into very minute bubbles*, which (being made lighter than air) fly off from the surface *in the form of steam*.

Q. *Why does not* WOOD MELT*, like metal?*

A. Because the heat of the fire *decomposes* the wood into *gas, smoke, and ashes*; and the different parts *separate from each other*.

Q. *What is meant by* VAPORIZATION*?*

A. The *conversion of liquid into vapour*; as water is converted into vapour by the heat of the sun.

Q. *What are* CLOUDS*?*

A. Moisture *evaporated from the earth*, and collected in the upper regions of the air.

Q. *What is the difference between a* FOG *and a* CLOUD*?*

A. Clouds and fogs differ only in one respect. *Clouds are elevated above our heads*: but *fogs come in contact with the surface of the earth*.

Q. *If clouds are water, why do they float on the air?*

A. 1st—The vapour of clouds is composed of *very minute bubbles* (called ves'icles), which float like *soap bubbles*: and

2ndly—Warm air (between the bubbles) *keeps them apart*, and makes the mass *lighter*; and the currents of air (which constantly ascend from the warm earth) *buoy them up*.

Q. *Why does vapour sometimes form into clouds, and sometimes rest upon the earth as mist or fog?*

A. When the *surface of the earth* is *warmer than the air*, the vapour of the earth (being condensed by the chill air) becomes *mist or fog*. But when the *air* is *warmer than the earth*, the vapour *rises through the air*, and becomes cloud.

Q. *Are all clouds alike?*

A. No. They vary greatly in *density, height, and colour*.

Q. *What is the chief cause of fog and clouds?*

A. The changes of the wind.

Q. *How can the changes of the wind affect the clouds?*

A. If a *cold current of wind* blows suddenly over any region, it *condenses* the invisible vapour of the air into *cloud or rain*: but if a *warm current of wind*, blows over any region, it *disperses* the clouds, by *absorbing their vapour*.

Q. *What* countries *are the* most cloudy?

A. Those where the winds are *most variable*, as Britain.

Q. *What countries are the least cloudy?*

A. Those where the winds are *not variable*, as Egypt.

Q. *What distance are the clouds from the earth?*

A. Some *thin light clouds* are elevated above the highest mountain-top; some *heavy* ones touch the steeples, trees, and even the earth: but the *average* height is between *one and two miles*.

(Streaky curling clouds, *like hair*, are often five or six miles high.)

Q. *What clouds are the lowest?*

A. Those that are *most highly electrified*: lightning clouds are rarely more than about 700 yards above the ground; and very often actually *touch the earth with one of their edges*.

Q. *What is the* THICKNESS *of the* CLOUDS*?*

A. Some clouds are 20 *square miles in surface*, and above *a mile in thickness*; while others are only a *few yards or inches*.

Q. *How can persons ascertain the thickness of a cloud?*

A. As the *tops of high mountains* are generally *above the clouds*; therefore, travellers (who climb the mountains) may *pass quite through the clouds*, into a clear blue firmament, when they may see the clouds *beneath their feet*.

Q. *Why are the* CLOUDS *so* VARIABLE *in* SHAPE*?*

A. The *shape* of clouds depends upon two things:—Their state of *electricity*, and *the wind*.

Q. *How can* ELECTRICITY *affect the* SHAPE *of* CLOUDS*?*

A. If one cloud be *full of electricity*, and another *not*, they will be *attracted to each other*, and either coalesce,—diminish in size,—or vanish altogether.

Q. *Which clouds assume the most* FANTASTIC *shapes?*

A. Those that are the most *highly electrified*.

Q. *What effect have* WINDS *on the* SHAPE *of* CLOUDS*?*

A. They sometimes *absorb them entirely*: sometimes *increase their volume and density*; and sometimes *change the position of their parts*.

Q. *How can* WINDS ABSORB CLOUDS *altogether?*

A. *A warm dry wind* will convert the substance of the clouds into *invisible vapour*, and carry it in its own current.

Q. *How can* WINDS INCREASE *the bulk and density of* CLOUDS*?*

A. A *cold* current of wind will *condense the invisible vapour of the air*, and *add it to the clouds* as it passes by.

Q. *How can* WINDS CHANGE *the* SHAPE *of* CLOUDS *by altering the position of their parts?*

A. Because clouds are so voluble and light, that every breath of wind changes the position of those ves'icles or bubbles.

Q. *What are the general* COLOURS *of the* CLOUDS*?*

A. White and grey, *when the sun is above the horizon*: but red, orange, and yellow, *at sun-rise and sun-set*.

The *blue sky* cannot be considered as *clouds* at all.

Q. *Why are the* LAST CLOUDS *of* EVENING *generally of a* RED *tinge?*

A. Because *red* rays are the *least refrangible of all*; and, therefore, *are the last to disappear*.

Q. *What is meant by being "*LESS REFRANGIBLE*"?*

A. Being *less able to be bent*. Blue and green rays being very easily bent (*by the resistance of the air*) are thrown *off from the horizon*; but red rays not being *bent back* in the same way, give a tinge to the evening clouds.

Q. *Why are* MORNING CLOUDS *generally of a* RED *tinge?*

A. Because red rays are the *least refrangible of all*, and not being *bent back by the air* (like blue and green), *strike upon the horizon*, and give a tinge to the morning clouds.

Q. *Why is not the reflection of clouds always* ALIKE*?*

A. Because their *size, density, and situation in regard to the sun*, vary perpetually; so that sometimes *one* colour is reflected, and sometimes *another*.

Q. *What regulates the* MOTION *of the* CLOUDS*?*

A. The *motion of the clouds* is generally directed by the *winds*; but sometimes *electricity* will influence their motion also.

Q. *How do you know that* CLOUDS *move by* OTHER *influences besides* WIND*?*

A. Because we often see in calm weather *small clouds meeting each other* from opposite directions.

Q. *How do you know that* ELECTRICITY *affects the motion of the clouds?*

A. Because clouds often meet from *opposite directions*; and (after they have discharged their

opposite electricities into each other) *vanish altogether*.

Q. *Into how many* CLASSES *are the different sorts of* CLOUDS *generally divided?*

A. Into three classes:—viz. Simple, Intermediate, and Compound.

Q. *How are* SIMPLE CLOUDS *sub-divided?*

A. 1.—Cirrus. 2.—Cum'ulus; and 3.—Stra'tus.

Q. *What are* CIRRUS CLOUDS*?*

A. Clouds like *fibres*, *loose hair*, or *thin streaks*, are called cirrus clouds.

Q. *Why are these clouds called* CIRRUS*?*

A. From the Latin word, *cirrus* ("a lock of hair, or curl"): they are the most *elevated of all clouds*.

Q. *What do* CIRRUS *clouds* PORTEND*?*

A. When the streamers point *upwards*, the clouds are *falling*, and *rain is at hand*: but when the streamers point *downwards*, expect easterly wind or drought.

Q. *What are* CUM'ULUS CLOUDS*?*

A. Cum'ulus clouds are lumps like great *sugar-loaves*,—*volumes of smoke*,—or *mountain towering over mountain*.

Q. *Why are these monster masses called* CUM'ULUS CLOUDS?

A. From the Latin word, *cum'ulus* (a mass or pile).

Q. *What do* CUM'ULUS *clouds* FORESHOW?

A. When these piles of cloud are *fleecy*, and sail *against the wind*, they indicate *rain*; but when their outline is very *hard*, and they come up *with the wind*, they foretell *fine weather*.

Cumulus clouds should be *smaller* towards evening than they are at noon. If they *increase* in size at sun-set, a thunder-storm may be expected in the night.

Q. *What are* STRA'TUS CLOUDS?

A. Creeping mists, especially prevalent in a summer's evening: these clouds rise at sun-set *in low*

damp places, and are always *nearer the earth*, than any *other* sort of cloud.

Q. *Why are these mists called* STRA'TUS *clouds?*

A. From the Latin word, *stra'tus* ("laid low," or "that which lies low").

Q. *How are the* INTERMEDIATE CLOUDS *sub-divided?*

A. Into two sorts. 1.—The Cirro-Cum'ulus; and 2.—The Cirro-Stra'tus.

Q. *What are* CIRRO-CUM'ULUS CLOUDS*?*

A. When *cirrus* clouds spring from a *massy centre*; or when *heavy masses of cloud* terminate at their edges in *long streaks*, or what are called "*mares' tails*."

A system of small round clouds may be called cirro-cum'ulus.

Q. *What do* CIRRO-CUM'ULUS *clouds generally* FOREBODE*?*

A. Continued drought, or hot dry weather.

Q. *What are* CIRRO-STRA'TUS CLOUDS*?*

A. They compose what is generally called a "*mackarel sky*." This class of clouds always indicate *rain and wind*; hence the proverb—

"Mackarels' scales and mares' tails
Make lofty ships to carry low sails."

Q. *How are* COMPOUND CLOUDS *sub-divided?*

A. Compound clouds are also sub-divided into two sorts. 1.—The Cum'ulo-stra'tus; and 2.—The Nimbus.

Q. *What is meant by* CUM'ULO-STRA'TUS *clouds?*

A. Those clouds which assume all sorts of *gigantic fancy forms*; such as vast towers and rocks,—huge whales and dragons,—scenes of battle,—and cloudy giants. This class of clouds is the most romantic and strange of all.

Q. *What do the cumulo-stratus clouds foretell?*

A. *A change of weather*; either from fine to rain, or from rain to fine weather.

Q. *What are* NIMBUS CLOUDS*?*

A. Nimbus is the Latin word for “clouds which bring a storm;” and all clouds from which *rain falls* are so named.

Q. *What* APPEARANCE *takes place in the* CLOUDS *at the approach of* RAIN*?*

A. The *cum’ulus* cloud becomes *stationary*, and *cirrus streaks settle upon it*, forming cumulo-stratus clouds; which are *black* at first, but afterwards of a *grey* colour.

Q. *Why do* CLOUDS *gather* ROUND MOUNTAIN-TOPS*?*

A. Because (as they float along) *they dash against the mountains*; and (being *arrested* in their motion) collect round the top.

Q. *What is the* USE *of* CLOUDS*?*

A. 1st—They act as screens to arrest *the radiation of heat from the earth*:

2ndly—They temper the heat of the *sun’s rays*: and

3rdly—They are the great *store-houses of rain*.

Q. *Why is* WIND *said to* BLOW UP *the* CLOUDS*?*

A. When a *dry* wind travels over sea, and accumulates *more* vapour than the air can *sustain*, it *relinquishes a part* (as it flies along) in the form of clouds.

Q. *Why does* WIND *sometimes* DRIVE AWAY *the* CLOUDS*?*

A. When wind travels over *dry climes* or *thirsty deserts*, it becomes *so dry itself*, that it absorbs vapour from the clouds, and *disperses* them.

Q. *What is the* CAUSE *of a* RED SUN-SET*?*

A. Because the vapour of the air is not *actually condensed into clouds*, but only on the *point of being condensed*; in which state it bends the *red rays of the sun towards the horizon*, where they are reflected at sun-set.

Q. *Why is a* RED SUN-SET *an indication of a* FINE DAY *to-morrow?*

A. Because (notwithstanding the cold of sun-set) the vapours of the earth are *not condensed into clouds*. Our Lord referred to this prognostic in the following words: “When it is evening ye say, it will be fair weather, for the sky is red.” (Matt. xvi. 2.)

Q. *What is the cause of a coppery* YELLOW SUN-SET*?*

A. Because the vapour of the air is *actually condensed into clouds*; in which case it "refracts" (or bends) the *yellow rays of the sun towards the horizon*, where they are reflected at sun-set.

Q. *Why is a* YELLOW SUNSET *an indication of* WET*?*

A. Because the vapours of the air *are already condensed into clouds*; rain, therefore, may be shortly expected.

Q. *What is the cause of a* RED SUN-RISE*?*

A. Vapour in the upper region of the air *just on the point of being condensed*.

Q. *Why is a* RED *and* LOWERING *sky at* SUNRISE *an indication of a* WET DAY*?*

A. Because the higher regions of the air are *laden with vapour*, on the very *point of condensation*, which the rising sun cannot disperse. Hence our Lord's observation, "In the morning (ye say) it will be foul weather to-day, for the sky is red and lowering." (Matt. xvi. 3.)

Q. *Why is a* GREY MORNING *an indication of a* FINE DAY*?*

A. Because *that* air alone *contiguous to the earth* is damp and full of vapour. There are no vapours in the *higher* regions of the air *to reflect red rays*; and hence the morning-light looks grey.

Q. *What difference (in the state of the air) is required, to make a* GREY *and* RED SUNRISE*?*

A. In a *grey* sunrise, only that portion of air *contiguous to the earth is filled with vapour*; all the rest is clear and dry. But in a *red* sunrise the air in the *upper regions* is so full of vapour that the rising sun cannot disperse it.

Q. *Why is a* GREY SUNSET *an indication of* WET*?*

A. If the air on the *surface of the earth* be very *damp at sunset*, it is a proof that the air is *saturated with vapour*, and wet may be expected: hence the proverb—

"Evening red and morning grey
Will set the traveller on his way;
But evening grey and morning red
Will bring down rain upon his head."

Q. *The proverb says, "A* RAINBOW *in the* MORNING *is the shepherd's* WARNING*:" why is it so?*

A. A rainbow can only be formed *when the clouds* (containing or dropping rain) *are opposite the sun*: a *morning* rainbow, therefore, is *always in the west*, and indicates that bad weather is *on the road to us*.

Q. *Why does a* RAINBOW *in the* WEST *indicate that* BAD WEATHER *is on the road to us?*

A. Because our heavy rains are usually *brought by west or south-west winds*; and, therefore, clouds which reflect the colour of the rainbow *in the west*, are coming up *with the wind*, bringing rain with them.

Q. *The proverb says, "A* RAINBOW *at* NIGHT, *is the shepherd's* DELIGHT; *" why is it so?*

A. As a rainbow is always *opposite to the sun*, therefore a rainbow at *night* is in the *east*, and indicates that bad weather is *leaving us*.

Q. *Why does a* RAINBOW *in the* EAST *indicate that bad weather is* LEAVING *us?*

A. As *west* and *south-west* winds bring *rain*, if the clouds have been driven *from the west to the east*, they have passed *over us*, and are going *away from us*.

Q. *What is meant by an* AURORA BOREA'LIS, *or northern light?*

A. A *luminous white cloud* in the *north of the sky* at night-time. Sometimes streaks of blue, purple, and red,—and sometimes flashes of light, are seen also.

In our island this phenomenon generally rises from a dark cloud (running from the north to the east and west) elevated about 10 or 20 degrees above the horizon: above this dark bed of clouds the luminous white light appears.

Q. *What is the* CAUSE *of the* AURORA BOREALIS, *or northern light?*

A. *Electricity* in the clouds.

Q. *Why is the* AURORA BOREALIS *generally a* WHITE *light?*

A. Because the electric fluid passes through air *extremely rarefied*: and whenever electric fluid passes through *air much rarefied*, it always produces a *white light*.

Q. *Why are there sometimes* DIFFERENT COLOURS *in the aurora borealis, such as yellow, red, and purple?*

A. Because the electric fluid passes through *air of different densities*. The most *rarefied air* produces a *white light*; the most *dry air, red*; and the most *damp* produces *yellow* streaks.

Q. *Does the* AURORA BOREALIS *forbode fine weather or* WET?

A. When its *corruscations are very bright*, it is generally followed by stormy moist unsettled weather.

Q. *Why does a* HAZE *round the* SUN *indicate* RAIN*?*

A. Because the *haze* is caused by *very fine rain falling in the upper regions of the air*; when this is the case, a *rain* of 5 *or* 6 *hours continuance*, may be expected.

Q. *Why is a* HALO *round the* MOON *a sure indication of* RAIN*?*

A. Because the halo is caused by *fine rain falling in the upper regions of the air*. The *larger* the halo the *nearer the rain-clouds*, and the sooner may rain be expected.

Q. *Why does a* BLACK MIST *bring* WET *weather?*

A. The mist is *black*, because it is *overshadowed by dense clouds* or masses of vapour; and, therefore, it forebodes wet.

Q. *Why does a* WHITE MIST *indicate* FINE *weather?*

A. The mist is *white*, because *no clouds blacken it with their shadow*; and (as the sky is cloudless) *fine weather* may be expected.

Q. *Why do we* FEEL *almost* SUFFOCATED *in a hot cloudy night?*

A. Because the heat of the earth (being unable to escape into the upper region of the air, in consequence of the clouds) *floats*, like a sea of heat, *on the surface of the earth*.

Q. *Why do we feel more* SPRIGHTLY *in a clear bright night?*

A. Because the heat of the earth can readily escape into the upper regions of the air, and is not confined and *pent-in by thick clouds*.

Q. *Why do we* FEEL DEPRESSED *in* SPIRITS *on a* WET *murky* DAY*?*

A. 1st—Because when the air is laden with vapour, *it has less oxygen*.

2ndly—The air being lighter than usual, *does not balance the air in our body*: and

3rdly—Moist air has a tendency to relax the nervous system.

Q. *What is meant by the "air balancing the air" in our body?*

A. The human body is filled with air of the same density as that around: if, therefore, we ascend into *purer air*, or descend into *denser air*, the balance is destroyed, and *we feel oppressed and suffocated*.

Q. *Why do we feel* OPPRESSED *and* SUFFOCATED *if the air around is not of the* SAME DENSITY *as that in*

our body?

A. If the air around be more dense, it will *squeeze our body in* by its weight: if it be *less* dense, the air in our body will *blow us out*.

Q. *Why do* PERSONS *who* ASCEND *in* BALLOONS FEEL PAIN *in their eyes, ears and chest?*

A. Because the air in the upper regions is *more rare* than the *air in their bodies*; and (till the *equilibrium is restored*) great pain is felt in all the more sensitive parts of the body.

Q. *Why do* PERSONS *who* DESCEND *in* DIVING-BELLS FEEL PAIN *in their eyes, ears and chest?*

A. Because the air in the sea is *more dense* than the air in their bodies; and (till the *equilibrium is restored*) great pain is felt in all the more sensitive parts of the body.

Q. *Why does the* SEA HEAVE *and* SIGH *just* PREVIOUS *to a* STORM*?*

A. The density of the air (just previous to a storm) is *very suddenly diminished*, but the air in the sea is *not so quickly affected*; therefore the sea heaves and sighs *in its effort to restore an equilibrium*.

Q. *Why is the* AIR *so universally* STILL *just* PREVIOUS *to a* TEMPEST*?*

A. Because the air is *suddenly and very greatly rarefied*; and (as the *density of the air is diminished*) its power *to transmit sound is diminished also*.

Q. *How do you* KNOW *that* RAREFIED *air* CANNOT TRANSMIT SOUND *so well as dense air?*

A. Because the *sound of a bell* (in the receiver of an air-pump) *cannot be heard at all*, after the air has been partially exhausted; and a pistol *fired on a high mountain* would not sound louder than a *common cracker*.

Q. *Why do we* FEEL BRACED *and* LIGHT-HEARTED *on a* FINE *spring or* FROSTY *morning?*

A. 1st—Because there is *more oxygen* in the air on a fine frosty morning, than there is on a wet day: and

2ndly—A brisk and frosty air has a tendency to *brace* the nervous system.

Q. *Why do* DOGS *and* CATS *(confined to a room) feel* LAZY *and* DROWSY *at the approach of rain?*

A. 1st—Because the air does not contain *its full proportion of oxygen*: and

2ndly—Because the damp *relaxes their nervous system*, and makes them drowsy.

Q. *Why do* HORSES *neigh,* CATTLE *low,* SHEEP *bleat, and* ASSES *bray, at the approach of rain?*

A. 1st—As the air does not contain its full proportion of *oxygen*, they feel a *difficulty in breathing*: and

2ndly—As damp *relaxes their nerves*, they feel languid and uneasy.

Q. *Why do* CANDLES *and* FIRES *burn with a* BLUER FLAME *in* WET *weather?*

A. As the air contains *less oxygen* in wet weather, the *heat of fire is less intense*: and the flame is blue, *because the fuel is not thoroughly consumed*.

Q. *Why do* HILLS, *&c. appear* LARGER *in* WET *weather?*

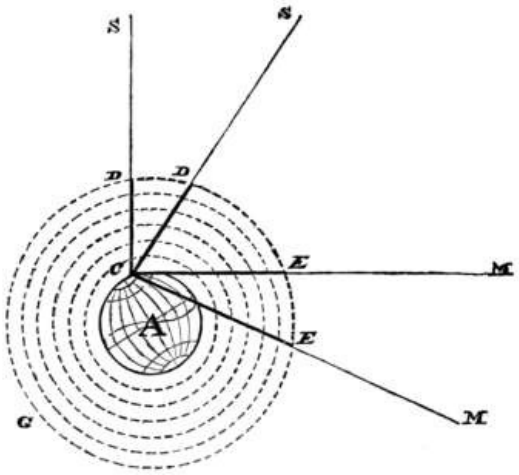
A. Because (when the air is *laden with vapour*) the rays of light are *more dispersed*, and produce a larger reflection; objects, therefore, seen at a distance, *appear larger*.

Q. *Why do* TREES, *&c. in* WET *weather appear* FURTHER OFF *than they really are?*

A. Because the fog or mist *diminishes the light* reflected from the object; and as the object becomes *more dim*, it seems to be *further off*.

Q. *Why does the* SUN *seem* LARGER *when he* SETS *and* RISES, *than he does at noon?*

A. Because the rays pass through *more of the vapoury atmosphere* which surrounds the earth; and this vapoury atmosphere acts like a *magnifying glass*.



It is very manifest that the lines D C are shorter than the lines E C: if, therefore, A be the earth, and D G E the boundary of the atmosphere round the earth, then the rays M E C (at the *horizon*) will pass through *more of the atmosphere*, than the rays S D C, which are more elevated.

Q. *Why does the* MOON *appear* LARGER *at her* RISING *and* SETTING, *than when above our heads?*

A. Because the rays pass through *more of the vapoury atmosphere* which surrounds the earth; and this vapoury atmosphere *magnifies* the moon, just like a magnifying glass.

Q. *Why do* CATS RUB *their* EARS *when it is likely to rain?*

A. Either because the *air is full of vapour*, and its humidity (piercing between the hair of the cat) *produces an itching sensation*; or more probably, because the air is *overcharged with electricity.*

Q. *How can the ELECTRICITY of air produce a sensation of ITCHING?*

A. If the *air* is overcharged with electricity, the *hair of the cat* is overcharged also; and this makes her feel *as if she were covered with cobwebs*.

Q. *Why does the CAT keep RUBBING herself?*

A. Her *hair will not lie smooth*, but has a perpetual tendency to become *turgid and ruffled*; so the cat keeps rubbing her coat and ears, to *smooth the hair down*, and brush away the feeling of cobwebs.

Q. *Why do our HEADS and SKIN itch before rain?*

A. Probably because the *air is overcharged with electricity*; and, therefore, a sensation (like that of cobwebs) *irritates the skin*, and produces an itching.

Q. *Why do we HEAR distant CLOCKS more distinctly when rain is near at hand?*

A. Because the *air is filled with vapour*, and water is a better conductor of sound than dry air.

Q. *Why do we hear CHURCH-BELLS further, just previous to rain?*

A. Because the *air is filled with vapour*, and vapour is a better conductor of sound than dry air.

Q. *Why do DOORS SWELL, when RAIN is at hand?*

A. Because the *air is filled with vapour*, which (penetrating into the pores of the wood) *forces the parts further apart*, and swells the door.

Q. *Why do DOORS SHRINK in DRY weather?*

A. Because the *moisture is absorbed from the wood*; and, as the particles are *brought closer together*, the size of the door is *lessened*, (or in other words, the *wood shrinks*).

Q. *Why is the AIR filled with offensive SMELLS previous to a coming RAIN?*

A. Because the volatile parts, (which rise from dunghills, sewers, &c.), being *laden with vapour*, are unable to rise so readily, as when they are rarefied by a bright sun.

Q. *Why do* FLOWERS *smell* SWEETER *and* STRONGER *just previous to* RAIN*?*

A. Because the volatile parts (which constitute the *perfume* of flowers) are *laden with vapour*; and (being unable to rise) are confined to the lower regions of the air.

Q. *Why do* HORSES *and other animals stretch out their necks, and* SNUFF *up the* AIR*, just previous to a fall of* RAIN*?*

A. Because they *smell the odour of plants and hay*, and delight to snuff in their fragrance.

Q. *Why does* SMOKE FALL *when* RAIN *is at hand?*

A. The air being less *dense* in wet weather, *cannot buoy up smoke* so readily, as when *more dry and heavy*.

Q. *Why do* SWALLOWS FLY LOW *when* RAIN *is at hand?*

A. Because the *insects* (of which they are in pursuit) *have fled from the cold upper regions of the air*, to the *warm* air near the earth: and as their *food is low*, the swallows *fly low*.

Q. *Why do these* INSECTS *seek the lower regions of the air in* WET *weather, more than in* FINE *weather?*

A. Because they are forced downward, by some current of cold air which *drives them down*.

Q. *Why does a* DOWNWARD *current of* COLD AIR *bring* RAIN*?*

A. Because it *condenses the warm vapour*; which then descends in rain.

Q. *The proverb says, "*A SINGLE MAGPIE *in spring,* FOUL WEATHER *will bring:" why is this the case?*

A. In cold stormy weather, *one magpie alone* will leave its warm snug nest *in search of food*, while the other stays with the *eggs or young ones*; but in *fine mild* weather (when their brood will not be injured by cold) *both the magpies will fly out together*.

Q. *Why is it* UNLUCKY *for* ANGLERS *to see a* SINGLE MAGPIE *in spring?*

A. Because when *magpies fly abroad singly*, the weather is cold and stormy; but when *both birds fly out together*, the weather is *warm and mild*, which is *favourable for fishing*.

Q. *Why do* SEA GULLS *fly about the* SEA *in* FINE *weather?*

A. Because they *live upon fish*, which are found near the *surface of the sea in fine weather*.

Q. *Why may we expect* STORMY RAINS, *when* SEA GULLS *assemble on the land?*

A. Because the fish (on which they live) leave the *surface* of the sea in stormy weather, and *go down too deep for the gulls to get at them*; they are obliged, therefore, to feed on the *worms and larvæ* which are driven out of the *ground* at such times.

Q. *Why does the* PETREL *always fly to the* SEA *during a storm?*

A. Because the petrel *lives upon sea insects*, which are always to be found in abundance *about the spray of swelling waves*.

(The Petrel is a bird of the duck-kind, which lives in the open sea. They run on the top of the sea, and are called Petrels, or rather Peter-els, from "St. Peter," in allusion to his walking on the sea, to go to Jesus.)

Q. *Why do* CANDLES *and* LAMPS SPIRT *when* RAIN *is at hand?*

A. Because the *air is filled with vapour*, and the humidity *penetrates the wick*; where (being formed into *steam*) it expands suddenly, and produces a little explosion.

Q. *Why does a* DROP *of* WATER *sometimes* ROLL *along a piece of hot iron without leaving the least trace?*

A. If the iron be *very hot indeed*, the *bottom* of the drop is turned into *vapour, before the drop can evaporate*; and the vapour thus formed *buoys the drop up*, without allowing it to touch the iron at all.

Q. *Why does it* ROLL*?*

A. The *current of air* (which is always passing over the heated surface) *drives it along*.

Q. *Why does a* LAUNDRESS *put a little* SALIVA *on an* IRONING-BOX *to know if it be hot enough?*

A. If the saliva *sticks to the box and is evaporated*, the box is *not* hot enough; but if the saliva *runs along the box*, it *is*.

Q. *Why is the* BOX HOTTER *if the saliva* RUNS ALONG THE BOX, *than if it adheres to it till it is evaporated?*

A. If the saliva *runs along the box*, the iron is hot enough to *convert the bottom of the drop* of spittle into *vapour*; but if the saliva *will not roll*, the box is *not* hot enough to convert the bottom of the drop of spittle into vapour.

CHAPTER XII.

4.—EVAPORATION.

Q. *What is meant by* EVAPORATION*?*

A. The dissipation of liquid by its being *converted into vapour*.

Q. *What* EFFECTS *are produced by evaporation?*

A. The *liquid vaporized absorbs heat* from the body whence it issues; and the *body deprived of the liquid* by evaporation, *loses heat* thereby.

Q. *If you* WET *your* FINGER *in your mouth, and hold it up in the air, why does it* FEEL COLD*?*

A. The saliva quickly *evaporates*; and (as it evaporates) *absorbs heat from the finger*, which makes it feel cold.

Q. *If you* BATHE *your* TEMPLES *with ether, why does it allay* INFLAMMATION *and feverish heat?*

A. Ether very rapidly *evaporates*; and (as it evaporates) *absorbs heat from the burning head*, producing a sensation of cold.

Q. *Why is* ETHER *better for this purpose than* WATER*?*

A. Because it requires *less heat to convert it into vapour*; and therefore it evaporates much more *quickly*.

(Ether is converted into steam with 104 *deg*$^{s.}$ of heat, but water requires 212 *deg*$^{s.}$ of heat to convert it into steam.)

Q. *Why does* ETHER *very greatly* RELIEVE *a* SCALD *or* BURN*?*

A. Because it *evaporates very rapidly*; and (while it is converted into vapour) *carries off the heat of the burn*.

Q. *Why do we* FEEL *so* COLD *when we have* WET FEET *or* CLOTHES*?*

A. As the wet of our shoes or clothes *evaporates*, it *keeps absorbing heat from the body*, which makes it feel cold.

Q. *Why do* WET FEET *or* CLOTHES *give us "*COLD*?"*

A. Because the evaporation *absorbs heat from the body so abundantly*, that it is *lowered below its natural standard*; and therefore health is injured.

Q. *Why is it* DANGEROUS *to* SLEEP *in a* DAMP BED*?*

A. Because the *heat of the body* is continually absorbed *in converting the damp of the sheets into vapour*; and as heat is abstracted from the body, its temperature is reduced *below the healthy standard*.

Q. *Why do we not feel the same sensation of cold, if we throw a* MACINTOSH *over our* WET CLOTHES*?*

A. The macintosh *prevents evaporation*, because the steam cannot escape through the air-tight fabric; and (as the *wet cannot evaporate* from the clothes) no heat is absorbed from our bodies.

Q. *Why do* NOT SAILORS *get* COLD*, who are so often wet all day with* SEA-WATER*?*

A. The *salt* of the sea *retards evaporation*; and (as the heat of the body is drawn off *very gradually*) the sensation of cold is prevented.

Q. *Why does* SPRINKLING *a* HOT ROOM *with water* COOL IT*?*

A. The heat of the room causes a *rapid evaporation of the sprinkled water*; and as the water evaporates, *it absorbs heat from the room*, and cools it.

Q. *Why does* WATERING *the* STREETS *and roads* COOL THEM*?*

A. The hot streets and roads part with their heat *to promote the evaporation of the water sprinkled on them*.

Q. *Why does a* SHOWER *of* RAIN *seem to* COOL *the* AIR *in summer-time?*

A. The earth (being wet with the rain) *parts with its heat to promote evaporation*; and as the *earth* is cooled, it *cools the air* also.

Q. *Why is* LINEN DRIED *by being exposed to the* WIND*?*

A. The air (blowing over the linen) *promotes evaporation*, by removing the vapour from the *surface of the wet linen*, as soon as it is formed.

Q. *Why is* LINEN DRIED *sooner in the open* AIR*, than in a confined room?*

A. Because the particles of vapour are more rapidly removed from the surface of the linen by evaporation.

Q. *Why are* WET SUMMERS *generally* SUCCEEDED *by* COLD WINTERS*?*

A. Because the great evaporation (carried on through the wet summer) *reduces the temperature of the earth lower than usual*, and produces cold.

Q. *Why is* ENGLAND WARMER *than it used to be, when* AGUES *were so common?*

A. Because it is *better drained* and *better cultivated*.

Q. *Why does* DRAINING *land promote* WARMTH*?*

A. Because it *diminishes evaporation*; in consequence of which *less heat* is abstracted from the earth.

Q. *Why does* CULTIVATION *increase the* WARMTH *of a country?*

A. 1st—Because *hedges and belts of trees* are multiplied;

2ndly—Because the land is *better drained*;

3rdly—Because the land is *dug and ploughed;* and

4thly—Because the vast *forests are cut down*.

Q. *Why do* HEDGES *and* BELTS *of* TREES *promote* WARMTH*?*

A. Because they *retard evaporation*, by keeping off the *wind*.

Q. *If belts of trees promote* WARMTH*, why do* FORESTS *produce* COLD*?*

A. 1st—Because they *detain and condense the passing clouds*:

2ndly—They prevent the access of both *wind and sun*:

3rdly—The soil of forests is always *covered with long damp grass, rotting leaves, and thick brushwood*: and

4thly—There are always many hollows in every forest *full of stagnant water*.

Q. *Why do* LONG GRASS *and* ROTTING LEAVES *promote* COLD*?*

A. Because *they are always damp*; and the evaporation which they promote, *is constantly absorbing heat* from the earth beneath.

Q. *Why do* DIGGING *and* PLOUGHING *help to make a country* WARM*?*

A. Digging and ploughing help *to pulverize the soil*, by admitting *air into it*, and this increases its mean temperature.

Q. *Why are* FRANCE *and* GERMANY WARMER *now, than when the vine would not ripen there?*

A. Chiefly because *their vast forests have been cut down*; and the soil is better *drained and cultivated*.

Q. *What becomes of the* WATER *of* PONDS *and* TUBS *in summer-time?*

A. Ponds and tubs in summer-time are often left dry, because their water is *evaporated by the air*.

Q. *How is this* EVAPORATION PRODUCED *and carried on?*

A. The air contains heat, and changes the *surface of the water into vapour*; this vapour (blending with the air) *is soon wafted away*; while *fresh* portions of air *blow over the water*, and produce a *similar evaporation*; till the pond or tub is left quite dry.

Q. *Why are the* WHEELS *of some machines kept* CONSTANTLY WET *with* WATER?

A. *To carry off the heat* (arising from *the rapid motion* of the wheels) *by evaporation*, as soon as it is developed.

Q. *Why is* MOULD HARDENED *by the* SUN*?*

A. Because (when the moisture of the mould has been *evaporated by the sun*) the earthy particles *come into closer contact*, and the mass becomes more solid.

Q. *Show the* WISDOM *of* GOD *in this arrangement.*

A. If the soil did not become *crusty and hard in dry weather*, the *heat and drought would penetrate the soil*, and kill both seeds and roots.

Q. *Why is* TEA *cooled* FASTER *in a* SAUCER *than in a cup?*

A. Because *evaporation is increased* by *increasing the surface*; and as tea in a saucer *presents a much larger surface to the air*, its heat is more rapidly carried off by evaporation.

(The subject of "convection" will be treated of in a future chapter, and would scarcely be understood in this place.)

Q. *Why is not the* VAPOUR *of the* SEA SALT*?*

A. Because the *salt* is always *left behind*, by the process of evaporation.

Q. *Why does a* WHITE CRUST *appear (in hot weather) upon* CLOTHES *wetted by sea water?*

A. The white crust is the *salt of the water* left on the clothes by evaporation.

Q. *Why does this* WHITE CRUST *always* DISAPPEAR *in* WET *weather?*

A. In *wet* weather the *moisture of the air dissolves the salt*; and, therefore, it no longer remains

visible.

Q. *Why should* NOT *persons, who take violent exercise,* WEAR *very* THICK CLOTHING*?*

A. When the heat of the body is increased by exercise, *perspiration reduces the heat* (by evaporation) *to a healthy standard*: as thick clothing *prevents this evaporation*, and confines the heat and perspiration *to the body*, it is injurious to health.

CHAPTER XIII.
COMMUNICATION OF HEAT.

1.—CONDUCTION.

Q. *How is* HEAT COMMUNICATED *from one body to another?*

A. 1. By Conduction. 2. By Absorption. 3. By Reflection. 4. By Radiation: and 5. By Convection.

Q. *What is meant by* CONDUCTION *of heat?*

A. Heat communicated from one body to another, *by actual contact*.

Q. *Why does a* PIECE *of* WOOD *(blazing at* ONE *end)* NOT FEEL HOT *at the* OTHER *end?*

A. *Wood is a bad conductor of heat*; and, therefore, heat does not traverse freely through it: hence, though one end of a stick be blazing-hot, the other end may be quite cold.

Q. *Why do* SOME THINGS *feel so much* COLDER *than others?*

A. Principally because *they are better conductors*; and, therefore, draw off the heat from our body (which touches them) so much faster.

Q. *What are the* BEST CONDUCTORS *of* HEAT*?*

A. *Dense solid bodies*, such as metal and stone.

Q. *Which* METALS *are the most* RAPID CONDUCTORS *of* HEAT*?*

A. *Silver* is the best conductor, then *copper*, then *gold* or *tin*, then *iron*, then *zinc*, and then *lead*.

Q. *What are the* WORST CONDUCTORS *of* HEAT*?*

A. All *light and porous bodies*, such as hair, fur, wool, charcoal, and so on.

Q. *Why are* COOKING VESSELS *so often furnished with* WOODEN HANDLES*?*

A. Wood is *not a good conductor, like metal*; and, therefore, many vessels (which are exposed to the heat of the fire) *have wooden handles, lest they should burn our hands* when we take hold of them.

Q. *Why is the* HANDLE *of a* METAL TEA-POT *made of* WOOD*?*

A. As *wood is a bad conductor*, the heat of the boiling water is *not so quickly conveyed to the wooden handle*, nor so quickly *poured into the hand* by it, as when the handle is made of metal.

Q. *Why would a* METAL HANDLE BURN *the* HAND *of the tea-maker?*

A. As metal is an *excellent conductor*, the heat of the boiling water *rushes quickly into the metal handle*, and *into the hand that touches it*.

Q. *How do you know that a* METAL HANDLE *would be* HOTTER *than a* WOODEN *one?*

A. By *touching the metal collar* into which the wooden handle is fixed: though the *wooden handle is quite cold*, this *metal collar is intensely hot*.

Q. *Why do persons use paper or* WOOLLEN KETTLE-HOLDERS *to take hold of a kettle with?*

A. Paper and woollen are both very *bad conductors of heat*; and, therefore, the heat of the kettle does *not readily pass through them to the hand*.

Q. *Does the heat of the boiling kettle* NEVER *get through the woollen or paper kettle-holder?*

A. Yes; but though the kettle-holder became as hot as the kettle itself, it would never *feel* so hot.

Q. *Why would not the kettle-holder* FEEL *so hot as the kettle, when it really is of the same temperature?*

A. Because (being a very *bad* conductor) *it disposes of its heat so slowly*, that it is *scarcely perceptible*; but metal (being an *excellent* conductor) disposes of its heat so *quickly*, that the sudden influx is painful.

Q. *Why then does* HOT METAL *feel so much* MORE *intensely* WARM *than* HOT WOOL*?*

A. Because it gives out a much *greater quantity of heat in the same space of time*; and the *influx* of heat is, therefore, *more perceptible*.

Q. *Why does money in our pocket feel so hot, when we stand before a fire?*

A. Metal is an *excellent conductor*; and, therefore, becomes rapidly heated. For the same reason it becomes *rapidly cold*, when it comes in contact with a body *colder than itself*.

Q. *Why does a pump-handle feel intensely cold in winter?*

A. As metal is an *excellent conductor*, when the hot hand touches the cold pump-handle, the heat passes rapidly *from the hand into the iron*; and this rapid loss of heat produces a sensation of intense coldness.

Q. *Is the iron handle of the pump really colder than the wooden pump itself?*

A. No; every inanimate substance (exposed to the same temperature) possesses the *same degree of heat*.

Q. *Why then does the iron handle seem so much colder than the wooden pump?*

A. Merely because the *iron is a better conductor*; and, therefore, *draws off the heat from our hand* much more rapidly than wood does.

Q. *Why does a stone or marble hearth feel to the feet so much colder than a carpet or hearth-rug?*

A. Because *stone and marble are good conductors*, but *woollen carpets and hearth-rugs* are very *bad conductors*.

Q. *Why does the stone hearth make our feet cold?*

A. As soon as the hearth-stone has absorbed a portion of heat from our foot, it instantly disposes of it, and *calls for a fresh supply*; till the hearth-stone has become of the *same temperature as the foot placed upon it*.

Q. *Do not the woollen carpet and hearth-rug, also, conduct heat from the human body?*

A. Yes; (but being very *bad conductors*) they convey *the heat away so slowly*, that it is scarcely perceptible.

Q. *Is the cold hearth-stone and warm carpet then of the same temperature?*

A. Yes; everything in the room is *really of the same temperature*; but some feel colder than others *because they are better conductors*.

Q. *How* LONG *will the hearth-stone feel cold to the feet resting on it?*

A. Till the *feet and the hearth-stone are both of the same temperature*; and then the sensation of cold in the hearth-stone will go off.

Q. *Why would not the* HEARTH-STONE *feel* COLD, *when it is of the* SAME *temperature as our* FEET*?*

A. Because the heat would no longer *rush out of our feet into the hearth-stone*, in order to produce an equilibrium.

Q. *Why does the* HEARTH-STONE *(when the fire is lighted) feel so much* HOTTER *than the* HEARTH-RUG*?*

A. The hearth-stone is an *excellent conductor*; and, therefore, *parts with its heat more readily* than the woollen hearth-rug; which (being a very *bad conductor*) parts with its heat reluctantly.

Q. *Why does* PARTING *with* HEAT RAPIDLY *make the* HEARTH-STONE *feel* WARM*?*

A. As the heat of the stone rushes *quickly into our foot*, it raises its temperature *so suddenly*, that we cannot *help perceiving the increase of heat*.

Q. *Why does the non-conducting power of the* HEARTH-RUG *prevent its feeling so* HOT *as it really is?*

A. Because it parts with its heat *so slowly and gradually*, that we scarcely *perceive its transmission* into our feet.

Q. *When we plunge our* HANDS *into a basin of* WATER, *why does it produce a sensation of* COLD*?*

A. Though the water (in which we wash) *is really warmer* than the air of our bed-room; yet because it is a *better conductor*, it *feels colder*.

Q. *Why does the* CONDUCTING *power of water make it feel* COLDER *than the air, though in reality it is* WARMER*?*

A. Because *it abstracts heat from our hands so rapidly*, that we feel its loss; but the air abstracts heat *so very slowly*, that its *gradual loss is hardly perceptible*.

Q. *Is water a* GOOD CONDUCTOR *of heat?*

A. No; *no liquid is a good conductor* of heat; but yet water is a *much better conductor than air*.

Q. *Why is* WATER *a* BETTER CONDUCTOR *of heat than* AIR*?*

A. Because *it is less subtile*; and the conducting power of any substance depends upon *its solidity*, or the *closeness of its particles*.

Q. *How do you know that* WATER *is* NOT *a* GOOD CONDUCTOR *of heat?*

A. Because water may be made to *boil at its surface*, without imparting sufficient heat to *melt ice a quarter of an inch below the boiling surface*.

Q. *Why are* NOT LIQUIDS GOOD CONDUCTORS *of heat?*

A. Because the heat (which should be transmitted) *produces evaporation*, and *flies off in the vapour*.

Q. *Why does a* POKER *(resting on the fender) feel so much* COLDER *than the* HEARTH-RUG, *which is further off the fire?*

A. The poker (being an excellent conductor) *draws heat from the hand much more quickly than the rug*, which is a bad conductor: and, therefore, (though both are *equally warm*) the poker seems to be much colder.

Q. *Why are* HOT BRICKS *(wrapped in cloth) employed in cold weather to* KEEP *the* FEET WARM*?*

A. Bricks are *bad conductors* of heat, and cloth or flannel *still worse*: therefore a hot brick (wrapped in flannel) will *retain its heat a very long time*.

Q. *Why is a* TIN PAN *(filled with* HOT WATER*) employed as a* FOOT WARMER*?*

A. Because *polished tin* (being a bad radiator of heat) *keeps hot a very long time*; and warms the feet resting upon it.

Q. *What is meant by being a "bad* RADIATOR *of heat?"*

A. To radiate heat is to *throw off heat by rays*, as the sun; a polished tin pan does *not throw off the heat of boiling water* from its surface, but *keeps it in*.

Q. *Why is the* TIN FOOT-WARMER *covered with* FLANNEL*?*

A. 1st—To prevent the perspiration of the foot from taking off the *polish* of the tin:

2ndly—Flannel is a *very bad conductor*; and, therefore, helps to keep the tin hot *longer*: and

3rdly—If the feet were *not protected*, the conducting surface of the tin *would feel painfully hot*.

Q. *What harm would it be if the* POLISH *of the tin were injured by the perspiration of our feet?*

A. *Polished* tin throws off its heat *very slowly*; but dull, scratched, painted, or dirty tin, *throws off its heat very quickly*: if, therefore, the tin foot-warmer were to *lose its polish*, it would *get cold in a much shorter time*.

Q. *Why are* FURNACES *and stoves (where much* HEAT *is required) built of porous* BRICK*?*

A. As bricks are bad conductors, they *prevent the escape of heat*: and are, therefore, employed where great heat is required.

Q. *Why are* FURNACE DOORS*, &c. frequently* COVERED *with a paste of* CLAY *and* SAND*?*

A. Because this paste is a *very bad conductor of heat*; and, therefore, prevents the *escape of heat from the furnace*.

Q. *If a stove be placed in the* MIDDLE *of a room, should it be made of bricks or* IRON*?*

A. A stove in the *middle of a room* should be made of *iron*; because iron is an *excellent conductor*, and rapidly communicates its heat to the air around.

Q. *Why does the Bible say, that God "giveth* SNOW *like* WOOL*?"*

A. As *snow is a very bad conductor of heat*, it protects vegetables and seeds from the frost and cold.

Q. *How does the non-conducting power of* SNOW PROTECT VEGETABLES *from the* FROST *and cold?*

A. As snow is a bad conductor, it prevents the *heat* of the earth *from being drawn off* by the cold air which rests upon it.

Q. *Why are* WOOLLENS *and* FURS *used in* COLD *weather for* CLOTHING*?*

A. Because they are *very bad conductors* of heat; and, therefore, *prevent the warmth of the body from being drawn off* by the cold air.

Q. *Do not woollens and furs actually* IMPART *heat to the body?*

A. No; they merely *prevent the heat of the body from escaping*.

Q. *Where would the heat* ESCAPE *to, if the body were* NOT *wrapped in wool or fur?*

A. The heat of the body would *fly off into the air*; for the cold air (coming into contact with our body) *would gradually draw away its heat*, till it was as cold as the air itself.

Q. *What then is the* PRINCIPAL USE *of* CLOTHING *in winter-time?*

A. *To keep the body air-tight*; and prevent the *external air* (or wind) from *coming into contact with it*, to absorb its heat.

Q. *Why are BEASTS COVERED with FUR, HAIR, or WOOL?*

A. Because fur, hair, and wool are very *slow conductors of heat*; and (as dumb animals cannot be clad like human beings) God has given them a *robe of hair* or wool, to *keep them warm*.

Q. *Why are BIRDS covered with DOWN or FEATHERS?*

A. Because down and feathers are *very bad conductors of heat*; and (as birds cannot be clad like human beings) God has given them a *robe of feathers to keep them warm*.

Q. *Why are WOOL, FUR, HAIR, or FEATHERS such SLOW CONDUCTORS of heat?*

A. Because a *great quantity of air* lurks entangled between their fibres; and *air is a very bad conductor of heat*.

Q. *If AIR be a BAD CONDUCTOR of heat, why should we not feel as warm WITHOUT clothing, as when we are wrapped in wool and fur?*

A. Because the air (which is cooler than our body) *is never at rest*; and, therefore, fresh particles (perpetually passing over our body) *keep drawing off the heat little by little*.

Q. *Why does the ceaseless CHANGE of air tend to DECREASE the WARMTH of a naked body?*

A. Thus:—the air which cases the body *absorbs as much heat from it as it can, while it remains in contact*; it is then blown away, and makes room for a *fresh coat of air*, which does the *same*.

Q. *Does the AIR (which encases a naked body) become by contact as WARM as the BODY itself?*

A. It would do so, if it remained *motionless*; but as it remains only *a very short time*, it absorbs as much heat as it *can in the time*, and passes on.

Q. *Why do we feel COLDER in WINDY WEATHER, than in a CALM day?*

A. Because (in windy weather) the particles of air *pass over us more rapidly*; and every *fresh* particle takes from us *some* portion of heat.

Q. *Show the wisdom of God in making the AIR a BAD CONDUCTOR.*

A. If air were a *good conductor* (like iron and stone) the heat would be drawn *so rapidly from our body*, that we must be *chilled to death*. Similar evils would be felt also by all the animal and vegetable world.

Q. *Does not the bad conducting power of air enable persons to judge whether an EGG be NEW or STALE?*

A. Yes; touch your tongue against the shell at the larger end; if it *feels warm* to the tongue, the *egg is stale*; if *not*, it is new-laid.

Q. *Why will the* SHELL *of a* STALE EGG *feel* WARM *to the tongue?*

A. Between the shell and the "white of the egg" *there is a small quantity of air*, which *expands in a stale egg*, from the *shrinking of the white*.

Q. *Why does the expansion of air (at the end of an egg) make it feel* WARM *to the tongue?*

A. As air is a very bad conductor, the *more air an egg contains*, the *less heat will be drawn from the tongue* when it touches the shell.

Q. *Why do ladies* FAN *themselves in summer, to make their* FACES COOL*?*

A. The fan *puts the air in motion*, and makes it pass more *rapidly over their face*; and (as the temperature of the *air is always lower* than that of the human *face*) each puff of air *carries off some portion of heat* from the face.

Q. *Does* FANNING *the air make the* AIR *itself* COOLER*?*

A. No; fanning makes the *air hotter and hotter*.

Q. *Why does* FANNING *the air increase its* HEAT*?*

A. By causing the air continually to *absorb heat from the human body* which it passes over.

Q. *If fanning makes the* AIR HOTTER*, how can it make a* PERSON *feel* COOLER*?*

A. Fanning makes the *air hotter*, but the *face cooler*; because it keeps *taking the heat out of the face*, and *giving it to the air*.

Q. *Why is* BROTH COOLED *by* BLOWING *it?*

A. The breath causes a rapid *change of air* to pass over the broth; and (as the air is not so hot as the broth) *it keeps absorbing heat*, and thus makes the broth cooler and cooler.

Q. *Would not the air absorb heat from the broth just as well* WITHOUT BLOWING*?*

A. No; *air is a very bad conductor*; unless, therefore, *the change be rapid*, the air nearest the surface of the broth *would soon become as hot as the broth itself*.

Q. *But would not the hot air part with its heat instantly to the circumjacent air?*

A. No; not instantly. Air is so bad a conductor, *that it parts with its heat very slowly*: unless, therefore, the air be kept in *continual motion*, it would *cool the broth very slowly indeed*.

Q. *Why does wind generally feel cool?*

A. Wind is only air in motion; and the more quickly the *air passes over our body*, the more rapidly it *absorbs the heat* therefrom.

Q. *Why does air absorb heat more quickly by being set in motion?*

A. Because every fresh gust of air *absorbs a fresh portion of heat*; and the more rapid the *succession of gusts*, the greater will be the quantity of air absorbed.

Q. *If the air were hotter than our body, would the wind feel cool?*

A. No; if the air were *hotter than our body*, it would feel *insufferably hot*.

Q. *Why would the air feel intensely hot, if it were warmer than our blood?*

A. Because then the wind would *add to the heat of* our body, instead of *diminishing it*.

Q. *Is the air ever as hot as the human body?*

A. Not in *this* country: in the hottest summer's day, the air is always 10 or 12 *degrees cooler than the human body*.

Q. *Is the earth a good conductor of heat?*

A. No; the power of *conducting* heat depends upon the *continuity of matter*; if the particles of which a thing is composed are not *continuous*, they have very little power to *conduct heat*.

Q. *Why is the earth (below the surface) warmer in winter than the surface itself?*

A. Because the earth is a *bad conductor of heat*; and, therefore (although the ground be frozen) the frost never penetrates *above an inch or two below the surface*.

Q. *Why is the earth (below the surface) cooler in summer than the surface itself?*

A. Because the earth is a *bad conductor of heat*; and, therefore, (although the surface be scorched with the burning sun) the intense heat cannot penetrate to *the roots* of the plants and trees.

Q. *Shew the* WISDOM *of* GOD *in making the* EARTH *a* BAD CONDUCTOR.

A. If the *heat and cold could penetrate the earth* (as freely as the heat of a fire penetrates iron), the springs would be dried up in summer and frozen in winter, and all vegetation would perish.

Q. *Why is* WATER *from a* SPRING *so* COOL *in* SUMMER?

A. As the earth is a *bad conductor*, the burning rays of the sun can penetrate only a few inches below the surface; in consequence of which, the *springs of water are not affected*.

Q. *Why is it* COOL *under a* SHADY *tree in a hot summer's day?*

A. 1st—Because the overhanging foliage *screens off the rays of the sun*:

2ndly—As the rays of the sun are warded off, *the air* (beneath the tree) *is not heated by the reflection of the earth*: and

3rdly—The leaves of trees, being *non-conductors*, allow no heat to penetrate through them.

Q. *Why do the* LAPLANDERS *wear* SKINS, *with the* FUR INWARDS?

A. The *dry skin* prevents the *wind from penetrating to their body*; and as the *fur* contains a *quantity of air* between its hairs (which soon *becomes heated by the body*) the Laplander is clad in *a case of hot air, impervious to the cold and wind*.

Q. *Why does a* LINEN SHIRT *feel* COLDER *than a* COTTON ONE?

A. *Linen is a much better conductor* than cotton; and, therefore, (as soon as it touches the body) *it more rapidly draws away the heat*, and produces a sensation of cold.

Q. *Why is the* FACE COOLED *by wiping the temples with a fine* CAMBRIC HANDKERCHIEF?

A. The fine fibres of the cambric have a *strong capillary attraction for moisture*; and are *excellent conductors of heat*: thus the moisture and heat are *both abstracted from the face*, and a sensation of coolness is produced.

"Capillary attraction," i. e. *the attraction of a thread or hair*. The wick of a candle is wet with grease, because the melted tallow runs up the cotton from capillary attraction.

Q. *Why would not a* COTTON *handkerchief do as well?*

A. The coarse fibres of cotton have much less capillary attraction, and are *nothing like such good conductors* as linen: and, therefore, wiping the face with a *cotton handkerchief*, increases the sensation of warmth.

CHAPTER XIV.
2.—ABSORPTION OF HEAT.

Q. *What is the difference between* CONDUCTING *heat, and* ABSORBING *heat?*

A. To *conduct* heat, is to *transmit it from one body to another* through a conducting medium: to *absorb* heat, is to *suck it up*, as a sponge sucks up water.

Q. *Give me an example.*

A. *Black cloth absorbs*, but does not *conduct heat*: thus, if black cloth be laid in the sun, *it will absorb the rays* very rapidly; but if *one end of the black cloth* be made hot, it would not *conduct the heat* to the *other* end.

Q. *Are good* CONDUCTORS *of heat, good* ABSORBERS *also?*

A. No; every *good conductor of heat* is a *bad absorber of it*; and *no good absorber of heat* can be a *good conductor* also.

Q. *Is* IRON *a good* ABSORBER *of heat?*

A. No; *iron is a good conductor*, but a very *bad absorber* of heat.

Q. *Why do the* FENDER *and* FIRE-IRONS *(which lie upon it) remain* COLD, *although they are before a good fire?*

A. Because the metal fender and fire-irons have very *little capacity for absorbing heat*; although they are soon made hot (by conduction), when placed in *contact* with the hot fire or stove.

Q. *Why does a* KETTLE *boil faster, when the bottom and back are* COVERED *with* SOOT*?*

A. The *black soot absorbs heat* very quickly from the fire, and the metal *conducts it to the water*.

Q. *Why will not a* NEW KETTLE *boil so fast as an* OLD *one?*

A. Because the *bottom and sides* of a new kettle are *clean and bright*; but in an *old* kettle *are covered with soot*.

Q. *Why would the* KETTLE *be* SLOWER BOILING, *if the* BOTTOM *and* BACK *were* CLEAN *and bright?*

A. *Bright* metal does *not absorb heat*, but *reflect it* (i. e. throw the heat *back* again); and as the heat is *thrown off from the surface of bright metal*, therefore, a new kettle is longer boiling.

Q. *Why do we wear* WHITE LINEN *and a* BLACK *outer* DRESS, *if we want to be warm?*

A. The *black outer dress* quickly *absorbs heat from the sun*, and conveys it to the body; and the *white linen* (being a *bad* absorbent) abstracts no heat from the warm body.

Q. *Why do persons* WEAR WHITE *dresses in* SUMMER *time?*

A. White *throws off the heat of the sun by reflection*, and is, therefore, a very bad absorbent of heat; in consequence of which, it never becomes *so hot from the scorching sun* as dark colours do.

Q. *Why do* NOT *persons* WEAR WHITE *dresses in* WINTER *time?*

A. *White will not absorb heat*, like black and other dark colours; and, therefore, *white* dresses are *not so warm as dark ones*.

Q. *What* COLOURS *are* WARMEST *for dresses?*

A. For *outside* garments *black is the warmest*, and then such colours as *approach nearest to black* (as dark blue and green). *White is the coldest colour* for external clothing.

Q. *Why are* DARK COLOURS *(for external wear) so much* WARMER *than* LIGHT ONES?

A. Because *dark colours absorb heat from the sun* more abundantly than *light* ones.

Q. *How can you prove that* DARK *colours are* WARMER *than* LIGHT *ones?*

A. If a piece of *black* cloth and a piece of *white* were laid upon snow, in a few hours the *black cloth will have melted the snow beneath*; whereas the *white* cloth will have produced little or *no effect upon it at all*.

N. B. The darker any colour is, the warmer it is, because it is a better absorbent of heat. The order may be thus arranged:—1. Black (warmest of all).—2. Violet.—3. Indigo.—4. Blue.—5. Green.—6. Red.—8. Yellow: and 9. White (coldest of all).

Q. *Why are* BLACK KID GLOVES *so* HOT *in summer time?*

A. 1st—Because the *black absorbs the solar heat*: and

2ndly—The *kid* will not allow the heat of the hand *to escape through the glove*.

Q. *Why are* LISLE THREAD GLOVES *so* COOL *in summer time?*

A. 1st—Because thread *absorbs the perspiration of the hands*: and

2ndly—It *conducts away the heat* of our hot hands.

Q. *Are Lisle thread gloves* ABSORBENTS *of heat?*

A. As Lisle thread gloves are generally of a *grey or lilac colour*, they do *not absorb solar heat*.

Q. *Why is a* PLATE-WARMER *made of* UN-PAINTED BRIGHT TIN*?*

A. Bright tin reflects (or *throws back*) *the heat*, which issues from the fire in rays; and (by reflecting the heat upon the meat) assists greatly in roasting it.

Q. *Why would not the tin* REFLECTOR *do as well if it were* PAINTED*?*

A. If the tin reflector were *painted*, it would be utterly spoiled, because it would then *absorb* heat, and *not reflect it at all*. A plate-warmer should be kept *very clean, bright, and free from all scratches*.

Q. *Why should a* REFLECTOR *be kept so very* CLEAN *and free from* SCRATCHES*?*

A. If a reflector be *spotted, dull, or scratched*, it will *absorb* heat, instead of *reflecting* it; and, therefore, would be of no use whatsoever as a *reflector*.

Q. *Why does* HOAR-FROST *remain on* TOMBSTONES*, long after it has melted from the* GRASS *and* GRAVEL-WALKS *of a church-yard?*

A. Tomb-stones being *white*, will *not absorb heat*, like the darker grass and gravel; and, therefore, *the white tombstones* (being so much colder) *retain the hoar-frost* after it has melted from other things.

Q. *If black absorbs heat, why have those who live in* HOT *climates* BLACK SKINS*, and not* WHITE *skins (which would not absorb heat at all)?*

A. Though the black skin of the negro *absorbs heat* more plentifully than the *white skin of a European*, yet the *blackness* prevents the sun from *blistering* or *scorching it*.

Q. *How is it known that the* BLACK *colour prevents the sun from either* BLISTERING *or* SCORCHING *the skin?*

A. If you put a *white glove* on *one hand*, and a *black glove* on *the other* (when the sun is burning hot), the hand with the *white* glove will be *scorched*, but *not the other*.

Q. *Which hand will* FEEL *the* HOTTER*?*

A. The hand with the *black glove* will *feel* the *hotter*, but it will not be *scorched* by the sun; whereas the hand with the *white glove* (though much *cooler*) will be *severely scorched*.

Q. *Why does the* BLACK *skin of a* NEGRO *never* SCORCH *or* BLISTER *with the hot sun?*

A. Because the *black colour absorbs* the heat,—conveys it *below the surface* of the skin, and converts it to *sensible heat* and *perspiration.*

Q. *Why does the* WHITE EUROPEAN SKIN BLISTER *and* SCORCH *when exposed to the hot sun?*

A. Because the *white will not absorb* the heat; and, therefore, the hot sun *rests on the surface of the skin*, and scorches it.

Q. *Why has a* NEGRO BLACK EYES*?*

A. The black colour of a negro's eyes defends them from the strong light of the tropical sun. If a negro's eyes were not *black*, the sun would *scorch them*, and every negro would be blind.

Q. *Why is* WATER KEPT COOLER *(in summer time) in a* BRIGHT TIN POT, *than in an* EARTHEN *one?*

A. Because bright metal will *not absorb* the heat of the summer sun, like an *earthen* vessel.

Q. *Why is* BOILING *water* KEPT HOT *in a* BRIGHT TIN VESSEL *longer, than in an earthen one?*

A. Because bright tin will not suffer the heat of the boiling water *to escape in rays*, as an earthen vessel does.

CHAPTER XV.
3.—REFLECTION OF HEAT.

Q. *What is meant by* REFLECTING HEAT*?*

A. To reflect heat, is *to throw it back in rays* from the surface of the reflecting body, towards the place from whence it came.

Q. *What are the* BEST REFLECTORS *of heat?*

A. All *bright* surfaces, and *light colours*.

Q. *Are* GOOD ABSORBERS *of heat* GOOD REFLECTORS *also?*

A. No; those things *which absorb heat best, reflect* heat *worst*; and those *which reflect heat worst, absorb* it *best*.

Q. *Why are those things which* ABSORB HEAT *unable to* REFLECT *it?*

A. Because if any thing *sucks in heat* like a sponge, it cannot *throw it off* from its surface; and if any thing *throws off heat* from its surface, it cannot *drink it in*.

Q. *Why are* REFLECTORS *always made of* LIGHT-COLOURED *and highly* POLISHED METAL*?*

A. Because *light* coloured and *highly polished metal* makes the best of all reflectors.

Q. *Why do not* PLATE-WARMERS BLISTER *and scorch the* WOOD *behind?*

A. Because the bright tin front *throws the heat of the fire back again*, and will not allow it to penetrate to the wood behind.

Q. *If metal be such an excellent* CONDUCTOR *of heat, how can it* REFLECT *heat, or throw it off?*

A. Polished metal is a *conductor of heat*, only when *that heat is communicated by actual contact*; but whenever heat *falls upon bright metal in rays*, it is *reflected back again*, and the metal remains *quite cool*.

Q. *What is meant by "heat falling upon metal* IN RAYS*," and not "by contact"?*

A. If a piece of tin were thrust *into* a fire, it would be *in actual contact with the fire*; but if it be *held before a fire*, the heat of the fire *falls upon it in rays*.

Q. *What is the use of the* TIN SCREEN *or* REFLECTOR *used in* ROASTING*?*

A. The tin reflector *throws the heat of the fire back upon the meat*; and, therefore, assists the *process of roasting* and helps *to keep the kitchen cool*.

Q. *How does a tin* REFLECTOR *tend to keep the* KITCHEN COOL*?*

A. Because it *confines the heat to the hearth*, and prevents it from being dispersed throughout the kitchen.

Q. *Why does a* LAMP GLASS DIMINISH *the* SMOKE *of a* LAMP*?*

A. As *glass is a reflector*, it reflects the heat of the lamp *back upon the flame*; in consequence of which, *less carbon escapes unconsumed* (as smoke).

Q. *Why are* SHOES HOTTER *for being* DUSTY*?*

A. 1st—Because dust absorbs heat: and

2ndly—As it destroys the *blackness of our shoes*, it prevents them from *throwing off the heat of*

our feet in rays.

Q. *Why can we not* SEE *into the* ROAD *or* STREET, *when a* CANDLE *is lighted in a room?*

A. *Glass is a reflector*; and, therefore, throws the rays of the candle *back into the room*, and thus prevents our seeing into the road or street.

Q. *Why can persons in the* DARK STREET *see into a* ROOM *(lighted by a candle or lamp)?*

A. The pupil of the eye *expands greatly*, when persons are in the dark; and, therefore, when any one in the dark street looks into a light room, *his dilated pupil* sees every thing distinctly.

Q. *Why does it always* FREEZE *on the* TOP *of a* MOUNTAIN*?*

A. Air is heated *by the reflection of the earth*, and not by the rays of the sun; and, as there is no earth round a mountain-top *to reflect heat*, therefore, it remains intensely cold.

CHAPTER XVI.

4.—RADIATION.

Q. *What is meant by* RADIATION*?*

A. Radiation means *the emission of rays*: thus the sun radiates both light and heat; that is, it emits *rays of light and heat* in all directions.

Q. *When is heat* RADIATED *from one body to another?*

A. When the two bodies are *separated by a non-conducting medium*: thus the sun *radiates* heat towards the earth, because the *air comes between* (which is a very bad conductor).

Q. *On* WHAT *does* RADIATION DEPEND*?*

A. On the *roughness* of the radiating surface: thus if metal be *scratched*, its radiating power is increased, because the *heat has more points to escape from*.

Q. *Does a* FIRE RADIATE *heat?*

A. Yes; and because *burning fuel emits rays of heat*, therefore we *feel warm* when we stand before a fire.

Q. *Why does our* FACE FEEL *uncomfortably* HOT, *when we approach a* FIRE*?*

A. Because the fire radiates heat upon the face; which (not being *covered*) feels the effect immediately.

Q. *Why does the fire catch the* FACE *more than the* REST *of the body?*

A. The *rest* of the body is *covered with clothing*, which (being a *bad conductor* of heat) prevents the same sudden and rapid transmission of heat to the skin.

Q. *Do those substances which* RADIATE *heat,* ABSORB *heat also?*

A. Yes. Those substances which *radiate most*, also *absorb most heat*: and those which *radiate least*, also *absorb the least* heat.

Q. *Does any thing* ELSE *radiate heat,* BESIDES *the* SUN *and* FIRE*?*

A. Yes; *all* things radiate heat in *some* measure, but *not equally well*.

Q. *What things* RADIATE *heat the* NEXT BEST *to the sun and fire?*

A. All *dull* and *dark substances* are *good radiators* of heat; but all *light* and *polished substances* are *bad radiators* of heat.

Q. *Why does a* POLISHED METAL TEA-POT *make* BETTER TEA *than a black earthen one?*

A. As polished metal is a very *bad radiator* of heat, it *keeps the water hot much longer*; and the hotter the water is, the better it “draws” the tea.

Q. *Why will not a* DULL BLACK TEA-POT *make good tea?*

A. Because the heat of the water *flies off so quickly* through the dull black surface of the tea-pot, that the *water is rapidly cooled*, and will not “draw” the tea.

Q. *Do not pensioners, and most aged cottagers, prefer the little* BLACK EARTHEN TEA-POT *to the bright* METAL *one?*

A. Yes; because they *set it on the hob “to draw;”* in which case, the little *black tea-pot* will make the *best tea*.

Q. *Why will a* BLACK TEA-POT *make better tea than a bright metal one, if it be set upon the* HOB *to* DRAW*?*

A. Because the black tea-pot will *absorb heat plentifully* from the fire, and keep the water *boiling hot*: whereas, a bright *metal* tea-pot (set upon the hob) would *throw off* the heat by *reflection*.

Q. *Then sometimes a* BLACK EARTHEN *tea-pot is the best, and sometimes a bright* METAL *one?*

A. Yes; when the tea-pot is *set on the hob "to draw,"* the black *earth* is the *best*, because it *absorbs heat*: but when the tea-pot is *not* set on the hob, the bright *metal* is the *best*, because it *radiates heat very slowly*, and therefore *keeps the water hot*.

Q. *Why does a* SAUCEPAN *which has been* USED, *boil* QUICKER *than a* NEW ONE*?*

A. Because the bottom and back are *covered with soot*; and the *black soot* rapidly *absorbs the heat* of the glowing coals.

Q. *Why should the* FRONT *and* LID *of a* SAUCEPAN *be clean and* BRIGHT*?*

A. As they do not come in contact with the fire, they cannot *absorb heat*; and (being bright) they will not suffer *the heat to escape* by radiation.

Q. *In what state should a* SAUCEPAN *be, in order that it may* BOIL QUICKLY*?*

A. All those parts which *come in contact with the fire* should be covered with *soot*, to absorb heat; but all the *rest* of the saucepan should be as *bright as possible*, to prevent the *escape of heat* by radiation.

Q. *Why is it said that "*SATURDAY'S KETTLE BOILS *the* FASTEST*?"*

A. Because on Saturday the *front* and *top* of the kettle are generally *cleaned* and *polished;* but the *bottom* and *back* of the kettle are *never* cleaned.

Q. *Why should* NOT *the* BOTTOM *and* BACK *of a kettle be* CLEANED *and polished?*

A. Because they *come in contact with the fire*, and (while they are covered with black soot) *absorb heat freely* from the burning coals.

Q. *Why should the* FRONT *and* TOP *of a kettle be* CLEAN *and well polished?*

A. Because polished metal *will not radiate heat*; and, therefore, (while the front and top of the kettle are well polished) *the heat is kept in*, and not suffered to escape by radiation.

Q. *Why is the* INSIDE *of a* KETTLE *and* SAUCEPAN WHITE*?*

A. *White will not radiate heat*: if, therefore, the inside of a boiler be *white*, the liquor in it is *kept hot much longer*.

Q. *Why is the* BOTTOM *of a* KETTLE *nearly* COLD, *when the* WATER *is* BOILING HOT?

A. Black soot is a very *bad conductor of heat*; and, therefore, the heat of the boiling water is some considerable time, before it gets *through the soot* which adheres to the bottom of the kettle.

Q. *Why is the* LID *of a* KETTLE *so intensely* HOT, *when the water boils?*

A. The bright metal lid of the kettle *is an admirable conductor* of heat; and, therefore, *the heat from the boiling water pours into our hand* the moment we touch it.

Q. *Show the benefit of* SMOKE *in* COOKING.

A. The carbon of the fuel (which flies off in smoke) naturally *blackens* all culinary vessels set upon the fire to boil, and thus renders them fit for use.

("Culinary vessels" are vessels used in kitchens for cooking, as saucepans, boilers, kettles, &c.)

Q. *How does* SMOKE *make culinary vessels* FIT *for* USE?

A. If it were not for the *smoke*, (which gathers round a kettle or saucepan) *heat would not be absorbed*, and the process of boiling would be greatly retarded.

Q. *Why is boiling water* KEPT HOT *best in a* BRIGHT METAL *pot?*

A. Because bright metal being a *bad radiator* will not *throw off the heat* of the boiling water *from its surface*.

Q. *Why is* WATER KEPT COLD *in summer-time in a* BRIGHT METAL *pot, better than in an* EARTHEN *vessel?*

A. Because bright metal *will not absorb heat* from the hot air, like an *earthen vessel*; in consequence of which, the water is kept cooler.

Q. *Why are* DINNER-COVERS *made of* BRIGHT TIN *or* SILVER?

A. Light-coloured and highly-polished metal *is a very bad radiator of heat*; and, therefore, bright tin or silver will not allow the heat of the cooked food *to escape through the cover by radiation*.

Q. *Why should a* MEAT-COVER *be very brightly* POLISHED?

A. If the cover be *dull or scratched* it will *absorb heat from the hot food beneath it*; and (instead of *keeping it hot*) will *make it cold*.

Q. *Why should a* SILVER MEAT-COVER *be* PLAIN, *and not* CHASED?

A. If the cover be *chased*, it will *absorb the heat of the food* covered by it; and instead of *keeping it hot*, will *make it cold by absorption*.

Q. *What is* DEW*?*

A. Dew is the *vapour of the air condensed*, by coming in contact with bodies *colder than itself*.

Q. *Why is the* GROUND *sometimes* COVERED *with* DEW*?*

A. The *earth is more heated* by solar rays *than the air*, during the *day*; but at *night*, the earth *parts with more heat* than the *air*, and becomes (in consequence) 5 or 10 degrees *colder*.

Q. *How does the* EARTH *being* COLDER *than the* AIR *account for the deposition of* DEW*?*

A. As soon as the air *touches the cold earth*, its warm vapour is *chilled*, and *condensed into dew*.

Q. *Why is the surface of the* GROUND COLDER *in a* FINE *clear* NIGHT*, than in a* CLOUDY *one?*

A. On a fine clear star-light night, *heat radiates from the earth freely*, and is lost in open space: but on a *cloudy* night, the clouds *arrest the process of radiation*.

Q. *Why is* DEW *deposited only on a* FINE *clear* NIGHT*?*

A. Because, when the night is *clear* and *fine*, the *surface of the ground radiates heat most freely*; and (being cooled down by this loss of heat) *chills the vapour of the air into dew*.

Q. *Why is there* NO DEW *on a dull* CLOUDY NIGHT*?*

A. The clouds *arrest the radiation of heat from the earth*; and (as the heat cannot freely escape) the surface is not sufficiently cooled down *to chill the vapour of the air into dew*.

Q. *Why is a* CLOUDY NIGHT WARMER *than a* FINE *one?*

A. Because the clouds *prevent the radiation of heat from the earth*; and, therefore, the surface of the earth remains *warmer* on a dull cloudy night.

Q. *Why is* DEW *most* ABUNDANT *in situations most* EXPOSED*?*

A. Because the radiation of heat *is not arrested* by houses, trees, hedges, or any other thing.

Q. *Why is there scarcely any* DEW *under a shady* TREE*?*

A. The shady head of the tree both *arrests the radiation of heat from the earth*, and also radiates some of its own heat *towards the earth*; and, therefore, the ground (underneath a tree) *is not*

sufficiently cooled down to chill the vapour of the air into dew.

Q. *Why is there never much* DEW *at the foot of* WALLS *and* HEDGES*?*

A. 1st—Because the wall or hedge acts as a screen, *to arrest the radiation of heat from the earth*: and

2ndly—The wall or hedge also *radiates some portion of heat* towards the earth.

Q. *How do these things prevent the deposition of dew?*

A. As the ground (beneath a wall, tree, or hedge) is *not cooled by the radiation of heat*, it remains of the *same temperature as the air* above it; in consequence of which, the vapours of the air are *not chilled by it into dew*.

Q. *Why is there little or* NO DEW *beneath a* FLOWER-AWNING*, although that awning be open on all four sides?*

A. 1st—Because the awning *arrests the radiation of heat from the ground beneath*: and

2ndly—It *radiates some of its own heat downwards*; in consequence of which, the ground beneath an awning is *not sufficiently cooled down* to chill the vapour of air into dew.

Q. *How can a thin covering of* BASS *or even* MUSLIN *protect trees from* FROST*?*

A. Because *any covering* prevents the *radiation of heat from the tree*; and if the tree be *not cooled down by radiation*, the vapour of the air will *not be frozen* as it comes in contact with it.

Q. *Why is the* BASS *or* CANVASS *itself (which covers the tree) always* DRENCHED *with* DEW*?*

A. The bass or canvass covering *radiates heat* both *upwards and downwards*; and is, therefore, *so cooled down*, that it readily *chills all the vapour of the air* (which passes over it) *into dew*.

Q. *Why does* SNOW *at the foot of a* HEDGE *or* WALL *melt sooner, than in an open field?*

A. Because the hedge or wall *radiates heat into the snow beneath*, which melts it.

Q. *Why is there* NO DEW *after a* WINDY NIGHT*?*

A. 1st—Because the wind *evaporates the moisture*, as fast as it is deposited; and

2ndly—It *disturbs the radiation of heat*, and diminishes the deposition of dew thereby.

Q. *Why are VALLEYS & HOLLOWS often thickly covered with* DEW*, although they are sheltered?*

A. The surrounding hills prevent the *repose of air* (in the valleys) *from being disturbed*; but do not *overhang* and *screen* them, so as to *arrest their radiation*.

Q. *Why does* DEW FALL *more* ABUNDANTLY *on* SOME THINGS *than upon* OTHERS*?*

A. Because some things *radiate heat more freely* than others, and therefore become *much cooler* in the night.

Q. *Why are things which* RADIATE HEAT MOST FREELY, *always the most* THICKLY COVERED *with* DEW*?*

A. Because the vapour of the air is *chilled into dew*, the moment it comes in contact with them.

Q. *What kind of things* RADIATE HEAT *most* FREELY*?*

A. Grass, wood, and the leaves of plants, radiate heat *very freely*: but polished metal, smooth stones, and woollen cloth, part with their heat *very tardily*.

Q. *Do the leaves of* ALL *plants radiate heat* EQUALLY WELL*?*

A. No. Rough *woolly leaves* (like those of a holly-hock) radiate heat much *more freely*, than the *hard smooth polished leaves* of a common laurel.

Q. *Shew the* WISDOM *of* GOD *in making grass, the leaves of trees, and* ALL VEGETABLES, EXCELLENT RADIATORS *of heat.*

A. As vegetables *require much moisture*, and would often perish without a plentiful deposit of dew, God wisely made them to *radiate heat freely*, so as to *chill the vapour* (which touches them) *into dew*.

Q. *Will polished* METAL, *smooth* STONES, *and woollen* CLOTH, *readily collect* DEW*?*

A. No. While grass and the leaves of plants *are completely drenched with dew*, a piece of *polished metal*, or of *woollen cloth* (lying on the same spot) will be *almost dry*.

Q. *Why would* POLISHED METAL *and* WOOLLEN CLOTH *be* DRY, *while grass and leaves are drenched with* DEW*?*

A. Because the polished metal and woollen cloth *part with their heat so slowly*, that the vapour of the air is *not chilled into dew* as it passes over them.

Q. *Why is a* GRAVEL WALK *almost* DRY, *when a grass plat is covered thick with* DEW*?*

A. *Grass*, (*being a good radiator*) throws off its heat very *freely*; but *gravel (being a very bad radiator)* parts with its heat very *reluctantly*.

Q. *Is that the reason why* GRASS *is* SATURATED *with* DEW, *and the* GRAVEL *is* NOT?

A. Yes. When the vapour of warm air comes in contact with the *cold grass*, it is instantly chilled into dew; but (as the gravel is *not so cold as the grass*) the vapour of air is *not so freely condensed* as it passes over the gravel.

Q. *Why does* DEW *rarely fall upon hard* ROCKS *and* BARREN *lands?*

A. Rocks and barren lands are so *compact* and *hard*, that they can neither *absorb nor radiate much heat*; and (as their *temperature varies but very little*) very little *dew* distils upon them.

Q. *Why does* DEW *fall more abundantly on* CULTIVATED *soils, than on* BARREN *lands?*

A. Because cultivated soils (being *loose and porous*) *absorb* heat freely during the day, and *radiate it* by night; and (being *much cooled by the rapid radiation of heat*) as the vapour of the air passes over them, it is plentifully *condensed into dew*.

Q. *Shew the* WISDOM *of* GOD *in this arrangement.*

A. Every plant and inch of land which *needs the moisture of dew*, is adapted to *collect it*; but *not a single drop even of dew is wasted*, where its refreshing moisture is *not required*.

Q. *Shew the* WISDOM *of* GOD *in making polished* METAL *and woollen* CLOTH BAD RADIATORS *of heat.*

A. If polished metal collected dew as easily as grass, it could *never be kept dry*, and *free from rust*. Again, if woollen garments collected dew as readily as the leaves of trees, we should be *often soaking wet*, and subject to *constant colds*.

Q. *Shew how this affords a beautiful illustration of* GIDEON'S MIRACLE, *recorded in the book of Judges, VI. 37, 38.*

A. The *fleece of wool* (which is a *very bad radiator* of heat) was *soaking wet* with dew: when the *grass* (which is a most *excellent radiator*) was *quite dry*.

Q. *Was not this* CONTRARY *to the laws of* NATURE?

A. Yes; and was, therefore, a plain *demonstration of the power of God*, who could change the very *nature of things* at his will.

Q. *Why do our* CLOTHES FEEL DAMP, *after walking in a fine evening in* SPRING *or* AUTUMN?

A. Because the vapour (*condensed by the cold earth*) lights upon them, like dew.

Q. *Why are* WINDOWS *often covered with thick* MIST, *and the frames wet with standing* WATER?

A. The temperature of the *external air* always *falls at sun-set*, and *chills the window-glass*, with which it comes in contact.

Q. *How does this account for the* MIST *and* WATER *on a* WINDOW*?*

A. As the warm vapour of the room *touches the cold glass*, it is *chilled* and *condensed into mist*; and the mist (collecting into drops) *rolls down the window-frame* in little streams of water.

Q. *Does the* GLASS *of a window* COOL *down more* RAPIDLY *than the* AIR *of the room itself?*

A. Yes; because the air is *kept warm by fires*, and the *animal heat* of the people in the room; in consequence of which, the *air of a room suffers very little diminution of heat* from the setting of the sun.

Q. *Whence arises the* VAPOUR *of a* ROOM*?*

A. 1st—The very *air* of the room *contains vapour*:

2ndly—The *breath* and *insensible perspiration* of the inmates *increase* this vapour: and

3rdly—*Hot dinners*, the *steam of tea*, &c. contribute to *increase it still more*.

Q. *What is meant by "the* INSENSIBLE PERSPIRATION*?"*

A. From every part of the human body an *insensible and invisible perspiration issues* all night and day; not only in the hot weather of *summer*, but also in the coldest day of *winter*.

Q. *If the perspiration be both* INSENSIBLE *and* INVISIBLE*, how is it* KNOWN *that there* IS *any such perspiration?*

A. If you put your naked arm *into a clean dry glass cylinder*, the *perspiration* of your arm will soon *condense* on the glass, like mist.

Q. *Why are* CARRIAGE WINDOWS *very* SOON *covered with thick* MIST*?*

A. The warm vapour of the carriage *is condensed the moment it touches the cold glass*, and covers it over with a thick mist.

Q. *Why is the glass window* COLD *enough to condense the vapour of the carriage?*

A. Because the *inside* of the carriage is much *warmer* than the *outside*, and the glass window is made cold by contact with the *external air*.

Q. *Where does the* WARM *vapour of the carriage come from?*

A. The warm *breath* and *insensible perspiration* of the persons riding in the carriage, load the air of it with warm vapour.

Q. *What is the cause of the pretty* FROST-WORK *seen on bed-room* WINDOWS *in winter-time?*

A. The *breath* and *insensible perspiration* of the sleeper (coming in contact with the ice-cold window) is *frozen* by the cold glass, and forms those beautiful appearances seen in our bed-rooms in a winter morning.

Q. *Why is the* GLASS *of a window colder than the* WALLS *of a room?*

A. Glass is a very *excellent radiator*; and, therefore, most *rapidly parts with its heat*.

Q. *Why is a* TUMBLER *of cold* WATER *made quite* DULL *with mist, when brought into a room* FULL *of* PEOPLE*?*

A. Because the *hot vapour of the room* (coming in contact with the cold tumbler) *is condensed upon it*; and changes its invisible and gaseous form for that of a *thick mist*.

Q. *Why is a* GLASS *made quite* DULL*, by laying a* HOT HAND *upon it?*

A. The *insensible perspiration* of the hot hand is *condensed* upon the cold glass, and thus made perceptible.

Q. *Why are* WINE-GLASSES *made quite* DULL *when they are brought into a room* FULL *of* COMPANY*?*

A. The *hot vapour of the room* (coming in contact with the cold wine-glasses) *is condensed* upon them, and covers them with vapour like dew.

Q. *Why does this misty appearance* GO OFF *after a little time?*

A. Because the glass becomes of the *same temperature* as the *air of the room*, and will no longer *chill the vapour* which touches it, and *condense it into mist*.

Q. *Why is a* WINE-GLASS *(brought out of a* CELLAR *into the* AIR*) covered with a thick* MIST *in summer-time?*

A. The vapour of the hot air is *condensed* by the cold glass, and covers it as a thick mist.

Q. *Why does* BREATHING *on a* GLASS *make it quite* DULL*?*

A. Because the hot breath is *condensed* by the cold glass; and, therefore, covers it with a thick mist.

Q. *Why do* WALLS *stand thick with* WET *in a sudden* THAW*?*

A. The walls (being thick) cannot *change their temperature so fast* as the thin air can; and, therefore, they *retain their cold* after the thaw has set in.

Q. *How does* RETAINING *their* COLD *account for their being so* WET*?*

A. As the vapour of the warm air *touches the cold wall*, it is *chilled* and *condensed into water*, which *sticks to the wall*, and sometimes trickles down in little streams.

Q. *Why does a thick* WELL-BUILT HOUSE *contract more* DAMP *of this kind, than an* ORDINARY *one?*

A. Because the walls are much *thicker*; and (if the frost has penetrated *far into the bricks*) it takes a long time to reduce them to the *same temperature as the air*.

Q. *Why are* BANISTERS, &c. DAMP *after a* THAW*?*

A. The wooden banister (being made of some very close-grained, varnished wood) cannot *change its temperature so fast* as the air; and, therefore, *remains cold* some time after the thaw has set in.

Q. *How does* THIS *account for the* BANISTERS *being* DAMP*?*

A. The vapour of the warm air (*coming in contact with the cold banister*) is *chilled*, and condensed into *water upon it*.

Q. *Why is our* BREATH VISIBLE *in* WINTER *and* NOT *in* SUMMER*?*

A. In *winter* the coldness of the air condenses our breath into *visible vapour*; but in *summer* the air is *not cold enough* to condense it into visible vapour.

Q. *Why are our* HAIR *and the* BRIM *of our* HAT *often covered with little drops of pearly* DEW *in winter-time?*

A. The breath (issuing from our mouth and nose) *is condensed into drops*, as it comes in contact with our cold hair or hat; and (being condensed) hangs there in little dew-drops.

Q. *Why does the* STEAM *of a* RAILWAY BOILER *often pour down, like fine rain, when the steam is "let off?"*

A. The steam from the steam-pipe (when the air is cold) *is condensed by contact with the chill air*, and falls like fine rain.

Q. *Why is there* LESS DEW *when the* WIND *is* EASTERLY*, than when the wind is* WESTERLY*?*

A. *Easterly* winds cross the *continent of Europe*, and, (as they pass over *land*) are *dry* and *arid*; but *westerly* winds cross the *Atlantic Ocean*; and (as they pass over *water*) are *moist* and *full of vapour*.

Q. *How does the* DRYNESS *of an eastern wind* PREVENT DEW-FALLS*?*

A. As the easterly winds are *dry*, they *imbibe* the moisture of the air; and, therefore, there *is very little* left to be condensed into *dew*.

Q. *How does the* MOISTNESS *of a western wind* PROMOTE *dew-falls?*

A. As the westerly winds are *saturated with vapour*, they require a *very little reduction of heat* to cause a *copious deposition of dew*.

Q. *When is* DEW *most* COPIOUSLY *distilled?*

A. After a hot day in summer or autumn, with the *wind in the west*.

Q. *Why is* DEW *distilled most* COPIOUSLY *after a* HOT *day?*

A. Because the surface of the earth *radiates* heat very freely at sunset; and (becoming thus *much colder than the air*) *chills its vapour*, and condenses it into dew.

Q. *Does not* AIR *radiate heat, as well as the* EARTH *and its various plants?*

A. No. The air *never radiates heat*, nor is the air itself *made hot* by the *rays of the sun*.

Q. *How is the* AIR *made* HOT *or* COLD*?*

A. By *convection of hot or cold currents*.

Q. *What is meant by "*CONVECTION *of hot and cold currents?"*

A. The air (which is heated by the surface of the earth) *ascends, warming the air* through which it passes. *Other* air (being warmed in a similar way) *also ascends, carrying heat*; till *all the air* is made hot.

Q. *Is the* AIR *made* COLD *in a similar way?*

A. Yes. The air resting on the earth is *made cold by contact*: this cold air makes the *air above it cold*; and cold currents or winds *shake the whole together*, till all becomes of one temperature.

Q. *Why is* MEAT *very subject to* TAINT *on a* MOON-LIGHT *night?*

A. In a bright moon-light night, *meat radiates heat very freely*; and is, therefore, soon *covered with dew*, which produces *rapid decomposition*.

Q. *Why do* PLANTS GROW RAPIDLY *in* MOON-LIGHT *nights?*

A. In bright moon-light nights *rapid radiation is carried on*, and *dew is plentifully deposited* on young plants, which conduces much to their growth and vigour.

Q. *Why is evening* DEW INJURIOUS *to* HEALTH*?*

A. Because the condensed vapours are always laden with *noxious exhalations from the earth*: this is especially the case in *marshy* countries.

Q. *Is* HONEY-DEW *a similar thing to* DEW*?*

A. No. Honey-dew is a sweet liquid *shed by a very small insect* (called the aphis), and deposited in autumn *on the under surface* of favourite leaves.

Q. *Does* HONEY-DEW INJURE *leaves, or do them good?*

A. It injures them very much, because it *fills the pores* of the leaf with a *thick clammy liquid*; and, therefore, prevents the leaf from *transpiring and absorbing*.

Q. *What* EFFECT *has honey-dew upon the* APPEARANCE *of a leaf?*

A. After a little time, the leaf (being *smothered* and *starved*) begins to turn a *dingy yellow*.

Q. *Are not* ANTS *very* FOND *of* HONEY-DEW*?*

A. Yes; and they crawl up the loftiest trees, in order to obtain it.

Q. *What is the cause of* MIST *(or earth-fog)?*

A. If the *night has been very calm*, a *rapid* radiation of heat has taken place in the earth; in consequence of which, the *air* (resting on the earth) *is made so cold*, that its vapour is *chilled*, and condensed into a thick mist.

Q. *Why does not the* MIST *become* DEW*?*

A. Because the chill of the air *is so rapid*, that vapour is condensed *faster than it can be deposited*; and (covering the earth in a mist) *prevents any further radiation of heat* from the earth.

Q. *When the earth can no longer* RADIATE *heat upwards, does it continue to* CONDENSE *the vapour of the air?*

A. No; the air (in contact with the earth) becomes about *equal in temperature* with the surface of the earth itself; for which reason, the mist is *not condensed into dew*, but remains *floating above the earth* as a thick cloud.

Q. *Why does this* MIST *seem to* RISE HIGHER *and* HIGHER, *and yet remain quite as dense below as before?*

A. The air *resting on the earth* is first chilled, and *chills the air* resting on *it*; the air which touches *this new layer of mist* being also *condensed*, layer is added to layer; and the mist seems to be *rising*, when (in fact) it is only *deepening*.

Q. *Why does* MIST *and* DEW VANISH *as the* SUN *rises?*

A. Because the condensed vapour is *again rarefied by the heat of the sun*, and separated into invisible particles.

Q. *Why is a* DEW-DROP ROUND*?*

A. Because every part of the drop *is equally balanced*; and, therefore, there is no cause why *one part* of the drop *should be further from the centre* than *another*.

Q. *Why is the* DEW-DROP *on a broad leaf sometimes* FLATTENED*?*

A. Whenever two or more drops of dew *roll together*, they make one large *spheroid* (or flattened drop).

Q. *Why will DEW-DROPS ROLL ABOUT CABBAGE-PLANTS, POPPIES, &c. without wetting the surface?*

A. The leaves of cabbages and poppies are *covered with a very fine powder*; and the dew-drop rolls over this fine powder, as a drop of rain *over dust*, without wetting the surface.

Q. *Why does not the drop of* RAIN WET *the* DUST *over which it rolls?*

A. Because it is driven from grain to grain by *capillary repulsion*.

Q. *Why does not the* DEW-DROP WET *the* POWDER *of the* CABBAGE*-plant?*

A. Because it is driven from grain to grain by *capillary repulsion*.

Q. *Why will* DEW-DROPS ROLL *over* ROSES, &c. *without wetting their petals?*

A. The leaves of a rose *contain an essential oil*, which prevents them from absorbing the dew immediately.

Q. *Why can a* SWAN *or* DUCK *dive under water* WITHOUT *being* WETTED*?*

A. Because their feathers are covered *with an oily secretion*, which repels the water.

Q. *What is the cause of* MIST*?*

A. When currents of air *from land* mix with currents of air *from water*, the currents *from the water are condensed into mist* by the colder currents *blowing from the land*.

Q. *Why are the currents of air from the* LAND COLDER *than those blowing over* WATER*?*

A. Because the earth *radiates heat very freely*, and (being greatly cooled down) *cools the air also* which comes in contact with it.

Q. *Why is not the* AIR, *which passes over* WATER, *so* COOL *as that which passes over* LAND*?*

A. Because *water does not cool down at sun-set*, so fast as the *land* does; and, therefore, the air in contact with it is *warmer*.

Q. *Why does not* WATER *cool down so fast as* LAND*?*

A. 1st—Because the *surface* of water is *perpetually changing*, and as fast as *one* surface is made cold, *another* is presented: and

2ndly—The moment water is made cold *it sinks*, and *warmer portions of water rise to occupy its place*: therefore, before the *surface of water is cooled*, the *whole volume* must be made cold; which is not the case with land.

Q. *What is the cause of a "pea-soup"* LONDON FOG*?*

A. These fogs (which occur generally in the winter time) are occasioned thus:—Some current of air (being suddenly *cooled*) *descends into the warm streets*, preventing the rise of the smoke, and *forcing it back in a mass* towards the earth.

Q. *Why are there not* ALWAYS FOGS *every night?*

A. Because the air will always hold in solution a certain quantity of vapour, (which varies according to its temperature): and when the air is *not saturated with vapour*, it may be condensed without parting with it.

Q. *Why are there* EVER FOGS *at night?*

A. If the air be *pretty well saturated with vapour* during the day, as soon as its capacity for holding vapour *is lessened by the cold night*, it deposits some of the superabundant vapour in the form of dew or fog.

Q. *Why is there very* OFTEN *a fog over* MARSHES *and* RIVERS *at night-time?*

A. The air of marshes is almost *always near saturation*; and, therefore, the *least depression of temperature*, will compel it to relinquish some part of its moisture in dew or fog.

Q. *What is the* DIFFERENCE *between* DEW *and* RAIN*?*

A. In *dew*, the condensation is made *near the earth's surface*:

In *rain*, the drops fall *from a considerable height*; but the cause of both is the same, viz.—COLD *condensing the vapour of the air*, when it is near the point of *saturation*.

Q. *Why does* MIST *and* FOG VANISH *at sunrise?*

A. Because the condensed particles are again *changed into invisible vapour*, by the heat of the sun.

Q. *What is the difference between a* MIST *and* FOG*?*

A. MIST is generally applied to *vapours condensed on marshes, rivers*, and *lakes*.

FOG is generally applied to *vapours condensed on land*, especially if those vapours are *laden with smoke*.

Q. *What is the reason why condensed vapour sometimes forms into* CLOUDS*, and sometimes into* FOG*?*

A. If the surface of the EARTH be *hotter than the air*, then the vapour of the earth (*being chilled by the cold air*) becomes FOG: but if the AIR be *hotter than the earth*, the vapour *rises through the air*, and becomes CLOUD.

Q. *If cold air produces* FOG*, why is it not foggy on a* FROSTY MORNING*?*

A. 1st—Because *less vapour is formed on a frosty day*; and

2ndly—The vapour *is frozen upon the ground* before it can rise from the earth, and becomes HOAR-FROST.

Q. *Why are* FOGS *more general in* AUTUMN *than in spring?*

A. In spring *the earth is not so hot* as it is in autumn. In AUTUMN the *earth* is generally *warmer than the air*; and, therefore, the vapour (issuing from the earth) *is condensed into fog* by the chill air.

Q. *Why are* FOGS *more common in* VALLEYS *than on* HILLS*?*

A. 1st—Because valleys *contain more moisture than hills*: and

2ndly—They are *not exposed to so much wind*, (which dissipates the vapour).

Q. *How does* WIND *dissipate* FOGS*?*

A. Either by *blowing them away*; or else by *dissolving them into vapour again*.

Q. *What is* HOAR-FROST*?*

A. There are two sorts of hoar-frost: 1.—FROZEN DEW: and 2.—FROZEN FOG.

Q. *What is the cause of the* GROUND *hoar-*FROST*, or frozen* DEW*?*

A. Very *rapid radiation of heat from the earth*; in consequence of which, the *surface is so cooled down*, that it *freezes the dew* condensed upon it.

Q. *Why is* HOAR-FROST *seen only after a very* CLEAR NIGHT*?*

A. Unless the night has been very clear indeed, the earth will not have thrown off heat enough by radiation, to *freeze* the vapour condensed upon its surface.

Q. *Why does* HOAR-FROST *very often* COVER *the* GROUND *and* TREES*, when the water of rivers is not frozen?*

A. Hoar-frost is not the effect of cold in the *air*, but the cold of the *earth* (produced by excessive radiation); in consequence of which, *the dew* (condensed upon it) *is frozen*.

Q. *Why is the* HOAR-FROST *upon* GRASS *and* VEGETABLES *much thicker than that upon lofty* TREES*?*

A. Because the air (resting on the *surface of the ground*) is much colder after sun-set, than the *air higher up*; in consequence of which, more vapour is condensed and frozen there.

Q. *Why is the* AIR *(resting on the surface of the* EARTH*) colder than that in the* HIGHER *regions?*

A. Because the *earth radiates more heat* than the *leaves of lofty trees*; and, therefore, *condenses and freezes* the vapour of the air *more rapidly*.

Q. *Why are* EVERGREENS *often* FROST-BITTEN*, when lofty trees are* NOT*?*

A. Evergreens do not *rise far above the surface of the earth*; and (as the air *contiguous to the earth* is much *colder than that in the higher regions*) therefore, the *low evergreen is often frost-bitten*, when the lofty tree is uninjured.

Q. *Why are* TOMB-STONES *covered with* HOAR-FROST, *long after it has melted from every object around?*

A. *White is a very bad absorbent of solar heat*; and, therefore, the *white tomb-stone* remains *too cold* to thaw the frost congealed upon its surface.

Q. *Why is there little or* NO HOAR-FROST *under* SHRUBS *and shadowy* TREES*?*

A. 1st—Because the leafy shrubs and trees *arrest the process of radiation* from the earth: and

2ndly—Shrubs and trees *radiate a little heat* towards the earth; and, therefore, the *ground beneath* is never *cold enough to congeal the little dew* which rests upon it.

Q. *What is the cause of that* HOAR-FROST *which arises from* FROZEN FOG*?*

A. The thick fog (which invested the earth during the night) is condensed *by the cold frost* of early morning, and *congealed upon every object* with which it comes in contact.

CHAPTER XVII.

5.—CONVECTION.

Q. *What is meant by the* CONVECTION *of* HEAT*?*

A. Heat communicated *by being carried* to another thing or place; as the hot water resting on the *bottom* of a kettle, carries heat to the water *through which it passes*. (*see p.* 246).

Q. *Are* LIQUIDS *good* CONDUCTORS *of heat?*

A. No; liquids are *bad conductors*; and are, therefore, made hot by *convection*.

Q. *Why are* LIQUIDS BAD CONDUCTORS *of heat?*

A. Because heat *converts a liquid into steam*, and flies off with the vapour, instead of being *conducted through the liquid*.

Q. *Explain how* WATER *is made* HOT*?*

A. The water *nearest the fire is first heated*, and (being heated) *rises to the top;* other cold water succeeds, is *also* heated, and rises in turn; and this interchange keeps going on, *till all the water boils*.

Q. *Why is* WATER *in such continual* FERMENT, *when it is* BOILING*?*

A. This commotion is mainly produced by the *ascending and descending currents* of hot and cold water.

The escape of *air* from the water contributes also to increase this agitation.

Q. *How do these two currents* PASS *each other?*

A. The *hot ascending current* passes close by the *metal sides* of the kettle; while the *cold descending current* passes *down the centre*.

Q. *Why does* BOILING WATER BUBBLE*?*

A. The bubbles are *portions of steam* (formed at the bottom of the vessel) which *rise to the surface*, and escape into the air.

Q. *Why does a* KETTLE RUN OVER, *when the water* BOILS*?*

A. As the heat insinuates itself between the particles of water, *it drives them asunder*; and (as the particles of water are *driven apart from each other*) the *same* vessel will no longer hold the expanded water, and some runs over.

Q. *Why does a* KETTLE SING, *when it is* ABOUT *to* BOIL*?*

A. Water contains *a great deal of air*, which (being expanded by the heat of the fire) escapes by fits *through the spout of the kettle*; which sings in the same way as a trumpet does, when a person blows in it.

Q. *Why does* WATER BOIL*?*

A. Boiling is the effect of a *more violent escape of air* from the heated water; when, therefore, the air is *not permitted to escape*, water will *never boil*.

Q. *Why is* HEAT *applied to the* BOTTOM, *and not to the top of a* KETTLE*?*

A. Because the heated water *always ascends to the surface*, heating the water through which it passes: if, therefore, heat were applied to the *top of a vessel*, the water *below the surface* would *never be heated*.

Q. *As the lower part of a* GRATE *is made* RED-HOT *by the fire* ABOVE, *why would not the* WATER *boil, if fire were applied to the* TOP*?*

A. The *iron* of a grate is an *excellent conductor*; and, therefore, if *one* part be heated, the heat is conducted to *every other part*: but *water* is a *very bad conductor*, and will not diffuse heat in a similar way.

Q. *How do you know that* WATER *is a* BAD CONDUCTOR *of heat?*

A. When a blacksmith immerses his red-hot iron in a tank of water, the water which *surrounds* the red-hot iron is made *boiling hot*, but the water *below* the surface remains quite cold.

Q. *If you wish to* COOL LIQUIDS, *where should the cold be applied?*

A. To the *top of the liquid*; because the *cold* portion will always *descend*, and allow the warmer parts to come in contact with the cooling substance.

Q. *Does* BOILING *water get hotter by being* KEPT *on the* FIRE*?*

A. No; not if the steam be suffered to escape.

Q. *Why does not boiling water get* HOTTER, *if the steam be suffered to* ESCAPE*?*

A. Because *as fast as the water boils*, it is converted into *steam*; and the steam *carries away* the additional heat, as fast as it is communicated.

Q. *Is* STEAM *visible or* INVISIBLE*?*

A. Steam is *invisible*; but when it comes in contact with the air (being *condensed into small drops*) it instantly becomes visible.

Q. *How do you know that* STEAM *is* INVISIBLE*?*

A. If you look at the spout of a boiling kettle, you will find that the steam (which issues from the spout) is always invisible *for about half an inch*; after which, *it becomes visible*.

Q. *Why is the steam* INVISIBLE *for only* HALF AN INCH, *and not either all* INVISIBLE *or all* VISIBLE*?*

A. The air is not able to condense the steam as it first issues from the spout, but when it *spreads* and comes in contact with a larger volume of air, the *invisible steam* is readily condensed into *visible drops*.

Q. *Why is our* BREATH VISIBLE *in winter-time?*

A. Because *it is condensed by the cold air* into small drops, which are visible to the eye.

Q. *Why do* STEAM-ENGINES *sometimes* BURST*?*

A. Steam is very *elastic*; and this elasticity increases in a greater proportion than the heat which produces it; unless, therefore, some *vent* be freely allowed, the steam heaves and swells, till it bursts the vessel which confined it.

Q. *What* BECOMES *of the steam, after it has been condensed?*

A. It is *dissolved by the air*, and forms a part of its invisible vapour.

Q. *Is* AIR *a good* CONDUCTOR*?*

A. No; *air is a very bad conductor*, and is heated (like water) *by convection*.

Q. *How is a* ROOM WARMED *by a* STOVE*?*

A. The air *nearest the fire* is made hot *first*; *the cold air descends*, is heated also, and rises in turn; and this goes on, *till all the air of the room is warmed*.

Q. *Why are* FIRES *placed on the* FLOOR *of a room, and not towards the* CEILING*?*

A. As heated air always *ascends*, if the fire were not *near the floor*, the lower part of the air (which we want to be the warmest) would never be benefited by the fire at all.

Q. *If you take a* POKER *out of the fire, and hold the* HOT END DOWNWARDS*, why is the* HANDLE *so intensely* HOT*?*

A. Because the hot end of the poker *heats the air around it*, and this hot air (in its ascent) *scorches the poker*, and the *hand which holds it*.

Q. *How should a* RED-HOT POKER *be carried so as not to* BURN *our fingers?*

A. With the hot end *upwards*; because then the air (heated by the poker) *would not pass over our hand* to scorch it.

Q. *Why is a* POKER *(resting on the* FENDER*)* COLD*; but if it leans against the* STOVE*, intensely warm?*

A. The poker is an *excellent conductor*; while, therefore, it rests against the hot stove, the heat of the stove is *conducted into the poker*; but when it *rests on the fender*, it does not come in *contact with the hot stove*.

Q. *Why does it feel so* COLD*, when it rests on the* FENDER*?*

A. Not being so warm as our hand, it *imbibes the heat from it* with such *rapidity*, that our loss of heat is *palpable*, and produces the sensation of coldness.

Q. *Why are* FLUES *(which are carried through a church or room) always* BLACKENED *with* BLACK LEAD*?*

A. In order that the heat of the flue *may be more readily diffused* throughout the room. Black lead radiates heat more freely than any other known substance.

Q. *Why do country people touch the thick end of an* EGG *with their* TONGUE, *to know if it be* STALE *or not?*

A. The thick end of an egg always contains *a little air* (between the shell and the white); but, when the egg is stale, *the white shrinks*, and the air expands.

Q. *How can the* TONGUE *tell from this, whether the egg be* STALE *or* FRESH *laid?*

A. As air is a *very bad conductor*, if the egg be *stale*, it will feel much *warmer to the tongue*, than if it be new-laid.

Q. *Why will the big end of an egg feel* WARMER *to the tongue, because it contains more* AIR*?*

A. As air is a *bad conductor*, it will draw off the heat of the tongue *very slowly*, and, therefore, *appear warm*; but when there is only a *very little air in the egg* (as the *white* is a pretty good conductor), the heat of the tongue will be *more rapidly* drawn off, and the egg *appear colder*.

Q. *Why is the large* END *of an* EGG CRACKED, *when put into a saucepan to boil?*

A. *To let the air out*; if the large end were *not cracked*, the air (expanded by the heat) *would enter the white of the egg*, and give it an *offensive taste*.

PART II.

AIR.

CHAPTER XVIII.

Q. *Of what is atmospheric* AIR *composed?*

A. Principally of two gases, *oxygen* and *nitrogen*; mixed together in the following proportion: viz. 1 part of oxygen, to 4 parts of nitrogen.

Q. *What are the uses of the* OXYGEN *of the air?*

A. It is the *oxygen* of the air which *supports combustion*, and *sustains life*.

Q. *What is meant when it is said, that the* OXYGEN *of the air "*SUPPORTS COMBUSTION*?"*

A. It means this; that it is the *oxygen of the air* which makes *fuel burn*.

Q. *How does the* OXYGEN *of the air make* FUEL BURN*?*

A. The fuel being decomposed (by heat) into *hydrogen* and *carbon*; the *carbon combines with the oxygen of the air*, and produces *combustion*.

Q. *What does the combination of carbon and oxygen produce?*

A. The *carbon of the fuel* combining with the *oxygen of the air* makes CARBONIC ACID GAS. (*see pp. 36, 37*).

Q. *What becomes of the* HYDROGEN *of the* FUEL*?*

A. Hydrogen (being very inflammable) *burns with a blaze*, and is the cause of the *flame* which is produced by combustion. (*see p.34*).

Q. *What becomes of the* NITROGEN *of the air, amidst all these changes and combinations?*

A. The *nitrogen of the air escapes*, and is *absorbed by the leaves* of grass, trees, and various other vegetables.

Q. *What is meant when it is said, that* OXYGEN *"*SUSTAINS LIFE*"?*

A. It means this: if a person *could not inhale oxygen*, he would *die*.

Q. *What* GOOD *does this inspiration of* OXYGEN *do?*

A. 1st—It gives *vitality to the blood*: and

2ndly—It is the *cause of animal heat*.

Q. *How is* FOOD *converted into* BLOOD*?*

A. After it is swallowed, it is dissolved in the stomach into a *grey pulp*; it then passes into the intestines, and is converted by the "bile" *into a milky substance* (called *chyle*).

Q. *What* BECOMES *of the milky substance, called* CHYLE*?*

A. It is absorbed by the vessels called "*lacteals*," and poured into the veins *on the left side of the neck*.

Q. *What becomes of the chyle* AFTER *it is* POURED *into the* VEINS*?*

A. It then *mingles with the blood*, and is itself *converted into blood*.

Q. *How does the* OXYGEN *we inhale* MINGLE *with the* BLOOD*?*

A. The oxygen of the air mingles with the blood *in the lungs*, and converts it into a *bright red colour*.

Q. *What colour is the blood* BEFORE *it is oxydized in the lungs?*

A. *A dark purple.* The oxygen turns it to *a bright red*.

Q. *Why are* PERSONS *so* PALE *who live in* CLOSE ROOMS *and* CITIES*?*

A. The blood derives its redness from the *oxygen* of the air inhaled; but, as the air in close rooms and cities *is not fresh*, it is *deficient in oxygen*, and cannot turn the blood to a beautiful bright red.

Q. *Why are* PERSONS *who live in the* OPEN AIR *and in the country, of a* RUDDY *complexion?*

A. As the blood derives its bright red colour from the *oxygen* of the air inhaled, therefore, country-people (who inhale *fresh air*) are more ruddy than citizens.

Q. *Why is not the air in* CITIES *so* FRESH *as that in the* COUNTRY*?*

A. Because it is impregnated with the *breath of its numerous inhabitants*, the *odour of its sewers*, the *smoke of its fires*, and many other impurities.

Q. *How does the* COMBINATION *of* OXYGEN *with the* BLOOD *produce animal* HEAT*?*

A. The principal element of the blood is *carbon*, which (combining with the oxygen of the air inhaled) produces *carbonic acid gas*, (in the same way as burning fuel.) (*see pp.*33,36).

Q. *What becomes of the* NITROGEN *of the air, after the oxygen enters the blood?*

A. The nitrogen is *exhaled*, and taken up by the leaves of trees and other vegetables. (*see p.*35).

Q. *Why does the vitiated air (after the oxygen has been absorbed) come out of the mouth, and not sink into the stomach?*

A. The vitiated air (being *heated by the heat of the body*) *ascends naturally*, and passes by the *heavier fresh air* (which we inhale) without obstruction or injury.

Q. *If (both in combustion and in respiration) the oxygen of the air is consumed, and the nitrogen rejected—Why are not the proportions of the air destroyed?*

A. Because the *upper surface of vegetable leaves* (during the day) *gives out oxygen* and *absorbs nitrogen*, and thus the proper balance is perpetually restored.

Q. *Show how God has made animal and vegetable life dependent on each other?*

A. *Animals* require *oxygen* to keep them alive, and *draw it from the air* by inspiration; the upper surface of *leaves* (all day long) *gives out oxygen*, and thus supplies the air with the *very gas* required by man and other animals.

Q. *Do not animals exhale the very gas needed by vegetables?*

A. Yes; animals reject the *nitrogen of the air* (as not suited to the use of animal life), but *vegetables absorb it*, as it is the food they live on; and thus the vegetable world restores the equilibrium of the air, disturbed by man and other animals.

Q. *Is air a good conductor?*

A. No; air is a very *bad conductor*.

Q. *How is air heated?*

A. By “convective currents.”

Q. *What are meant by “convective currents?”*

A. When a portion of air is heated, *it rises upward in a current*, carrying the heat with it: other *colder air succeeds*, and (being *heated* in a similar way) *ascends also*; and these are called convective currents.

(“Convective currents;” so called from the Latin words, cum-vectus (*carried with*) because the *heat* is “carried with” the current.)

Q. *Is air heated by the rays of the sun?*

A. No; air is *not heated* (in any sensible degree) *by the action of the sun’s rays* passing through it.

Q. *Why then is the* AIR HOTTER *on a* SUNNY DAY, *than on a* CLOUDY *one?*

A. On a fine day, the sun *heats the surface of the earth*, and the air (resting on the earth) *is heated by contact*; as soon as it is heated *it ascends*, and *other* air succeeding is *heated in a similar way*, till all is heated by convection.

Q. *If* AIR *be a* BAD CONDUCTOR, *why does hot* IRON *get* COLD, *by being* EXPOSED *to the* AIR?

A. A piece of hot iron exposed to the air, is made cold—1st—By "convection;" and

2ndly—By "radiation."

Q. *How is hot iron (exposed to the air) made cold by* CONVECTION?

A. The air around the iron (being intensely heated by contact) rapidly ascends, *carrying some of its heat with it*: other air succeeds, *absorbs more heat*, ascends, and gives place to that which is *colder*; till the hot iron *is cooled completely down*.

Q. *How is hot iron cooled by* RADIATION?

A. While the heat of the iron is being carried off by "convection," it is *throwing off heat* (on all sides) *by radiation*.

Q. *What is meant by* RADIATION?

A. Heat emitted (in all directions) from any surface, by *innumerable rays*.

Q. *Why is* BROTH COOLED *by being left exposed to the* AIR?

A. Hot broth throws off *some* heat by *radiation*; but it is *mainly* cooled down *by convection*.

Q. *How is hot* BROTH *cooled down by* CONVECTION?

A. The air *resting on the hot broth* (being heated) *ascends*; *colder* air succeeding *absorbs more heat*, and *ascends also*; and this process is repeated, till the broth is *made cool*.

Q. *Why is hot* TEA *and* BROTH COOLED *faster, for being* STIRRED *about?*

A. 1st—The agitation assists the liquor in *bringing its hottest particles to the surface*:

2ndly—The action of stirring *agitates the air*, and brings it *quicker* to the broth or tea: and

3rdly—As the hottest particles are more rapidly brought into contact with the air, therefore *convection is more rapid*.

Q. *Why is* HOT TEA, &c. *cooled more rapidly by* BLOWING *it?*

A. Because the heated air is *blown more rapidly away*; in consequence of which, *cold air more rapidly succeeds* to *absorb heat* from the surface of the tea or broth.

Q. *If a shutter be closed in the day-time, the stream of light (piercing through the crevice) seems in* CONSTANT AGITATION. WHY *is this?*

A. The air (in the sun-beam piercing through the shutter-crevice) is *more heated*, than *that in its neighbourhood*; the convective current, therefore, is *distinctly seen*, where little motes and particles of dust are *thrown into agitation* by the *violence* of the current.

Q. *Why is the* GALLERY *of a* CHURCH *or theatre* HOTTER *than the* AISLE *or pit?*

A. The hot air ascends from the *bottom* to the *top of the room*, and cold air (from the doors and windows) flies to the *bottom* to supply its place.

Q. *Why does a* CROWDED ROOM *produce* HEAD-ACHE*?*

A. Because we breathe air *vitiated by the crowd*.

Q. *How does a* CROWD VITIATE *the* AIR *of a* ROOM*?*

A. Whenever we breathe, the elements of the air are *separated* in the lungs, *some of the oxygen is absorbed by the blood*, and some of it is converted into *carbonic acid gas*, and exhaled with the nitrogen.

Q. *Is* ALL *the* NITROGEN REJECTED *by the lungs?*

A. Yes; all the nitrogen of the air is always exhaled.

Q. *What is* CARBONIC ACID GAS*?*

A. As carbon has a very great affinity for oxygen, therefore, whenever they are exposed to heat, they *combine*, and form carbonic acid gas (or what is vulgarly called fixed air).

Q. *Is* CARBONIC ACID GAS *wholesome?*

A. No; it is quite *fatal to animal life*; and whenever it is inhaled, it acts like a narcotic poison, (producing drowsiness which ends in death).

Q. *Why is a* CROWDED ROOM UNWHOLESOME*?*

A. Because the oxygen of the air is either *absorbed by the lungs*, or substituted for *carbonic acid gas*, which is a noxious poison.

Q. *Mention the historical circumstances, so well known in connection with the "Black Hole of Calcutta."*

A. In the reign of George II, the Raja (or Prince) of Bengal[12] marched suddenly to Calcutta to drive the English from the country; as the attack was unexpected, the English were obliged to submit, and 146 persons were taken prisoners.

[12] The Sur Raja, at Dowlat; a young man of violent passions, who had but just succeeded to the throne. A. D. 1756.

Q. *What became of these prisoners?*

A. They were driven into a place about 18 feet square, and 15 or 16 feet in height, with only two small grated windows. 123 of the prisoners died in one night; and (of the 23 who survived) the larger portion died of putrid fevers, after they were liberated in the morning.

Q. *Why were 123 persons suffocated in a few hours, from confinement in this close hot prison-hole?*

A. Because the *oxygen of the air* was soon consumed by so many lungs, and its place supplied by *carbonic acid* exhaled by the hot breath.

Q. *Why do persons in a crowded church feel drowsy?*

A. 1st—Because the crowded congregation *inhale a large portion of the oxygen of the air*, which alone can sustain vitality and healthy action: and

2ndly—The air of the church is impregnated with carbonic acid gas, which (being a strong narcotic) produces drowsiness in those who inhale it.

Q. *Why did the captives in the black hole die sleeping?*

A. 1st—Because the *absence of oxygen* quickly affects the vital functions, depresses the nervous energies, and produces a lassitude which ends in death: and

2ndly—The *carbonic acid gas* inhaled by the captives (being a narcotic poison) would also produce *drowsiness and death*.

Q. *Why do persons, who are so much in the open air, enjoy the best health?*

A. Because the air they inhale is *much more pure*.

Q. *Why is country air more pure than the air in cities?*

A. 1st—Because there are fewer inhabitants to vitiate the air:

2ndly—There are more trees to restore the equilibrium of the vitiated air: and

3rdly—The free circulation of air keeps it pure and wholesome (in the same way as running streams are pure and wholesome, while stagnant waters are the contrary).

Q. *Why does the* SCANTINESS *of a country* POPULATION *render the* COUNTRY AIR *more* PURE*?*

A. Because the fewer the inhabitants, *the less carbonic acid will be exhaled*; and thus country people will inhale *pure oxygen*, instead of air *impregnated with the narcotic poison*, called carbonic acid gas.

Q. *Why do* TREES *and* FLOWERS *help to make country* AIR WHOLESOME*?*

A. Because trees and flowers *absorb the carbonic acid* generated by the lungs of animals, putrid substances, and other noxious exhalations.

Q. *Why is the* AIR *of* CITIES LESS *wholesome than* COUNTRY *air?*

A. 1st—Because there are *more inhabitants* to vitiate the air:

2ndly—The *sewers*, *drains*, *bins*, and *filth of a city*, very greatly vitiate the air:

3rdly—The streets and alleys prevent a free circulation: and

4thly—Besides all this, there are fewer trees to absorb the excess of carbonic acid gas, and *restore the equilibrium*.

Q. *Why are* PERSONS *who live in* CLOSE ROOMS *and crowded* CITIES*, generally* SICKLY*?*

A. Because the air they breathe is not pure, but is both *defective in oxygen*, and impregnated with *carbonic acid gas*.

Q. *Where does the* CARBONIC ACID *of close* ROOMS *and* CITIES COME *from?*

A. From the lungs of the inhabitants, the sewers, drains, and so on: besides, trees and gardens are not numerous enough *to absorb the noxious gas* as fast as it is generated.

Q. *What* BECOMES *of the* CARBONIC ACID *of crowded cities?*

A. Some of it is *absorbed by vegetables*, and the rest is *blown away by the wind*, and diffused through the whole volume of the air.

Q. *Does not this constant diffusion of carbonic acid affect the* PURITY *of the* WHOLE AIR*?*

A. No; because after it is thus diffused, *it is carried to various lands*, and *absorbed* in its passage by the *vegetable world*.

Q. *Why do persons who ascend in balloons feel intense pain in their eyes and ears?*

A. Because the air of the upper regions is *more rarefied than the air on the earth*; and the air inside their bodies (seeking to become of the same rarity) *bursts through their eyes and ears*, producing an intense pain.

Q. *Why is it often* PAINFUL, *and difficult to* BREATHE, *on a* MOUNTAIN *top?*

A. Because the pressure of air on the mountain top is *not so great as on the plain*; and the air inside our bodies (seeking to become of the same rarity) *bursts through the pores of the body*, and produces great pain.

Q. *Why do we feel* OPPRESSED *just* PREVIOUS *to a* STORM*?*

A. Because the air is *greatly rarefied by heat and vapour*; and the air inside us (seeking to become of the same rarity) produces an oppressive and suffocating feeling.

Q. *Why do* DIVERS *suffer great pain in their eyes and ears under water?*

A. Because the air at the bottom of the sea *is more dense* than the air *on the surface*; and while the air inside the diver's body is settling into the same density, he feels oppressed with pain, especially in the ears.

Q. *Why is this* PAIN *felt especially about the* EARS *of a* DIVER*?*

A. The ear is fitted with a small membrane called *the drum* (or tympanum), through which the dense air bursts, and the rupture very often *produces incurable deafness*.

Q. *Why do our* CORNS *ache just previous to* RAIN*?*

A. Previous to rain, the density of air is greatly lowered (as every one knows from the fall of the barometer); in consequence of an unequal pressure, *our feet swell*; but the hard corn, *not being elastic*, is painfully stretched and pressed.

(Some of this pain is due to electricity.)

Q. *Why do* CELLARS *feel* WARM *in* WINTER*?*

A. As the external air has not free access into cellars, they remain at a *pretty even temperature*, which (in winter time) is about 10 degrees *warmer* than the external air.

Q. *Why do* CELLARS *feel* COLD *in* SUMMER *time?*

A. As the external air has not free access into cellars, they remain at a *pretty even temperature*, which (in summer time) is about 10 degrees *colder* than the external air.

Q. *Why does lightning strike the* OAK*-tree more frequently than any* OTHER *tree?*

A. 1st—Because the *grain of the oak, being closer* than that of any other tree, renders it a better conductor: and

2ndly—The *sap* of the oak contains a *large quantity of iron* in solution, which is a most admirable

conductor of lightning.

Q. *Why does air rust iron?*

A. The *oxygen of the air* combines with the *surface of the iron*, and produces *oxide of iron*, which is generally called rust.

This rust is a species of combustion.

Q. *Why does hot iron scale and peel off, when struck with a hammer?*

A. The *oxygen of the air* very readily unites with *the surface of the hot iron*, and forms a metallic oxide (or rust) which scales off when struck with a hammer.

Q. *Does iron rust in dry air?*

A. No; iron undergoes no change in dry air.

Q. *Why do stoves and fire-irons become rusty, in rooms which are not occupied?*

A. Because the air is damp; and moist air *oxidizes* (or rusts) iron and steel.

Q. *In what part of the year is it most difficult to keep stoves and fire-irons bright?*

A. In *autumn and winter*; because the capacity of the air for holding water *being on the decrease*, its vapour is deposited on every-thing with which it comes in contact.

Q. *Why does greasing iron prevent its becoming rusty?*

A. Because *grease* prevents the humidity of air from coming in contact with the *surface of the iron*.

Q. *Why do not stoves rust so frequently as pokers and tongs?*

A. Because stoves are generally *covered with plumbago*, or black lead.

Q. *What is plumbago, or black lead?*

A. A mixture of charcoal and iron filings.

A most excellent varnish to prevent rust is made of 1 pint of fat oil varnish, mixed with 5 pints of highly rectified spirits of turpentine, rubbed on the iron or steel with a piece of sponge. This varnish may be applied to bright stoves and even mathematical instruments, without injuring their delicate polish.

Q. *Why does ornamental* STEEL *(of a purple or* LILAC *colour) rust more readily than polished* WHITE *steel?*

A. Because the lilac tinge is produced by *partial oxidation*; and the process which forms rust has, therefore, *already* commenced.

Q. *How can lilac* STEEL *be kept* FREE *from* RUST*?*

A. By keeping it in a very *dry place*; for then no additional oxygen will come in contact with it, to increase its amount of rust.

Q. *Do any* OTHER *metals (besides iron) combine rapidly with oxygen?*

A. Yes; copper, lead, mercury, and even silver to some extent.

Q. *Why does* COPPER TARNISH*?*

A. The tarnish of copper is caused by its *oxidation*; that is, the oxygen of the air combines with the surface of the copper, and instead of *rusting it*, covers it with a *dark tarnish*.

Q. *Why does* LEAD *lose its* BRIGHTNESS*, and become* DULL *and of a* DARKER *hue, by being exposed to the air?*

A. The vapour of the air combines with the lead, and *oxidizes its surface*; but instead of becoming *rusty*, the surface becomes *dull*, and of a *darker colour*.

Q. *Why is it difficult to keep* SILVER BRIGHT*?*

A. Because the vapour of the air oxidizes its surface, and *tarnishes* it.

Q. *Why do silver* TEA-POTS *and* SPOONS *tarnish more quickly than silver ore or bullion?*

A. Because alloy (of some *baser* metal) is used to make it more *hard and lasting*; and this *alloy* oxidizes more quickly than silver itself.

Q. *Why does* GERMAN *silver turn a dingy yellow in a few hours?*

A. German silver has a great affinity for oxygen, and shows its oxidation by a *sickly yellow tarnish*, instead of rust.

Q. *If quicksilver (or mercury) is tarnished like copper and lead,—Why does it preserve its* BRILLIANCY *in* BAROMETERS *and* THERMOMETERS*?*

A. Because *air* is excluded from it, and no moisture comes in contact with it to *oxidize* (or *tarnish* it).

Q. *Is* GOLD *affected by the atmosphere?*

A. Not readily: gold will never combine with oxygen of itself, (or without aid).

Q. *Which of the* METALS *is capable of resisting oxidation altogether?*

A. Plat'inum; in consequence of which, the graduated arcs of delicate instruments for observation are made of plat'inum instead of any *other* metal.

Q. *Why is* PLAT'INUM *used for the graduated arcs of delicate mathematical instruments, instead of any other metal?*

A. Because it will never oxidize; but retain its *bright surface* in all weathers free from both *rust and tarnish*.

Q. *Before plat'inum was discovered, which of the metals was employed for the same purpose?*

A. Gold.

Platinum, (a white metal), so called from "plata," the Spanish word for *silver*. It was first introduced into England by Mr. Wood, (A. D. 1749) from South America.

Q. *For what other* SCIENTIFIC *purposes is* PLAT'INUM *now used?*

A. For crucibles in which *acids* are employed, and for galvanic batteries.

Q. *Why are* CRUCIBLES *(in which acids are employed) made of* PLAT'INUM*?*

A. Because the acid would act upon *other metals*, or upon *glass*, and prevent the experimenter's success.

Q. *Which of the* METALS *have the* GREATEST *affinity to* OXYGEN*?*

A. Those called *potassium* and *sodium*.

Potassium and sodium derive their names from potash and soda. Potassa is the oxide of potassium; and soda is the oxide of sodium.

Q. *How is the affinity of potassium and sodium for oxygen shewn?*

A. They *decompose water* the moment they are brought into contact with it.

Q. *What effect has* POTASSIUM *on* WATER*?*

A. It *catches fire* the moment it is thrown into water, and burns with a vivid flame, which is still further increased by the combustion of *hydrogen* separated from the water.

(N.B. Water is composed of oxygen and hydrogen; and potassium separates the two gases.)

Q. *What effect has* SODIUM *on* WATER*?*

A. It does *not take fire* as potassium does, but undergoes very rapid *oxidation*.

Q. *Is the* FURR *of* KETTLES *an oxide?*

A. No; the furr (or deposit of boiling water) is a precipitate of *lime and mineral salt*, separated from the water by the process of boiling.

Q. *Is not this* FURR *of boiling water often* DANGEROUS*?*

A. Yes; especially in *tubular boilers*, such as those employed in railways.

Q. *Why is this* FURR *especially* TROUBLESOME *in* RAILWAY *engines?*

A. Because it is a *bad conductor of heat*; in consequence of which, it hinders the evaporating effect of the fire, and prevents the economy of fuel.

Q. *Why is this* FURR *especially* DANGEROUS *in* RAILWAY *engines?*

A. Because when it is deposited in the boilers, they are likely to become *over-heated*; and then *explosion* will take place from the sudden generation of highly elastic steam.

Q. *Why cannot* RAILWAY *engines be fed with* BRACKISH WATER*?*

A. Because brackish water contains *mineral salt*, which makes a much larger deposit of furr, than that which contains *only vegetable matter*.

CHAPTER XIX.
CARBONIC ACID GAS.

Q. *What is* CHOKE DAMP*?*

A. *Carbonic acid gas* accumulated at the bottom of wells and pits, which renders them noxious, and often fatal.

Q. *Why is not this carbonic acid* TAKEN UP *by the* AIR, *and* DIFFUSED, *as it is in cities?*

A. Because (being *heavier than common air*) it cannot *rise from the well or pit*; and no wind can get to it to blow it away.

Q. *Is* CARBONIC ACID WHOLESOME*?*

A. No; it is *fatal to animal life*, when inhaled through the mouth; acting on the stomach, *as a narcotic poison* (i. e.. a poison which produces death from drowsiness).

Q. *How can any one* KNOW, *if a place be infested with* CARBONIC ACID GAS*?*

A. If a pit or well contain carbonic acid, *a candle* (let down into it) *will be instantly extinguished*. The rule, therefore, is this—Where a *candle will burn, a man can live*; but *what will extinguish a candle*, will *also destroy life*.

Q. *Why does a* MINER *lower a* CANDLE *into a mine, before he descends?*

A. Because the *candle will be extinguished*, if the mine contains carbonic acid gas: but if the candle is *not extinguished*, the mine is *safe*, and the man may fearlessly descend.

Q. *Why are* PERSONS *sometimes* KILLED, *by leaning over* BEER VATS*?*

A. Vats (where beer has been made) contain a *large quantity of carbonic acid gas*, produced by the "vinous fermentation" of the beer; and when a man incautiously *leans over a beer vat*, and inhales the carbonic acid, he is immediately *killed* thereby.

Q. *Why are* PERSONS *often* KILLED, *who enter* BEER VATS *to clean them?*

A. Carbonic acid (being *heavier than atmospheric air*) often rests upon the *bottom of a vat*: when, therefore, a person enters the vat, and *stoops to clean the bottom*, he inhales the pernicious gas, which *kills* him.

Q. *Why are the* JUNGLES *of Jarva and Hindostan so* FATAL *to life?*

A. Because vast quantities of *carbonic acid* are thrown off by decaying *vegetables*; and (as the wind cannot penetrate the thick brushwood to blow it away) *it settles there*, and destroys animal life.

Q. *Why are* PERSONS *sometimes* KILLED *by having a* CHARCOAL FIRE *in their bed-rooms?*

A. When charcoal is burned, the *carbon of the charcoal* unites with the *oxygen of the air*, and forms *carbonic acid gas*, which is a narcotic poison.

Q. *Why does the carbonic acid gas of a* CHARCOAL FIRE RISE *and* DISPERSE *itself about the room; whereas the carbonic acid gas of a* BEER VAT SETTLES *near the* FLOOR*?*

A. The carbonic acid gas of a charcoal fire *is heated* by the *combustion of the fuel*, and rises; but the carbonic acid gas of a beer vat is *not* heated, and, therefore, rests on the *bottom of the vat*.

Q. *Why do persons throw* LIME *into* BINS *to* PREVENT *their offensive* SMELL, *in summer time?*

A. Bins contain large quantities of *carbonic acid gas*, which readily *combines with lime*, and produces "*carbonate of lime*," which is entirely free from all offensive odour.

Q. *Why do persons throw* LIME *into* SEWERS *in summer time?*

A. Sewers (like bins) contain large quantities of *carbonic acid*, which readily *combines with lime*, and produces *carbonate of lime*; and thus the offensive gas of the sewer is neutralized.

Q. *Can carbonic acid be removed in any way* BESIDES *by* LIME*?*

A. Yes; *water* thrown into a pit will disperse the carbonic acid.

Q. *What effect has* WATER *on* CARBONIC ACID GAS*?*

A. Water (under *pressure*) *absorbs* carbonic acid gas; and *parts* with it (when the *pressure is removed*) in the form of EFFERVESCENCE.

Q. *Why does* AERATED WATER *effervesce, when the* CORK *is removed?*

A. While the *cork was fastened down*, the water *absorbed* the carbonic acid; but the moment *the pressure is removed* (by taking out the cork) the gas is given out with *effervescence*.

Q. *Why does* SODA WATER *effervesce?*

A. Soda water contains 8 times its own bulk of carbonic acid gas, which makes its escape in *effervescence*, the moment that the *cork is removed*.

Q. *Why does* GINGER POP *fly about in froth, when the string of the cork is cut?*

A. All vinous fermentation produces carbonic acid gas. While the *cork is fast*, the water of the liquor *absorbs* the carbonic acid; but the moment that the *pressure is removed*, the gas is given off in *effervescence*.

Q. *Why does* BOTTLED ALE *froth, more than* DRAUGHT *ale?*

A. Because the *pressure* is greater in a *bottle* than in a tub which is perpetually tapped: and effervescence is always produced *in proportion to the pressure*.

Q. *Why does bottled* ALE *and* PORTER *become "*LIVELY*" and* FROTHY *by being* SET *before the* FIRE*?*

A. The heat of the fire *expands the air* (between the liquid and the cork), and as this air expands, *it presses the liquid down*, which causes effervescence.

Q. *What produces the* FROTH *of* BOTTLED PORTER*?*

A. The *carbonic acid gas*, produced by its *vinous fermentation*; which is *absorbed by the liquor* so long as the bottle is *well corked*, but is *given off in froth* as soon as the pressure of the cork is *removed*.

Q. *What gives the pleasant* ACID *taste to soda water, ginger beer, champagne, and cider?*

A. The presence of *carbonic acid*, generated by fermentation, and liberated by effervescence when the pressure of the cork is removed.

Q. *Why does fresh* SPRING WATER SPARKLE, *when poured from one vessel to another?*

A. Because fresh spring and pump water contain *carbonic acid*; and it is the presence of this gas *which makes the water sparkle*.

Q. *What is the* FERMENTATION *of* BEER *and* WINE*?*

A. The production of carbonic acid gas and al'cohol.

Q. *How is* CARBONIC ACID GAS *produced by* FERMENTATION*?*

A. Malt and fruit *both contain sugar*; and sugar consists of carbon, oxygen, and hydrogen. In fermentation, a part of the *carbon and oxygen* of the sugar escape, *in the form of carbonic acid gas*.

Carbonic acid gas is a compound of carbon and oxygen, in the following proportions:—3 lbs. of carbon and 8 lbs. of oxygen will form 11 lbs. of carbonic acid gas. Now, 100 lbs. of white sugar contains 43 lbs. of carbon; 50 lbs. of oxygen; and 7 lbs. of hydrogen.

Q. *How is* AL'COHOL *produced by* FERMENTATION*?*

A. The *hydrogen of the sugar* combines with the *residue of the oxygen and carbon* to form "AL'COHOL."

Q. *What is* AL'COHOL*?*

A. Al'cohol is the *spirit* of wine or beer, obtained by *fermentation*.

(100 gallons of alcohol consist of 38 gallons of oxygen; 43-1/2 of carbon; 15 of hydrogen; and 3-1/2 of nitrogen.)

Q. *Why is* BARLEY MALTED*?*

A. Because *germination* is produced by the artificial heat; and in germination the *starch of the grain* is converted into *sugar*.

Q. *How is barley malted?*

A. The barley is *moistened with water*, and *heaped up*; by which means, great *heat* is produced, which makes the *barley sprout*.

Q. *Why is not the* BARLEY *suffered to* GROW*, as well as* SPROUT*?*

A. Plants in the *germ* contain *more sugar* than in any *other state*; as soon as the germ *puts forth shoots*, the *sugar* of the plant is *consumed*, to *support the shoot*.

Q. *How is* BARLEY PREVENTED *from* SHOOTING*, in the process of* MALTING*?*

A. The barley is *put into a kiln* as soon as it sprouts; and the *heat* of the kiln checks or *destroys the young shoot*.

Q. *Why is* YEAST *put into* BEER *to make it* WORK*?*

A. Yeast supplies the beer with *nitrogen*, which is one of the ingredients of alcohol.

Alcohol consists of *oxygen*, *carbon*, and *hydrogen*, (obtained from the sugar of malt), and *nitrogen*, (obtained from yeast).

Q. *Why is it* NOT *needful to put* YEAST *into* WINE*?*

A. Because fruit contains *carbon*, *hydrogen*, *oxygen*, and *nitrogen*, in the form of "gluten;" and, therefore, ferments *spontaneously*.

(Gluten is explained fully in the Appendix.—Turn to the word in the Index.)

Q. *Does not* MALT *contain carbon, hydrogen, oxygen, and nitrogen, as well as* FRUIT*?*

A. No; the sugar of malt contains *carbon*, *hydrogen*, and *oxygen*, but *no nitrogen*; in consequence of which, *yeast* (which contains *nitrogen*) is *added to the wort*.

Q. *Why do* NOT GRAPES *ferment while they hang on the* VINE*?*

A. 1st—Because the skin lets out the *water of the pulp*, which causes the grapes to shrivel and dry up: and

2ndly—The skin *prevents* the admission of *oxygen into the pulp*, from the air without.

Q. *What is the* FROTH *or* SCUM *of fermented* LIQUORS*?*

A. *Carbonic acid gas*, which (being heavier than common air) *settles on the top of the liquor*, in the form of scum.

Q. *Why does a small piece of raw* MEAT*, or a few* RAISINS *improve* FLAT BEER*?*

A. 1st—Because they supply it with *nitrogen* to form it into al'cohol.

2ndly—As the raw meat, &c. *putrifies*, it gives off *carbonic acid gas* into the beer, which gives it "life."

Q. *Why is* BEER FLAT*, if the cask be open too long?*

A. Because *too much of the carbonic acid gas* (produced by fermentation) is suffered to *escape*.

Q. *How is the* CARBONIC ACID GAS *of* BEER *generated?*

A. The saccharine (or sugar) of the malt is converted by *fermentation* into carbonic acid gas and alcohol.

Q. *Why does* BEER *turn* FLAT*, if the* VENT PEG *be left* OUT *of the tub?*

A. Because the *carbonic acid gas escapes* through the vent hole.

Q. *Why will* NOT *beer* RUN OUT *of the tub, till the* VENT PEG *is taken out?*

A. When the tap is turned, *air rushes through the tap* into the bottom of the tub, and *holds the liquor in*.

The *upward* pressure of air is illustrated by the

following simple experiment:—Fill a wine-glass with water; cover the top of the glass with a piece of writing paper; turn the glass topsy turvy, and the water will not run out. The paper is used merely to give the air a medium sufficiently dense to act against.

Q. *Why does the* BEER RUN FREELY*, immediately the* VENT PEG *is taken out?*

A. As soon as the vent peg is taken out, air rushes *through the vent hole* at the *top of the tub*,—presses the liquor *down*, and *forces it through the tap*.

Q. *Why does liquor flow reluctantly out of a* BOTTLE *held upside down?*

A. Because the *upward pressure of the air* prevents the liquor from flowing out.

Q. *Why should a bottle be held* OBLIQUELY, *in order to be emptied of its liquor?*

A. Because *air* will then *flow into the bottle*, and help the liquor out by *balancing the upward pressure*.

Q. *Why does wine (poured from a bottle* QUICKLY) SPIRT *about without going into the decanter?*

A. The liquor fills the *top of the decanter* (like a *cork*), and leaves *no room* for the air inside *to escape*; therefore, the decanter (being *full of air*) refuses to admit the *wine*.

Q. *Why is* BEER *made* STALE, *by being exposed to the* AIR*?*

A. Because air *absorbs its carbonic acid*, which gave it "life."

Q. *Why is* PORTER *made* STALE, *by being exposed to the* AIR*?*

A. Because air *absorbs its carbonic acid*, which gave it "life."

Q. *Why does the* EFFERVESCENCE *of soda water and ginger beer so soon go off?*

A. Because air *absorbs the carbonic acid*, which produced the effervescence.

Q. *Why is* BOILED WATER FLAT *and insipid?*

A. Because the whole of the *carbonic acid is expelled* by boiling, and *absorbed by the air*.

Q. *Why does* WATER *become* FLAT *and insipid, after it has been* DRAWN *some time?*

A. Because air *absorbs its carbonic acid*; and when its carbonic acid is absorbed, the water is flat and insipid.

Q. *Why should spring* WATER *(used for* WASHING*) be exposed to the* AIR*?*

A. Spring water *contains carbonic acid*; but (by being exposed to the *air*) this carbonic acid is *absorbed*, and the water becomes *more soft*.

Q. *Why does* YEAST *make* BREAD LIGHT*?*

A. Flour contains a small portion of *saccharine matter* (or sugar); and the yeast (mixing with this)

produces *fermentation*, as it does in brewing.

Q. *How does* FERMENTATION *make the* DOUGH RISE*?*

A. During fermentation, *carbonic acid gas is evolved*; but the sticky texture of the dough will not allow it to *escape*, so it *forces up little bladders* all over the dough.

Q. *Why is* DOUGH *placed* BEFORE *the* FIRE*?*

A. 1st—Because the heat of the fire *increases the fermentation*: and

2ndly—It *expands the gas* which is confined in the little bladders; in consequence of which, the bladders are *blown up larger*, and the dough becomes lighter and more porous.

Q. *Why is* BREAD HEAVY*, if the dough be removed from the fire?*

A. Because the dough *gets cold*, and then the air in the bladders *condenses*,—the paste falls,—and the bread is close and heavy.

Q. *Whence does the* HEAT *of* FIRE *arise?*

A. The *carbon of fuel* (when heated) *combines with the oxygen of the air*, and produces *carbonic acid gas*: again, the *hydrogen of the fuel* combining with *other portions of oxygen*, condenses into *water*; by which chemical actions *heat is evolved*.

Q. *Whence does the* HEAT *of our own* BODY *arise?*

A. The *carbon of the blood* combines with the *oxygen of the air inhaled*, and produces *carbonic acid gas*; which produces heat in a way similar to burning fuel.

Q. *Whence does the* HEAT *of a* DUNGHILL *arise?*

A. The *straw, &c. of the dunghill* undergoes *fermentation* as it decays: the fermentation produces *carbonic acid gas*, and heat is evolved by a species of combustion (as in the two former cases).

Q. *What changes do* VEGETABLES *undergo from* PUTREFACTION*?*

A. The *hydrogen of the vegetables* combines with the *oxygen of the air*, and forms *water*: again, the *carbon of the vegetables* combines with *oxygen of the air*, and forms *carbonic acid gas*. Putrefaction, therefore, is only another species of combustion.

Q. *What changes do* ANIMAL *bodies undergo from* PUTREFACTION*?*

A. The same as vegetables, with this addition—they give out *ammonia*, *sulphur*, and *phosphorus* also; which causes the *offensive smell* of putrefying animal bodies.

Q. *Why is* LIME *heated by a* KILN*?*

A. All marl and chalk abound *in carbonic acid*; and (when heated by a fire) the carbonic acid *flies off in gas*, producing great heat.

Q. *What is* MORTAR*?*

A. Lime mixed with sand and water.

Q. *What is* LIME*?*

A. *Lime-stone burnt* produces lime.

Q. *Why is the lime-stone* BURNT*, in order to make it into* LIME*?*

A. The fire *expels the carbonic acid*, and converts the hard lime-stone into a *loose powder*.

Q. *Why does* MORTAR *become* HARD*, after a few days?*

A. Because the lime *re-imbibes* the carbonic acid of the air, which was *expelled by fire*; and the loose *powder* again becomes as hard as the original *lime-stone*.

Q. *Why is* MORTAR *adhesive?*

A. When the carbonic acid is expelled, the hard lime-stone is *converted into a loose powder*, which (being mixed with sand and water) becomes a *soft and sticky plaster*; but, as soon as it is placed between bricks, it *imbibes carbonic acid again*, and hardens into *lime-stone*.

CHAPTER XX.
CARBURETTED HYDROGEN GAS.

Q. *What is* CHOKE-DAMP*?*

A. *Carbonic acid gas* accumulated at the bottom of wells and pits. It is called CHOKE damp, because it *chokes* (or suffocates) *every animal that inhales it*. (*see p.* 264).

Q. *What is marsh-gas or* FIRE-DAMP*?*

A. *Carburetted hydrogen gas* accumulated on marshes, in stagnant waters, and coal pits; it is frequently called “inflammable air.”

Q. *What is* CARBURETTED HYDROGEN GAS*?*

A. *Carbon* combined with *hydrogen*.

Q. *How may* CARBURETTED HYDROGEN GAS *be* PROCURED *on marshes?*

A. By *stirring the mud* at the bottom of any stagnant pool, and collecting the gas (as it escapes upwards) in an inverted glass vessel.

Q. *What is* COAL GAS*?*

A. *Carburetted hydrogen* extracted from coals, by the heat of *fire*.

Q. *Why is carburetted hydrogen gas called* FIRE-DAMP*, or inflammable air?*

A. Because it very readily *catches fire and explodes*, when a light is introduced to it.

Q. *Why is carburetted hydrogen gas frequently called* MARSH GAS*?*

A. Because it is generated in *meadows and marshes* from putrefying vegetable substances. (*See ignis fatuus, p.* 285).

Q. *What gas is evolved by the* WICK *of a burning* CANDLE*?*

A. *Carburetted hydrogen gas*: that is, the *carbon and hydrogen* of the tallow *combine into a gas* from the heat of the flame; and this gas is *carburetted hydrogen*, or inflammable air.

Q. *Why do* COAL-MINES *so frequently* EXPLODE*?*

A. Because the *carburetted hydrogen gas* (which is generated in these mines by the coals) explodes, when a light is incautiously introduced.

Q. *How can miners* SEE *in the coal-pits, if they may* NEVER *introduce a* LIGHT*?*

A. Sir Humphrey Davy invented a lantern for the use of miners, called “the Safety Lamp,” which may be used without danger.

Q. *Who was* SIR HUMPHREY DAVY*?*

A. A very clever chemist, born in Cornwall. (1778—1829).

Q. *What kind of thing is the* SAFETY LAMP*?*

A. It is a kind of lantern *covered with a fine gauze wire*, instead of glass or horn.

Q. *How does this fine* GAUZE WIRE *prevent an* EXPLOSION *in the coal mine?*

A. 1st—Because flame will *never pass through fine gauze wire*: and

2ndly—Though the wire get *red-hot*, it will not ignite the gas; for carburetted hydrogen gas can be ignited only by *flame*.

(N. B. The interstices of the gauze wire must not exceed the 7th of an inch in diameter.)

Q. *Why will not* FLAME PASS THROUGH *very fine wire-*GAUZE*?*

A. Because the metal wire is a very *rapid conductor of heat*; and when the flame of burning gas in the lamp reaches the wire gauze, the heat (which is needful to produce flame) is *conducted away by the wire*, and the flame is *extinguished*.

Q. *Does the gas of the* COAL-PIT *get* THROUGH *the wire gauze* INTO *the* LANTERN*?*

A. Yes; but the inflammable gas ignites and burns *inside the lamp*: as soon, however, as this is the case, *the miner is in danger*, and should withdraw.

Q. *Why is the miner in* DANGER*, if the gas ignites and burns in the* INSIDE *of the safety-lamp?*

A. Because the heat of the burning gas will soon *destroy the wire gauze*, and then the flame (being free) will set fire to the mine.

CHAPTER XXI.
PHOSPHURETTED HYDROGEN GAS.

Q. *From what does the very* OFFENSIVE EFFLUVIA *of* CHURCH-YARDS *arise?*

A. From a gas called PHOSPHURETTED HYDROGEN; which is *phosphorus* combined with *hydrogen gas*.

Q. *What is* PHOSPHORUS*?*

A. A pale amber-coloured substance, resembling wax in appearance. The word is derived from two Greek words, which mean "*to produce or carry light.*" (φῶς-φέρεινφῶς).

Q. *How is* PHOSPHORUS OBTAINED*?*

A. By heating bones to a white heat; by which means the animal matter and charcoal are *consumed*, and what is left is called "*phosphate of lime*."

Q. *How is* PHOSPHATE OF LIME *converted into* PHOSPHORUS*?*

A. It is reduced to *powder*, and mixed with *sulphuric acid*; which (being heated and filtered) is converted into *phosphorus*.

Q. *Of what are* LUCIFER MATCHES *made?*

A. Of phosphorus; and above 250 thousand lbs. of phosphorus are used every year in London alone, merely for the manufacture of lucifer matches.

Q. *Why does a* PUTREFYING *dead* BODY SMELL *so offensively?*

A. From the *phosphuretted hydrogen gas*, which always arises from putrefying animal substances.

The escape of *ammonia* and *sulphur* contributes also to this offensive effluvia.

Q. *What is the cause of the* IGNIS FATUUS*, Jack o'Lantern, or Will o'the Wisp?*

A. This luminous appearance (which haunts meadows, bogs, and marshes) arises from the *gas of putrefying animal and vegetable substances*; especially decaying fish.

Q. *What gases arise from these* PUTREFYING *substances?*

A. *Phosphuretted hydrogen gas* from putrefying *animal* substances: and

Carburetted hydrogen, (or inflammable gas) from fermenting *vegetable* matters.

Some persons erroneously think that the AURORA BOREALIS, or Northern Lights, may be attributed to the same gases, burning in the upper regions of the air.

Q. *How are these gases* IGNITED *on bogs and meadows?*

A. By the electricity of the air, the rays of the sun, some accidental spark, the lamp of some traveller, or in some similar way.

And sometimes from the spontaneous combustion of some dung-heaps, &c. in the locality.

Q. *Why does an ignis fatuus or Will o'the Wisp* FLY *from us when we* RUN *to* MEET *it?*

A. When we run *towards* an ignis fatuus, we produce a current of air, which drives the light gas *forwards*.

Q. *Why does an ignis fatuus run* AFTER *us, when we* FLEE *from it in fright?*

A. When we run *away* from the ignis fatuus, we produce a current in the way we run, which *attracts* the light inflammable gas in the *same course*.

Q. *Is not a kind of Jack o'Lantern sometimes produced by an* INSECT*?*

A. Yes; a swarm of luminous insects sometimes passes over a meadow, and produces an appearance exactly like that of the ignis fatuus.

Q. *May this meteoric appearance be attributed to any* OTHER *cause, besides those mentioned?*

A. Yes; if many horses, sheep, pigs, or oxen, are pastured on a meadow, the *animal vapour* arising from them (strongly electrified by the air) *will ignite*, and produce a luminous appearance.

Q. *May not many* GHOST *stories have risen from some ignis fatuus lurking about church-yards?*

A. Perhaps *all* the ghost stories (which deserve any credit at all) have arisen from the ignited gas of church-yards lurking about the tombs, to which *fear* has added its own creations.

CHAPTER XXII.
WIND.

Q. *What is* WIND*?*

A. Wind is *air in motion*.

Q. *What* PUTS *the air in motion, so as to produce* WIND*?*

A. The principal causes are the *variations of heat and cold*, produced by the succession of *day and night*, and the *four seasons*.

Q. *What effect has* HEAT *upon the air?*

A. Heat *rarefies* the air, and causes it to *expand*.

Q. *How do you* KNOW *that heat causes the air to* EXPAND*?*

A. If a bladder *half full of air* (tied tight round the neck), were laid before a *fire*, the heat of the fire would expand the air so much, that the bladder would soon be *entirely inflated*; (in this case,

the air in the bladder is expanded to *twice its original bulk*, by the heat of the fire).

Q. *What* EFFECT *is produced upon air by* RAREFACTION*?*

A. It causes the air to *ascend through colder strata*, as a cork (put at the bottom of a basin of water) would ascend through the water.

Q. *How do you* KNOW *that rarefied air* ASCENDS*?*

A. When a boy sets fire to the cotton of his balloon, the flame *heats the air* inside the balloon; and the air becomes *so light*, that it ascends, and *carries the balloon with it*.

Q. *What effect is produced upon* AIR *by* COLD*?*

A. Air is *condensed by cold*, or squeezed into a smaller compass; in consequence of which, *it becomes heavier*, and descends towards the ground.

Q. *How do you* KNOW *that air is* CONDENSED *by* COLD*?*

A. After the bladder is *fully inflated*, (by lying before the fire), if it be taken *away from the fire*, the bladder will *collapse*, and show that it is not half full.

Q. *What is meant by the bladder "*COLLAPSING*?"*

A. The skin will become *wrinkled, shrivelled, and flabby*, because there is not sufficient air inside to *fill it out*.

Q. *How do you* KNOW *that* CONDENSED *air will* DESCEND*?*

A. As soon as the cotton of the balloon *is burnt out*, the air inside becomes *cold again*, and the balloon *falls to the earth*.

Q. *Does the* SUN HEAT *the* AIR *as it does the* EARTH*?*

A. No; the air is *not heated by the rays of the sun*, because air (like water) is a very *bad conductor*.

Q. *How is the* AIR HEATED*?*

A. By *convection*, thus:—The *sun* heats the *earth*, and the *earth* heats the *air resting upon it*; the air thus heated *rises*, and is succeeded by *other air*, which is heated in a similar way, till *all is warmed* by "convective currents."

Q. *What is meant by "CONVECTIVE CURRENTS of air?"*

A. Streams of air heated by the earth, which *rise upwards* and *carry heat with them*, are called "convective currents" of hot air.

Q. *Is the air in a ROOM in perpetual motion, as the air ABROAD is?*

A. Yes; there are always *two currents of air* in the room we occupy, one of *hot* air flowing *out* of the room, and another of *colder* air flowing *into* the room.

Q. *How do you KNOW, that there are these TWO currents of air in every occupied ROOM?*

A. If I hold a lighted candle near the crevice *at the top of the door*, the flame will be blown *outward* (towards the *hall*); but if I hold the candle *at the bottom of the door*, the flame will be blown *inwards* (into the *room*).

Q. *Why would the flame be blown OUTWARDS (towards the HALL), if the candle were held at the TOP of the door?*

A. Because as the air of the room is warmed by the fire, &c., *it ascends*; and (floating about the upper part of the room) some of it escapes *through the crevice* at the *top of the door*, and thus produces a current of air *outwards* (into the *hall*).

Q. *Why would the flame be blown INWARDS (into the ROOM), if the candle were held at the BOTTOM of the door?*

A. Because after the warm air of the room has ascended to the ceiling, or made its escape into the hall, &c., a partial *vacuum* is made at the *bottom of the room*; and cold air (from the hall) *rushes under the door* to supply the void.

Q. *What is meant by a "partial VACUUM being made, at the BOTTOM of the ROOM?"*

A. A vacuum means a place *from which the air has been taken*: and a "*partial* vacuum" means, a place from which a *part of its air* has been taken away. Thus when the air on the floor *ascends to the ceiling*, a partial vacuum is made *on the floor*.

Q. *And how is the VACUUM filled UP again?*

A. It is filled up by *colder air*, which rushes (under the *door*, and through the *window* crevices) into the room.

Q. *Give me an ILLUSTRATION.*

A. If I dip a pail into a pond and fill it with water, a hole (or vacuum) is made in the pond *as big as the pail*; but the moment I *draw the pail out*, the hole is *filled up* by the water around.

Q. *Show how this illustration* APPLIES.

A. The heated air which ascends from the bottom of a room, is as much *taken away*, as the water in the pail; and (as the void was instantly supplied by *other water in the pond*) so the *void of air is supplied* by a current from *without*.

Q. *What is the* CAUSE *of* WIND?

A. The *sun* heats the *earth*, and the *earth* heats the *air resting upon it*; as the warm air ascends, the void is filled up by a *rush of cold air* to the place, and this *rush of air* we call WIND.

Q. *Does the* WIND ALWAYS *blow?*

A. Yes; there is always *some* motion in the air; but the *violence* of the motion is perpetually varying.

Q. *Why is there always* SOME *motion in the air?*

A. As the earth is *always turning round*, the vertical rays of the sun are always *varying*.

Q. *What do you mean by "the* VERTICAL RAYS *of the* SUN?"

A. The rays made at *noon-day*: when the sun is in a *direct line* above any place, his rays are said to be "vertical" to that place.

Q. *How are the* VERTICAL *rays of the sun always* VARYING?

A. Suppose the brass meridian of a globe to represent the vertical rays of the sun; as you turn the globe round, *different parts* of it will pass under the brass rim, in constant *succession*.

Q. *And is it* NOON-DAY *to the place over which the* SUN *is* VERTICAL?

A. Yes; as each place passes *under the brass meridian*, it is *noon-day* to *one* half, and *mid-night* to the *other*.

Q. *Show how this* ROTATION *of the earth affects the* AIR.

A. If we suppose the brass meridian to be the vertical sun, the whole column of air *beneath* will be heated by the *noon-day rays*; that part which the sun has *left*, will become gradually *colder and colder*; and that part to which the sun is *approaching*, will grow constantly *warmer and warmer*.

Q. *Then there are* THREE *qualities of air about this spot?*

A. Yes; the air over the place which *has passed the meridian* is *cooling*: the air under *the vertical*

sun is the *hottest*; and the air which is over the place *about to pass under the meridian*, is *increasing in heat*.

Q. *How does this* VARIETY *in the* HEAT *of* AIR *produce* WIND*?*

A. The air always seeks to *preserve an equilibrium*; so the *cold air* rushes to the *void*, made by the *upward current of the warmer air*.

Q. *Why does not the wind* ALWAYS BLOW ONE *way, following the direction of the* SUN*?*

A. Because the direction of the wind is subject to perpetual interruptions from *hills and valleys*, *deserts and seas*.

Q. *How can* HILLS *and* MOUNTAINS ALTER *the course of the* WIND*?*

A. Suppose a wind, blowing from the north, comes to a mountain, as it cannot pass *through it*, it must either rush *back again*, or *fly off at one side* (as a *marble* when it strikes against a *wall*).

Q. *Do* MOUNTAINS *affect the wind in any* OTHER *way?*

A. Yes; many mountains are *capped with snow*, and the *warm air* is *condensed* as it comes in contact with them; but as soon as the *temperature of the wind* is changed, its *direction* may be changed also.

Suppose A B C to be *three columns of air*. A, the column of air which is *cooling down*; B, the column to which the *sun is vertical*; and C, the column which *is to be heated next*. In this case the *cold* air of A will rush towards B C, because the air of B and C is *hotter* than A. But suppose now C to be a *snow-capped mountain*. As the hot air of B reaches C, it is *chilled*; and (being now *colder* than the air *behind*) it rushes *back again* towards A, instead of following the sun.

Q. *How can the* OCEAN *affect the direction of the* WIND*?*

A. When the ocean rolls beneath the *vertical sun*, the water is *not made so hot* as the *land*; and (as another *change of temperature* is produced) another obstacle is offered to the *uniform direction of the wind*.

Q. *Why is not the* WATER *of the sea made so* HOT *by the vertical sun, as the surface of the* LAND*?*

A. 1st—Because the *evaporation* of the sea is greater than that of the land:

2ndly—The waters are *never still*: and

3rdly—The rays of the sun strike *into* the water, and are *not reflected from its surface*, as they are by *land*.

Q. *Why does the* EVAPORATION *of the sea prevent its surface from being* HEATED *by the vertical sun?*

A. As water *absorbs* heat by being *converted into vapour*; the surface of the sea is continually *losing heat by evaporation*.

Q. *How does the* MOTION *of the sea prevent its surface from being* HEATED *by the vertical sun?*

A. As one portion is heated *it rolls away*, and is succeeded by *another*; and this constant motion prevents *one* part of the sea from being heated *more than another*.

Q. *How is the* WIND *affected by the* SEA*?*

A. When air from the hot earth *reaches the sea*, it is often *condensed*, and either rushes *back again*, or else its violence is very greatly *abated*.

Q. *Do* CLOUDS *affect the* WIND*?*

A. Yes. As passing clouds screen the direct heat of the sun from the earth, they diminish the *rarefication of the air also*: and this is *another* cause why neither the strength nor direction of the wind is *uniform*.

Q. *Would the winds blow regularly from east to west, if these* OBSTRUCTIONS *were* REMOVED*?*

A. Without doubt they would. If the whole earth were covered with *water*, the winds would always *follow the sun*, and blow from east to west. Their irregularity is owing to the interspersion of *sea and land*, and the irregularities of the earth's surface.

Q. *Do winds* NEVER *blow* REGULARLY*?*

A. Yes; in those parts of the world, where these obstructions do not exist; as on the Atlantic and Pacific Ocean, the winds are pretty uniform.

Q. *What are the winds, which blow over the* ATLANTIC *and* PACIFIC *Ocean, called?*

A. They are called "Trade Winds."

Q. *Why are they called* TRADE WINDS*?*

A. Because (as they blow uniformly in one direction) they are very convenient to those who *carry on trade* by means of these oceans.

Q. *In what* DIRECTION *do the* TRADE WINDS *blow?*

A. That in the *northern* hemisphere blows from the *north-east*: that in the *southern* hemisphere from the *south-east*.

Q. *Why do they not blow from the* FULL NORTH *and* SOUTH*?*

A. Because the *polar current*, combining with the *equatorial current*, give the wind a *new direction*.

Q. *What is the* CAUSE *of the* EQUATORIAL *current?*

A. The rotation of the earth upon its axis.

Q. *What is the cause of the* POLAR CURRENT*?*

A. As the heat in the *torrid zone* is always *greatest*, and at the *poles* the *least*, therefore a constant current of air rushes *from the poles* towards the *equator*.

Q. *How does the* COMBINATION *of these two currents give a new direction to them both?*

A. When these currents of air meet at the equator, they *clash together*, and fly off in a new direction.

Q. *Do trade winds blow from the north-east and south-east* ALL *the* YEAR ROUND*?*

A. Yes, *in the open sea*; that is, in the Atlantic and Pacific Oceans for about 30 deg$^{s.}$ each side of the equator.

Q. *Do the* TRADE WINDS *blow uniformly from north-east and south-east in the* INDIAN OCEAN*?*

A. No; nor yet in those parts of the *Atlantic* and *Pacific* which *verge on the land*.

Q. *Why do not the trade winds blow uniformly from north-east and south-east in the* INDIAN OCEAN*?*

A. Because when Arabia, Persia, India, and China, are exposed to the enormous heat of their summer sun, the *air is so rarefied*, that the colder air from the south pole rushes *towards these nations*, and not to the *equator*; in consequence of which, a SOUTH-WEST wind is produced for *six months of the year*.

Q. *How does it blow for the* OTHER *6 months?*

A. When the sun has left the *northern* side of the equator for the *southern*, then the *southern part of the torrid zone* is most heated; and the cold air from the north (rushing towards the southern tropic) is diverted to the NORTH-EAST, where it continues for the *other* six months of the year.

Q. *What are the six-month trade winds called?*

A. They are called MONSOONS; and blow from the *north-east* from September to April, and from the *south-west* for the *other* six months of the year.

Q. *Have we any regular winds in England?*

A. No; our island (having a *continent on one side*, and a *sea on the other*) has a most *variable* climate.

Q. *Have the winds in England no general direction throughout the year?*

A. We generally find that *easterly* winds prevail during the *spring* of the year, and *westerly* winds are most common in the *summer* and *autumn*.

S-West winds are most frequent in July and August. N-East winds in January, March, April, May, June; and most seldom in July, September, and December.

Q. *When are the winds in England generally the highest?*

A. The winds in December and January are generally the highest. Those in February and November the next; and those in August and September the least boisterous.

Q. *Why are the winds of Europe generally highest in December and January?*

A. Because the sun is *furthest south* in those months; and (as the heat in these northern regions rapidly *decreases*) the *contrast between our temperature* and that of the *torrid zone* is greater in December and January, than in any *other* two months throughout the year.

Q. *Why does this contrast of heat increase the violence of the winds?*

A. As the air always seeks to *preserve an equilibrium*, therefore the *greater the contrast*, the more violent will be the rush of air to *equalize* the two volumes.

Q. *Why are the winds in Europe generally the most placid during the months of September and August?*

A. August and September are our *warmest months*, when we approach nearer to the heat of the torrid zone than in any *other two months*; therefore, the air (to and from the equator) *moves with less velocity* in our northern hemisphere.

Q. *Show the goodness and wisdom of God in the constant tendency of air to equilibrium.*

A. If the cool air of the polar regions did not rush into the torrid zone, *it would become so hot*, that no human being could endure it. If (on the other hand) the hot air from the torrid zone did not modify the polar regions, they would soon become *insufferably cold*.

Q. *Why are east winds in England generally dry?*

A. Because, as they come over the *vast continents* of Asia and Europe, they absorb *very little water*.

Q. *Why does their imbibing so little water make them* DRY *winds?*

A. Being thirsty when they reach our island, they readily imbibe moisture from the air and clouds; and, therefore, *bring dry weather*.

Q. *Why is the* NORTH WIND *in England generally* COLD*?*

A. The north wind comes from the *polar regions*, over mountains of snow, and seas of ice; in consequence of which, it is very *cold*.

Q. *Why are* NORTH WINDS *in England generally* DRY *and biting?*

A. As they come from regions *colder than our own*, they are *warmed by the heat of our island*; and (as their temperature is raised) *they absorb moisture* from every thing they touch; in consequence of which, they are both *dry and parching*.

Q. *Why is the* SOUTH WIND *generally* WARM *in England?*

A. The south wind comes over the hot sandy deserts of Africa, and is heated by the land it traverses.

Q. *Why does the* SOUTH WIND *often bring us* RAIN*?*

A. The south wind (being much *heated* by the hot sands of Africa) *imbibes water very plentifully*, as it passes over the Mediterranean Sea and British Channel.

Q. *Why does the* SATURATION *of the south wind cause* RAIN*?*

A. As soon as it reaches our cold climate, *it is condensed*, and its vapour is squeezed out (as water from a wet sponge).

Q. *Why are* WEST WINDS *in England generally* RAINY*?*

A. The west winds come over the *Atlantic Ocean*, and are laden with *vapour*: if, therefore, they meet with the least *chill*, some of the vapour is squeezed out.

Q. *Why is a fine* CLEAR DAY *sometimes* OVERCAST *in a few minutes?*

A. Because some *sudden change of temperature* has condensed the vapour of the air *into clouds*.

Q. *Why are* CLOUDS *sometimes* DISSIPATED *quite as suddenly?*

A. Because some *dry wind* (blowing over the clouds) has *imbibed their moisture*, and carried it off in invisible vapour.

Q. *Why does a* SOUTH-WEST *wind bring us* RAIN*?*

A. As it comes from the *torrid zone*, and *crosses the ocean*, the hot wind is *laden with vapour*; and as some of the heat escapes (as soon as it reaches our northern island) the *vapour is condensed*, and precipitated as rain.

Q. *Why does a* NORTH-EAST *wind* RARELY *bring* RAIN*?*

A. As it comes from a climate *colder than our own*, its capacity for imbibing vapour is *increased* when it reaches our island; in consequence of which, it *dries the air*, dispels the clouds, and promotes evaporation.

Q. *Why does* WIND *sometimes bring* RAIN*, and sometimes* FINE *weather?*

A. If the wind be *colder than the clouds*, it will condense their vapour into *rain*: if the wind be *warmer than the clouds*, it will *dissolve* them, and cause them to disappear.

Q. *Why are* MARCH *winds* DRY*?*

A. Because they generally blow from the east or north-east; and, therefore, *sweep over the continent of Europe*.

Q. *What is the* USE *of* MARCH *winds?*

A. They *dry the soil* (which is saturated with the floods of February), *break up the heavy clods*, and fit the land for the *seeds* which are committed to it.

Q. *Why does "*MARCH COME IN *like a* LION*?"*

A. Because it comes in with *blustering east winds*, which are essential to dry the soil, which would otherwise *rot the seed* committed to it.

Q. *Why does "*MARCH GO OUT *like a* LAMB*?"*

A. Because the water (evaporated by the high winds) falls again in *showers* to fertilize the earth, and *breaks the violence of the winds*.

Q. *Why is it said that "A bushel of* MARCH DUST *is worth the king's ransom?"*

A. Because it indicates that there has been a continuance of *dry weather*; and unless *March be dry*, the seed will rot in the wet soil.

Q. *Why is it said "A dry cold March never begs bread?"*

A. Because the *dry cold winds* of March prepare the soil for *seeds*, which germinate, and produce fruit in the autumn.

Q. *Why is it said that "A wet March makes a sad autumn?"*

A. Because, if *March be wet*, so much of the seed *rots in the ground*, that the autumn crops are spoiled.

Q. *Why is it said that "March flowers make no summer bowers?"*

A. Because, if the *spring be very mild*, vegetation gets too forward, and is *pinched by the nightly frosts*, so as to produce neither fruits nor flowers.

Q. *Why is it said "A late spring makes a fruitful year?"*

A. Because if the vegetation of spring be *backward*, the frosty nights will *do no harm*; for the fruits and flowers will not put forth their tender shoots, till the nights become *too warm to injure them*.

Q. *Why is it said that "April showers bring May flowers?"*

A. Before seeds can germinate, *three* things are essential:—Darkness, Heat, and Moisture. April showers supply the principal nourishment on which seeds depend for existence.

Q. *Does rain-water possess any fertilizing properties besides that of mere moisture?*

A. Yes; rain-water contains "ammonia," to which much of its fertilizing power may be attributed.

(Ammonia is a compound of nitrogen and hydrogen. Common hartshorn is only ammonia and water.)

Q. *Why has God made November a very rainy month?*

A. Because the rain hastens the *putrefaction of the fallen leaves*, and this makes the earth fertile.

Q. *Why is there more rain from September to March than from March to September?*

A. From September to March, the temperature of the air is *constantly decreasing*; on which account, its *capacity for holding vapour* is on the *decrease*, and the vapour is precipitated as rain.

Q. *Why is there less rain from March to September, than from September to March?*

A. From March to September, the temperature of the air is *constantly increasing*; on which

account, *its capacity for holding vapour* is on the *increase*, and very little is precipitated as rain.

Q. *Why is the* RISING SUN *in summer accompanied with a* BREEZE*?*

A. Because the heat of the rising sun *stops the radiation of heat* from the earth, and *warms its surface*.

Q. *How does this* WARMTH *produce a* BREEZE*?*

A. The air (resting on the earth's surface) is *warmed by contact*, ascends upwards, and *colder air rushes in* to fill up the void, which is the cause of the *morning* breeze.

Q. *Why is there often an* EVENING BREEZE *during the summer months?*

A. The earth *radiates heat at sun-set*, and the air is cooled down quickly by contact: this condensation causes a *motion in the air*, which is the evening breeze.

Q. *Why are* TROPICAL ISLANDS *always subject to a* SEA*-breeze every* MORNING *(i. e.. a breeze blowing from the sea to the land)?*

A. The solar rays are unable to heat the surface of the *sea* as they do the *earth*; therefore, the *air resting on the earth* is more *heated* than the *air resting on the sea*; and the colder sea air blows *inland* to restore the equilibrium.

Q. *Why is the* LAND BREEZE UNHEALTHY*?*

A. Because it is frequently loaded with exhalations from *putrefying animal* and *vegetable* substances.

Q. *Why is the* SEA BREEZE *fresh and* HEALTHY*?*

A. Because it passes over the fresh sea, and is *not* laden with noxious exhalations.

It is *healthy*, therefore, to walk on the sea-beach before ten o'clock in the morning; but *unhealthy* after sun-set.

Q. *Why is there generally a fresh breeze from the* SEA *(in English watering places) during the summer and autumn* MORNINGS*?*

A. As the *land* is *more heated by the sun* than the *sea*; therefore, air resting on the *land* is hotter than air resting on the *sea*; in consequence of which, cooler sea air glides *inland*, to restore the equilibrium.

Q. *Why does the* SEA BREEZE *feel* COOL*?*

A. As the sun cannot make the surface of the *sea* so hot as the surface of the *land*; therefore, the

air which blows from the sea, feels *cooler than the air of the land*.

Q. *Why are* TROPICAL ISLANDS *subject to a* LAND BREEZE *every* EVENING *(i. e.. a breeze blowing from the land towards the sea)?*

A. The *surface of land* cools down *faster* (after sun-set) than the surface of the *sea*: in consequence of which, the air of the cold land *is condensed, sinks down*, and spreads itself into the warmer *sea air*, causing the LAND BREEZE.

Q. *Why is the* LAND BREEZE COOL*?*

A. As the surface of the land is cooled at sun-set *quicker than the surface of the sea*; therefore, the seaman feels the air from the land to be chill.

Q. *Why is the* TEMPERATURE *of* ISLANDS *more* EQUABLE *than that of* CONTINENTS*?*

A. Because the *water* around the island *absorbs* the extreme heat of summer, and *gives out* heat to mitigate the extreme cold of winter.

Q. *Why does the sea round an island* GIVE OUT *heat in winter?*

A. Unless the *sea be frozen* (which is rarely the case), it is *warmer* than the frozen land; and, therefore, the warmth of the sea air (mixing with the cold land air) helps to mitigate the intense cold.

Q. *Why are there* WAVES *in the sea?*

A. The wind (acting on the surface of the sea) *piles up ridges of water*, which leave behind an *indentation*: as the water on all sides rushes to *fill up this indentation*, the disturbance spreads on all sides, and billow rolls after billow.

Q. *Why does* WIND *in England generally feel* COLD*?*

A. Because a *constantly changing surface* comes in contact with our body, to draw off its heat.

Q. *Why is a* ROOM *(even without a fire) generally* WARMER *than the* OPEN AIR*?*

A. As the air in a room is *not subject to much change*, it soon becomes of the same temperature as our skin, and no longer feels cold.

Q. *Why do we generally feel* COLDER *out-of-doors?*

A. Because the air (which surrounds us) *is always changing*; and as fast as *one* portion of air has become warmer by contact with our body, *another colder portion* surrounds us to absorb more heat.

Q. *Why are* HOT FOODS *made* COOL *by* BLOWING *them?*

A. Blowing causes the air (which covers the hot food) *to change more rapidly*; in consequence of which, the hot air is *quickly blown away*, and gives place to fresh *cold air*.

Q. *Why do ladies* FAN THEMSELVES *in hot weather?*

A. By the action of the fan, *fresh particles of air* are perpetually brought in contact with the face, and every fresh particle of air *absorbs some heat* from the skin.

Q. *Does the fan* COOL *the* AIR*?*

A. No; it makes the *air hotter*, by imparting to it the heat *out of our face*: but it cools the *face* blown upon, by transferring its heat to the *air*.

Q. *Is the* AIR *in* SUMMER *time ever so hot as our bodies?*

A. No, not in England. In the hottest day in summer, the air of England is 15 or 20 degrees cooler than the human body.

Q. *How fast does wind travel?*

A. A gentle breeze goes at about the rate of 5 miles an hour. A high wind from 20 to 60. A hurricane from 80 to 100 miles an hour.

Q. *How is the* VELOCITY *of* WINDS *ascertained?*

A. By observing the velocity of the clouds, and by an instrument for the purpose.

This instrument is called an ANEMOMETER.

Q. *How is the* VELOCITY *of the* CLOUDS *ascertained?*

A. By observing the speed of their shadow along the ground; which is found in a high wind to vary from 20 to 60 miles an hour.

Q. *Why is there always a strong* DRAUGHT *through the* KEYHOLE *of a door?*

A. As the air of the room we occupy is *warmer than the air in the hall*, therefore the cold hall air *rushes through the keyhole* into the room, and causes a draught.

Q. *Why is there always a strong* DRAUGHT UNDER *the* DOOR*, and through the crevice on each side?*

A. The cold air *rushes from the hall* under the door, &c. into the room, to supply the *void* caused in the room (by the escape of warm air up the chimney, &c.)

Q. *Why is there always a* DRAUGHT *through the* WINDOW *crevices?*

A. The external air (being colder than the air of the room we occupy) rushes through the window crevices *to supply the deficiency*, caused by the escape of air up the chimney, &c.

Q. *Why is there more* DRAUGHT *if you open the* LOWER SASH *of a window, than if you open the UPPER sash?*

A. If the *lower* sash be open, the *cold external air* will rush more freely *into the room*; but if the *upper* sash be open the *heated air of the room* will *rush out*; and (of course) there will be less draught.

Q. *By which means is the* ROOM *better* VENTILATED, *by opening the lower or the upper sash?*

A. A room is better *ventilated* by opening the *upper sash*; because the hot vitiated air (which always ascends towards the ceiling) *can better escape*.

Q. *By which means is a* HOT ROOM *more quickly* COOLED*—By opening the upper or the lower sash?*

A. A hot room is *cooled more quickly* by opening the *lower sash*; because the cold air can enter more freely by an *under* current, than by one *higher up*.

Q. *Why does* WIND DRY *damp* LINEN*?*

A. Because dry wind (like a dry sponge) imbibes the particles of vapour from the surface of the linen, as fast as they are formed.

Q. *Which is the* HOTTEST PLACE *in a church, chapel, or theatre?*

A. The gallery.

Q. *Why is the* GALLERY *of all public places* HOTTER *than the lower parts of the building?*

A. Because the heated air of the room *ascends*, and all the *cold air* (which can enter through the doors and windows) *keeps to the floor*, till it has become heated.

Q. *Why do* PLANTS *often grow out of* WALLS *and* TOWERS*?*

A. Because sometimes the *wind* blows the seed there with the dust; and sometimes *birds* (flying over) drop the seed which they had formerly eaten.

CHAPTER XXIII.
BAROMETER.

Q. *What is a* BAROMETER*?*

A. A weather-glass, or instrument to show the changes of the weather, by marking the *variations in the weight of air*.

Q. *What is a* THERMOMETER*?*

A. An instrument to show how *hot or cold* anything is.

Q. *What is the* DIFFERENCE *between a* THERMOMETER *and a* BAROMETER*?*

A. In a THERMOMETER the mercury is *sealed up from the air*:

In a BAROMETER the mercury is left *exposed* (or open) to the air.

Q. *If the mercury of the thermometer be* SEALED UP *from the air, how can the air* AFFECT *it?*

A. The heat of the air passing *through the glass tube* into the mercury, causes it to *expand more or less*, and rise in the tube accordingly.

Q. *Why is the* TUBE *of a* BAROMETER *left* OPEN*?*

A. That the air may *press upon it* freely; and as this pressure is *more* or *less*, the mercury *rises or falls* in the tube.

Q. *How can weather be affected by the* WEIGHT *of the air?*

A. When air is warm or moist, it is *lighter* than usual:

When it is cold or dry, it is *heavier*: and as a barometer marks whether the air be *light* or *heavy*, it indicates these *changes*.

Q. *How can you tell (by looking at a* BAROMETER*) what* KIND *of* WEATHER *it will be?*

A. Because the mercury in the tube *rises and falls*, as the air becomes lighter or heavier: and we can generally tell by the *weight* of the air, what kind of weather to expect.

Q. *Does the* WEIGHT *of the air* VARY MUCH*?*

A. Yes; the atmosphere in England varies as much as *one-tenth part* more or less.

Q. *What is the chief* USE *of a* BAROMETER*?*

A. To warn *sailors* how to *regulate their ships*, before squalls come on.

Q. *How can a* BAROMETER *warn* SAILORS *to regulate their* SHIPS*?*

A. As the barometer will tell when *wind*, *rain*, or *storm* is at hand, the sailor can make his ship trim before it overtakes him.

Q. *Are there any* RULES *which can be depended on?*

A. Yes; there are *ten special rules* to direct us how to know the changes of weather, by marking the mercury of a barometer.

Q. *What is the 1ST SPECIAL RULE in regard to the barometer?*

A. The barometer is *highest of all* during a *long frost*; and it generally rises with a *north-east wind*.

Q. *Why is the barometer* HIGHEST *of all during a long* FROST*?*

A. Because long frost *condenses the air very greatly*; and the more air is *condensed*, the greater is its *pressure* on the mercury of the barometer.

Q. *Why does the barometer generally* RISE *with a* NORTH-EAST *wind?*

A. Because NORTH-EAST winds make the air both *cold and dry*: the air, therefore, is both *condensed*, and *without vapour*.

Q. *What is the 2ND SPECIAL RULE in regard to the barometer?*

A. The barometer is *lowest of all* during a *thaw which follows a long frost*: it generally falls with SOUTH and WESTERN winds.

Q. *Why does the barometer fall* LOWEST *of all at the* BREAKING UP *of a long* FROST*?*

A. 1st—Because the air (which had been much *dried* by the frost) *absorbs the moisture* of the fresh warm current of wind from the south or south-west: and

2ndly—The air (which had been much *condensed* by the frost) is suddenly *expanded* by the warm wind which is introduced.

Q. *Why does the barometer fall very low with* SOUTH *and* WEST *winds?*

A. Because SOUTH and WEST winds come heavily *laden with vapour*; and *vaporized* air is lighter than *dry air*.

Q. *What effect has WIND on the mercury?*

A. *All* winds make the barometer *drop*, except EASTERN winds: those winds which blow from the SOUTH, and SOUTH-WEST make it *drop the lowest*.

Q. *Why do WINDS generally make the mercury of a barometer DROP?*

A. Wind is caused by a *partial vacuum* in some parts of the globe; and as the air *rushes in* to supply this deficiency, *its general pressure is lessened*, and the barometer falls.

Q. *What is the 3RD SPECIAL RULE in regard to the barometer?*

A. While the barometer stands above 30°, the air must be very *dry* or very *cold*, or perhaps *both*, and *no rain* may be expected.

Q. *Why will there be NO RAIN if the AIR be very DRY?*

A. If the air be very *dry* it will *absorb moisture*, and not part with what it has *in rain*.

Q. *Why will there be NO RAIN if the AIR be very COLD?*

A. If the air be very *cold* it is *so much condensed*, that it has already parted with as much moisture as it can spare.

Q. *What is the 4TH SPECIAL RULE in regard to the barometer?*

A. When the barometer stands *very low* indeed, there is never *much* rain, although a *fine day* will seldom occur at such times.

Q. *What kind of WEATHER will it be when the barometer is UNUSUALLY LOW?*

A. There will be *short heavy showers*, with sudden *squalls of wind* from the *west*.

Q. *Why will there be VERY LITTLE RAIN if the barometer be UNUSUALLY LOW?*

A. Because the air must be very *warm*, or very *moist*, or perhaps *both*.

Q. *Why will there be little or no rain, if the* AIR *be very* WARM?

A. If the air be very warm it will have a tendency to *imbibe more moisture*, and not to part with what it has.

Q. *Why will there be little or no rain if the air be* MOIST, *and the barometer remains very* LOW*?*

A. If the air be ever so moist, rain will never fall till *cold air* has been introduced to *condense the vapour*; and the moment that the *cold* air is introduced, the barometer will *rise*.

Q. *What is the 5TH SPECIAL RULE in regard to the barometer?*

A. In summer-time (after a long continuance of fair weather) the barometer will *fall gradually* for 2 or 3 days before *rain* comes; but if the fall of the mercury be very *sudden*, a *thunder-storm* is at hand.

Q. *What is the 6TH SPECIAL RULE in regard to the barometer?*

A. When the sky is cloudless, and seems to promise fair weather, if the barometer be *low*, the face of the sky will soon be suddenly *overcast*.

Q. *What is the 7TH SPECIAL RULE in regard to the barometer?*

A. Dark dense clouds will pass over *without rain*, when the barometer is *high*; but if the barometer be low, it will often rain *without any gathering of clouds*.

Q. *What is the 8TH SPECIAL RULE in regard to the barometer?*

A. The *higher* the barometer, the greater is the probability of *fair weather*.

Q. *Why is the barometer* HIGH *in* FINE *weather?*

A. Because the air contains but *very little vapour*. The *drier* the air, the *higher* does the mercury of the barometer rise.

Q. *What is the 9TH SPECIAL RULE in regard to the barometer?*

A. When the mercury is in a *rising* state, *fine* weather is at hand; but when the mercury is in a *sinking* state, *foul* weather is near.

Q. *Why does the mercury* RISE *at the approach of* FINE *weather?*

A. Because the air is becoming more *dry*, and therefore its *pressure* is greater.

Q. *Why does the mercury* SINK *at the approach of* FOUL *weather?*

A. Because the air is *laden with vapour*, or *disturbed by wind*.

Q. *Why does* VAPOUR *in the air make the mercury* SINK*?*

A. Because vaporized air is *lighter than dry air*, and therefore its *pressure is less* on the mercury of the barometer.

Q. *What is the 10TH SPECIAL RULE in regard to the barometer?*

A. If (in frosty weather) it *begins to snow*, the barometer generally rises to 32°, where it remains as long as the snow continues to fall; if, after this, the weather *clear up*, you may expect *very severe cold*.

Q. *How can you know if the* MERCURY *of the barometer be* RISING*?*

A. If it be *convex* (i. e. higher in the *middle* than at the *sides*;) it is in a *rising state*.

Q. *How can you tell if the* MERCURY *of the barometer be about to* FALL*?*

A. If it be *concave* (i. e. *hollow* in the *middle*) it is in a *falling state*.

Q. *Why is the mercury* CONVEX *when it is* RISING*?*

A. The sides of the mercury *rub against the glass tube*, and are *delayed* by it, so that the *middle* part *rises faster* than the *sides*.

Q. *Why is the mercury* CONCAVE *when it is* FALLING*?*

A. The sides of the mercury *rub against the glass tube*, and are *delayed* by it, so that the *middle* part *sinks faster* than the *sides*.

Q. *What effect does a* THUNDER-STORM *produce on the weather?*

A. Thunder is generally *preceded by hot* weather, and *followed by cold* and showery weather.

Q. *What effect does a* SUDDEN CHANGE *produce on the weather?*

A. A great and sudden change (either from hot to cold, or from cold to hot) is generally followed *by rain within 24 hours*.

Q. *Why is a sudden* CHANGE *from* HOT *to* COLD *followed by* RAIN*?*

A. The cold *condenses the air* and its vapour; which, being condensed and squeezed out, *falls in rain*.

Q. *Why is a sudden* CHANGE *from* COLD *to* HOT *followed by* RAIN*?*

A. Because the air is *quickly saturated with moisture*; and as soon as *night* comes on, the temperature is *lowered again*, and some of the abundant moisture falls in rain.

Q. *Why is the air quickly* SATURATED *with* MOISTURE*, when* HEAT *succeeds rapidly from* COLD*?*

A. Because the evaporation (which was checked by the cold) is *carried on very rapidly*, in consequence of the *diminished pressure* of the air.

(N. B. The *less the pressure* of the air, the more *rapidly it evaporates* moisture.)

Q. *When does the barometer* VARY MOST*?*

A. In winter time.

Q. *Why does the barometer vary* MORE *in* WINTER *than in* SUMMER *time?*

A. Because the *difference of temperature* between the torrid and temperate zones is *so great*, that the state of the air is perpetually *disturbed* by their mixing together.

Q. *When does the barometer* VARY LEAST*?*

A. In summer time.

Q. *Why does the barometer vary* LESS *in* SUMMER *than in* WINTER *time?*

A. Because the temperature of our island is *so nearly equal* to that of the torrid zone, that its state is *not much disturbed* by interchange of currents.

Q. *What effect has* WIND *on the barometer?*

A. NORTH and EAST winds make the mercury *rise*; all *other* winds make it *sink*; but SOUTH and WEST winds make it *sink lower* than any other winds.

Q. *Have* HEAT *and* COLD *any effect on the barometer?*

A. No, not of *themselves*; but because *cold* weather is generally either *dry*, or *rough with north-east winds*, therefore the mercury *rises* in cold weather; and because warm weather is often *moist* or *fanned by south-west winds*, therefore, the mercury sinks.

Q. *Why is the mercury of a barometer* LOWER *in the* TORRID *than in the* FRIGID *zones?*

A. Because the warm air of the torrid zone contains much more *vapour* than the condensed air of the frigid zone; and the *moister* the air, the *less is its pressure*.

Q. *In what* MONTHS *is the barometer* HIGHEST*?*

A. In May and August; next to these, in June, March, September, and April.

Q. *In what* MONTHS *is the barometer* LOWEST*?*

A. In November and February; then in October, July, December, and January.

Q. *What are the* DRIEST *months?*

A. March and June; then May and August; then April and November.

Q. *What are the* WETTEST *months?*

A. October and February; then July and September; then January and December.

Q. *Why is there* LESS *wet from* MARCH *to* AUGUST*, than there is from August to March?*

A. Because the *heat is constantly increasing*; and the capacity of the air to absorb and retain moisture increases likewise.

Q. *Why is there* MORE *wet from* AUGUST *to* MARCH*, than there is from March to August?*

A. Because the *heat is constantly decreasing*, and the capacity of the air to retain moisture decreases also; so that (although it often rains) yet the air is always on the point of saturation.

Q. *Why does the mercury of a barometer* RISE *in a* FROST*?*

A. Because frost *condenses the air*; and condensed air is heavier than *rarefied* air.

Q. *Why does the mercury of a barometer* FALL *in a* THAW*?*

A. Because the air is both *warmer* (or more rarefied), and also filled with *vapour*.

Q. *What does a* SUDDEN *rise or fall of the barometer indicate?*

A. If the *rise* be sudden, fine weather will not continue long:

If the *fall* be sudden, foul weather will not continue long.

Q. *What sort of weather may we expect if the barometer be very* FLUCTUATING*?*

A. If the mercury fluctuates much, the weather will be very *changeable and unsettled*.

The FALL of the barometer.

In very *hot* weather, the fall of the mercury denotes *thunder*.

Except in very hot weather, the sudden falling of the barometer denotes high wind.

In *frosty* weather, the fall of the barometer denotes *thaw*.

If *wet* weather happens *soon* after the fall of the barometer, expect but *little* of it.

In *wet* weather if the barometer falls, expect much wet.

In *fair* weather, if the barometer falls much and *remains* low, expect much wet in a few days, and probably *wind*.

N. B. The barometer sinks lowest of all for wind and rain together, next to that for wind (except it be an east or north-east wind).

The RISE of the barometer.

In *winter* the rise of the barometer presages *frost*.

In *frosty* weather, the rise of the barometer presages *snow*.

If *fair* weather happens *soon* after the rise of the barometer, expect but *little* of it.

In *wet* weather, if the mercury rises high and *remains* so, expect continued *fine* weather in a day or two.

In wet weather, if the mercury rises suddenly very high, fine weather will not last long.

N. B. The barometer rises highest of all for north and east winds; for all *other* winds it sinks.

If the barometer be UNSETTLED.

If the motion of the mercury be *unsettled*, expect unsettled weather.

If it stand at "MUCH RAIN" and rise to "CHANGEABLE," expects *fair weather of short continuance*.

If it stand at "FAIR" and fall to "CHANGEABLE," expect *foul* weather.

N. B. Its motion *upwards* indicates the approach of fine weather: its motion *downwards* indicates the approach of foul weather.

CHAPTER XXIV.
SNOW. HAIL. RAIN.

Q. *What is* SNOW*?*

A. The condensed vapour of the air *frozen*, and precipitated to the earth.

Q. *What is the* CAUSE *of* SNOW*?*

A. When the air is nearly saturated with vapour, and condensed by a current of air *below freezing point*, some of the vapour is squeezed out, and frozen into snow.

A few years ago, some fishermen (who wintered at Nova-Zembla), after they had been shut up in a hut for several days, *opened the window*, and the cold external air rushing in, instantly condensed the air of the hut, and the vapour (which was squeezed out) fell on the floor *in a shower of snow*.

Q. *Why does* SNOW *fall in* WINTER *time?*

A. Because the sun's rays are too *oblique* to heat the surface of the earth; and (as the *earth has no heat* to radiate into the air) the air is very cold.

Q. *What is* SLEET*?*

A. When flakes of snow (in their descent) pass through a bed of air *above freezing point*, they melt; and fall to the earth as half-melted snow or sleet.

Q. *What is the* USE *of* SNOW*?*

A. To keep the *earth warm*, and to *nourish* it.

Q. *How can snow keep the* EARTH WARM*?*

A. Because it is a very *bad conductor*; in consequence of which, the earth which is covered with snow, very rarely descends *below freezing point*, even when the air is 15 or 20 degrees colder.

Q. *Why is* SNOW *a* BAD CONDUCTOR *of heat and cold?*

A. Because *air* is confined and entangled between the crystals, and *air* is a very *bad conductor*; when, therefore, the earth is covered with snow, it cannot throw off its heat by radiation.

Q. *Tell me the words of the* PSALMIST (cxlvii. 16.) *respecting snow, and explain what he means.*

A. The Psalmist says—"The Lord giveth snow like wool:" and he means not only that snow is as *white as wool*, but that it is also as *warm as wool*.

Q. *Why is* WOOL WARM*?*

A. Because *air* is entangled between the fibres of the wool, and air is a *bad conductor*.

Q. *Why is* SNOW WARM*?*

A. Because *air* is entangled between the crystals of the snow, and air is a *bad conductor*.

Q. *Why does* SNOW NOURISH *the earth?*

A. Because it supplies it with *moisture* for a considerable time; which penetrates slowly into the soil, and insinuates itself through every clod, ridge, and furrow.

Q. *Why is there* NO SNOW *in* SUMMER *time?*

A. No snow reaches the general surface of the earth in summer time, because the *heat of the earth* melts it in its descent.

Q. *Why are some* MOUNTAINS ALWAYS COVERED *with* SNOW*?*

A. 1st—Because the *air is more rarefied*; and rarefied air *abstracts heat* which it holds in a *latent state*:

2ndly—As the mountain top is *not surrounded by earth* to radiate heat into the air; therefore, the snow is *not melted* in its descent, but falls on the mountain, and lies there.

Q. *Why is* SNOW WHITE*?*

A. Snow is formed of an infinite number of very minute crystals and prisms, which reflect all the colours of the rays of light; and these colours *uniting* before they meet the eye, cause snow to appear white.

Q. *What is* HAIL*?*

A. Rain, which has passed in its descent *through some cold bed of air*, and has been frozen into drops of ice.

Q. *Why is* ONE *bed of air* COLDER *than another?*

A. This is frequently caused by *electricity* in the air, *unequally distributed*.

Q. *Why is* HAIL *frequently accompanied with* THUNDER *and* LIGHTNING*?*

A. 1st—Because the *congelation of water into hail* disturbs the electricity of the air: and

2ndly—The *friction* (produced by the fall of hail) excites it still more.

Q. *Why does* HAIL *fall generally in* SUMMER *and* AUTUMN*?*

A. 1st—Because the *air is more highly electrified* in summer and autumn: and

2ndly—The vapours (being rarefied) ascend to the more elevated regions, where the *cold is greater* than it is nearer the earth.

Q. *What* TWO *things are essential to cause HAIL?*

A. Two *strata of clouds* having *opposite electricities*, and *two currents of wind*. The *lower cloud* (being negative) is the one *precipitated*.

Q. *What is* RAIN*?*

A. The vapour of the clouds or air *condensed*, and precipitated to the earth.

Q. *Why is the vapour of the air or clouds* PRECIPITATED*?*

A. When the air is *saturated with vapour*, if a cold current *condenses* it, it is no longer *able to hold all its vapour* in solution, and some of it is squeezed out, and falls as rain.

Q. *Why does* RAIN *fall in* DROPS*?*

A. The vapoury particles in their descent *attract each other*; and those which are sufficiently near, *unite* and form into a drop.

Q. *Why does not the* COLD *of* NIGHT ALWAYS *cause rain?*

A. When the air is not *near saturation* (although condensed by the chill of evening), it will still be able to hold its vapour in solution.

Q. *Why does a* PASSING CLOUD *often drop* RAIN*?*

A. Because the cloud (travelling about on the wind) comes into contact with *something that chills it*; and its vapour being squeezed out, *falls to the earth as rain*.

Q. *Why are* RAIN-DROPS *sometimes much* LARGER *than at* OTHER *times?*

A. When the rain-cloud is floating *near the earth*, the drops are large, because such a cloud is *much more dense* than one which is more elevated.

The size of the rain-drop is increased according to the *rapidity* with which the vapours are condensed.

Q. *Does not* WIND *sometimes* INCREASE *the* SIZE *of rain-drops?*

A. Yes; by blowing two or more drops into one.

Q. *Why do clouds fall in rainy weather?*

A. 1st—Because the *clouds are heavy* with abundant vapour: and

2ndly—As the density of the air is *diminished*, it is less able to buoy the clouds up.

Q. *How do you know that the density of the air is diminished in rainy weather?*

A. Because the *mercury of a barometer falls*.

Q. *Why is rain-water more fertilizing than pump-water?*

A. Because it contains a compound of hydrogen and nitrogen (called *ammonia*), which is a very excellent food for young plants.

Q. *Why is November made by God to be a rainy month?*

A. Because rain *hastens the putrefaction of the fallen leaves* by causing fermentation.

Q. *Why does rain purify the air?*

A. 1st—Because it *beats down the noxious exhalations* collected in the air, and *dissolves* them:

2ndly—It mixes the air of the *upper* regions with that of the *lower regions*: and

3rdly—It *washes the earth*, and sets in motion the stagnant *sewers and ditches*.

Q. *Why are mountainous countries more rainy than flat ones?*

A. The air (striking against the side of the mountains) is *carried up the inclined plane*, and brought in contact with the *cold air of the higher regions*, by which it is *condensed*, and its *vapour squeezed out*.

Q. *Why does a sponge swell when it is wetted?*

A. Because the water *penetrates the pores* of the sponge, and drives the particles of the sponge *further from each other*; in consequence of which, the *bulk* of the sponge is greatly *increased*.

Q. *Why do fiddle-strings snap in wet weather?*

A. Because the moisture of the air (penetrating the string) *causes it to swell*; and (as the cord *thickens*) its *tension is increased*, and the string snaps.

Q. *Why does paper pucker when it is wetted?*

A. Because the moisture (penetrating the paper) *drives its particles further apart*; and (as the

moisture is absorbed *unequally* by the paper) some parts are more enlarged than others; in consequence of which, the paper *blisters* or *puckers*.

Q. *Why do the weather toys called* CAPU'CHINS *lift the cowl over the figures in wet weather, and remove it in dry?*

A. The cowl of the capu'chin is *fastened to a piece of cat-gut*. When the weather is *wet*, the moisture *swells the cat-gut* and it is *shortened*, by which means the *cowl is pulled up*; but in *dry* weather, the *string is loosened*, and the cowl falls down.

Q. *In another weather toy, the* MAN *comes out in* WET *weather, and the* LADY *in* FINE:—*Why is this?*

A. The two figures are attached to a piece of *cat-gut* in such a manner, that when the *cat-gut is shortened by moisture*, it pulls the *man out*; but when it is *loose*, the woman *falls out by her own weight*.

Q. *Why are* WET STOCKINGS DIFFICULT *to* PULL ON*?*

A. The moisture (by penetrating the threads of the stockings) causes them to *shrink in size*.

Q. *What is the* MOST RAINY *spot in* ENGLAND*?*

A. Keswick (in Cumberland); and then Kendal (a market town in Westmoreland).

(In Keswick, about 63 inches of rain fall in a year. In Kendal, 58; Manchester, 38; Liverpool, 34; Dublin and Cambridge, 25; Lincoln, 24; London, 21; and in Paris, only 18.)

Q. *In which* PART *of the* DAY *does the* MOST RAIN *fall?*

A. More rain falls by *night* than by day; because the cold night *condenses the air*, and diminishes its capacity for holding vapour in solution.

Q. *Does more rain fall in* SUMMER *or in* WINTER *time?*

A. There are *more rainy days* from September to March; but *heavier* rains between March and September.

Q. *Why are there* MORE RAINY DAYS *from September to March, than from March to September?*

A. Because the temperature of the air is *constantly decreasing*, and its capacity for vapour decreases also; in consequence of which, it is perpetually obliged to *part with some of its vapour* in rain.

Q. *In what* PART *of the* WORLD *does* RAIN *fall* MOST ABUNDANTLY*?*

A. Near the *equator*; and the quantity of rain *decreases* as we approach the *poles*.

Q. *Why does* MORE RAIN *fall at the* EQUATOR *than at the* POLES*?*

A. Because the *contrast* between the *night and day* is very great. The hot air *absorbs moisture very abundantly* during the day; and when the cold night *condenses* the air, it is unable to *retain the moisture imbibed*, and some of it falls in rain.

CHAPTER XXV.
WATER.

Q. *What is* WATER*?*

A. Water is composed of *two gases*, oxygen and hydrogen.

(In 9 lbs. of water, 8 are oxygen, and 1 is hydrogen.)

Q. *Why is* WATER FLUID*?*

A. Because its particles are kept separate by *latent heat*; but when a certain quantity of this latent heat is driven out, *water becomes solid*, and is called ice.

Q. *How can* WATER *be converted into a* GAS*?*

A. By increasing its *latent heat*, the particles, of water are again *subdivided into invisible steam*.

Q. *Why is* PUMP *water called* HARD *water?*

A. Because it is laden with foreign matters, and will not readily *dissolve substances* immersed in it.

Q. *What makes* PUMP*-water* HARD*?*

A. Because when it filters through the earth, it becomes impregnated with *sulphate of lime*, and many other impurities from the *earths and minerals* with which it comes in contact.

Q. *Why is it difficult to* WASH *our* HANDS *clean with* HARD *water?*

A. Because the *soda of the soap* combines with the *sulphuric acid* of the hard water, and the *oil of the soap* with the *lime*, and float in flakes on the top of the water.

N.B. Sulphate of lime consists of sulphuric acid and lime.

Q. *Why is it difficult to wash in* SALT WATER*?*

A. Because salt water contains *muriatic acid*; and the *soda of soap* combines with the *muriatic acid of the salt water*, and produces a cloudiness.

Q. *Why does a* BLACK HAT *turn* RED *at the* SEA SIDE*?*

A. The *muriatic acid of the sea-water* disturbs the *gallic acid of the black dye*, and turns it *red*.

Q. *Of what is* SOAP *made?*

A. Of kelp (or the ashes of sea-weed dried and burnt in a pit) mixed with oil or fat.

YELLOW SOAP is made of whale-oil, soda, and resin. SOFT SOAP is made of oil and potash. HARD SOAP of oil and soda.

Q. *Why does* WATER CLEAN *dirty* LINEN*?*

A. Because the *oxygen* of the water attaches itself to the *stains of the linen*, and *dissolves* them; as oxalic acid dissolves ink spots.

Q. *Why does* SOAP *greatly* INCREASE *the cleansing power of water?*

A. 1st—Because soap *increases the oxygen* of the water: and

2ndly—It *neutralizes the grease* of the things washed.

Q. *Why is* RAIN WATER SOFT*?*

A. Because it has *not come in contact with earths and minerals*.

Q. *Why is it* MORE EASY *to* WASH *with* SOFT *water than with* HARD*?*

A. Because it unites freely with the soap, *dissolving* it instead of *decomposing it*, as hard water does.

Q. *Why do* WOOD ASHES *make* HARD *water* SOFT*?*

A. 1st—Because the *carbonic acid of the wood ashes* combines with the *sulphate of lime in the hard water*, and converts it into *chalk*: and

2ndly—The *sulphuric acid of the water* combines with the *potash of the wood ashes*, and prevents it from neutralizing the oily matter of the soap.

Q. *Why has* RAIN *water such an* UNPLEASANT SMELL*, when it is collected in a rain water tub or tank?*

A. Because it is impregnated with *decomposed organic matter*, washed from roofs, trees, or the casks in which it is collected.

Q. *Why does* WATER MELT SUGAR*?*

A. Because very minute particles of water *insinuate themselves into the pores* of the sugar, and force the crystals *apart from each other*.

Q. *Why does* WATER MELT SALT*?*

A. Because very minute particles of water insinuate themselves into the *pores of the salt*, and force the crystals *apart from each other*.

Q. *Why does melted* SUGAR *or* SALT *give a* FLAVOUR *to the* WATER*?*

A. Because the sugar or salt (being disunited into very minute pieces) *floats about the water*, and mixes with *every part*.

Q. *Why does* HOT *water melt sugar and salt* QUICKER *than* COLD *water?*

A. 1st—Because the *heat* of the water entering the pores of the sugar or salt, *opens a passage for the water*: and

2ndly—The *particles of hot water* being *smaller* than those of cold, can *more readily penetrate* the pores of salt or sugar.

Q. *Why is* SEA*-water* SALT*?*

A. 1st—Because it contains *mines of salt* at the bottom of its bed:

2ndly—It is impregnated with *bituminous matter*, which is brackish: and

3rdly—It contains many *putrid substances*, which increase its brackishness.

Q. *Why is* NOT RAIN*-water* SALT*, although most of it is evaporated from the* SEA*?*

A. Because *salt will not evaporate*; and, therefore, when sea-water is turned to vapour, its *salt is left behind*.

Q. *Why does* STAGNANT *water* PUTREFY*?*

A. Because leaves, plants, insects, &c. are decomposed in it.

Q. *Why is* STAGNANT *water full of* WORMS, EELS, *&c.?*

A. Because numberless insects *lay their eggs* in the leaves and plants which float on the surface; these eggs are soon hatched, and produce swarms of worms, eels, and insects.

Q. *Why are* FLOWING *waters* FREE *from these* IMPURITIES*?*

A. 1st—Because the motion of running water *prevents its fermentation:*

2ndly—It *dissolves the putrid substances* which happen to fall into it: and

3rdly—It casts *on the bank* (by its current) such substances as it cannot *dissolve*.

Q. *Why does* RUNNING *water* OSCILLATE *and* WHIRL *in its current?*

A. 1st—Because it *impinges against its banks*, and is perpetually diverted from its forward motion: and

2ndly—Because the *centre* of a river *flows faster* than its *sides*.

Q. *Why do the* SIDES *of a river flow more* TARDILY *than its* CENTRE*?*

A. Because they *rub against the banks*, and are delayed in their current thereby.

Q. *Why does* SOAPY *water* BUBBLE*?*

A. Because the soap *makes the water tenacious*, and prevents the bubbles from *bursting* as soon as they are formed.

Q. *Why will not water bubble* WITHOUT SOAP*?*

A. Because it is not tenacious enough *to hold together the bubbles* that are formed.

Q. *When* SOAP BUBBLES *are blown from a pipe, why do they* ASCEND*?*

A. Because they are *filled with warm breath*, which is lighter than air.

CHAPTER XXVI.

ICE.

Q. *What is* ICE*?*

A. FROZEN WATER. When the air is reduced to 32 degrees of heat, water will no longer remain in a *fluid state*.

Q. *Why is* SOLID ICE LIGHTER *than* WATER*?*

A. Because water *expands by freezing*; and as the *bulk is increased*, the *gravity* must be *less*.

Nine cubic inches of water become ten when frozen.

Q. *Why do* EWERS BREAK *in a* FROSTY NIGHT*?*

A. Because the water in them *freezes*; and as the *water is expanded by frost*, it bursts the ewers to make room for its increased volume.

Q. *Why does it not expand* UPWARDS *(like boiling water), and* RUN OVER*?*

A. Because the *surface* is first frozen, and the frozen surface acts as a *plug*, which is more difficult to burst than the earthen ewer itself.

Q. *Why do* TILES, STONES, *and* ROCKS *often* SPLIT *in winter?*

A. Because the moisture (which they imbibed) *freezes*, and by its expansion *splits the solid mass*.

Q. *In winter time,* FOOT-MARKS *and* WHEEL-RUTS *are often covered with an icy* NET-WORK, *through the interstices of which the soil is clearly seen,—*WHY *does the water freeze in* NET-WORK*?*

A. The water in these hollows froze first at the *sides* of the foot-prints: other crystals gradually shot across the water, and would have *covered the whole surface*, had not the earth *absorbed* the water before it had time to freeze.

Q. *In winter time these* FOOT-MARKS *and* WHEEL-RUTS *are sometimes covered with a perfect* SHEET *of ice, and not an icy net-work,—Why is* THIS*?*

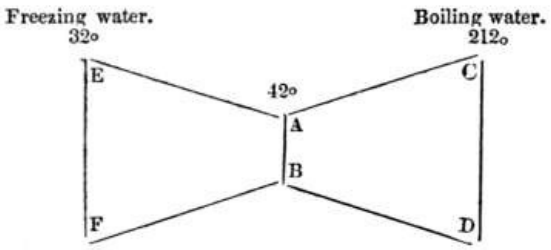
A. The *air being colder* and the *earth harder* (than in the former case), the *entire surface* of the foot-print is frozen over, before the earth can *draw the water in*.

Q. *Why is not the ice* SOLID *in these ruts?—*WHY *is there only a very thin* FILM *or* NET-WORK *of ice?*

A. Because the earth *absorbs the water*, and leaves the icy *film behind*.

Q. *Does not water expand by* HEAT *as well as* COLD*?*

A. Yes; it expands as soon as it is more than 42 degrees *till it boils*, and then it flies off in steam.



Here A B measures the bulk of a portion of water at 42 degrees.

It goes on increasing in bulk to C D, when it boils. It also goes on increasing in bulk to E F, when it freezes.

Q. *Why do* WATER-PIPES *frequently* BURST *in* FROSTY *weather?*

A. Because the water in them *freezes*; and as the water *expands by frost*, it bursts the pipes to make room for its increased volume.

Q. *When does* WATER *begin to* EXPAND *from cold?*

A. Water (which is wisely ordained by God to be an *exception* to a very general rule) *contracts* till it is reduced to 42 degrees, and then it *expands till it freezes*.

(Water freezes at 32°.)

Q. *Why does water expand when it freezes?*

A. Because it is converted into *solid crystals*, which *do not fit close*, like the particles of water.

Q. *Why is the water at the* BOTTOM *of a river* NEVER FROZEN*?*

A. Because when water is colder than 42 degrees, it instantly *ascends to the surface*; and (if it freezes) *floats there* till it is melted.

(When a river is frozen, the water below the surface is never less than 42°.)

Q. *Show the* WISDOM *of* GOD *in this wonderful exception to a general law.*

A. If ice were *heavier than water*, it would *sink*; and a river would soon become a solid *block of ice*, which could never be dissolved.

Q. *Why does not the cold* ICE *on the* SURFACE *of a river* CHILL *the water* BENEATH*, and make it freeze?*

A. 1st—Water is a *very bad conductor*, and is heated or chilled by CONVECTION only:

2ndly—If the ice on the surface were to communicate its *coldness* to the water beneath, the *water beneath* must communicate its *heat to the ice*, and the ice would instantly *melt*: and

3rdly—The ice on the surface acts as a *shield* to *prevent the cold air from penetrating the river* to freeze it below the mere crust.

Q. *Why does* WATER FREEZE *at the* SURFACE *first?*

A. Because the surface is in *contact with the air*, and the air *carries away its heat*.

Q. *Why does the coat of ice grow* THICKER *and* THICKER, *if the frost* CONTINUES*?*

A. Because the *heat of the water* (immediately below the frozen surface) *passes through the pores of the ice* into the *cold air*.

Q. *Why then are not* WHOLE RIVERS FROZEN *(layer by layer) till they become solid ice?*

A. Because water is *so slow a conductor*, that our frosts never continue *long enough* to convert a whole river into a solid mass of ice.

Q. *Why does not* RUNNING *water freeze so fast as* STILL *water?*

A. 1st—Because the motion of the current *dissolves the crystals* as fast as they are formed; and

2ndly—The heat of the *under* surface is more freely distributed to the *upper* surface by the *rolling water*.

Q. *When* RUNNING *water is* FROZEN, *why is the* ICE *generally very* ROUGH*?*

A. Because little flakes of ice are first formed and *carried down the stream*, till they meet some *obstacle* to *stop* them; *other* flakes of ice (*impinging against them*) are arrested in like manner; and the *edges* of the different flakes *overlapping* each other, *make the surface rough*.

Q. *Why do* SOME *parts of a* RIVER FREEZE LESS *than* OTHERS*?*

A. Because *springs* issue from the bottom, and (as they bubble upwards) *thaw the ice*, or make it thin.

Q. *When persons* FALL *into a* RIVER *in winter time, why does the* WATER *feel remarkably* WARM*?*

A. Because the *frosty air* is at least 10 or 12 degrees *colder* than the water.

(The water below the surface is at least 42°; but the air 32°, or even less.)

Q. *Why is* SHALLOW *water* FROZEN QUICKER *than* DEEP *water?*

A. Because (as the *whole volume* of water must be cooled to 42 degrees before the *surface can be frozen*) it will take a longer time to cool down a *deep* bed of water than a *shallow* one.

Q. *Why is* SEA-WATER RARELY FROZEN*?*

A. 1st—Because the *mass of water is so great* that it requires a very long time to cool the whole volume down to 42 degrees:

2ndly—The *ebb and flow* of the sea interfere with the cooling influence of the air: and

3rdly—*Salt* never freezes till the surface is cooled down at least 25 degrees *below the freezing point*.

Q. *Why do some* LAKES RARELY *if ever* FREEZE*?*

A. 1st—Because they are *very deep*:

2ndly—Because their water is supplied by *springs*, which bubble from the bottom.

Q. *Why does the* DEPTH *of the water* RETARD *its* FREEZING*?*

A. As the *whole volume of water* must be reduced to 42 degrees before the *surface will freeze*, the *deeper* the water, the *longer* it will be before the whole volume is thus reduced.

Q. *Why do* SPRINGS *at the bottom of a lake* PREVENT *its* FREEZING*?*

A. Because they keep continually sending forth *fresh water*, which prevents the lake from being reduced to the necessary degree of coldness.

Q. *Why is it* COLDER *in a* THAW *than in a* FROST*?*

A. When frozen water is *thawed*, it absorbs *heat from the air and objects around* to melt its ice, in consequence of which the cold is greatly increased.

Q. *Why is it* WARMER *in a* FROST *than in a* THAW*?*

A. When water freezes it *gives out its latent heat*, in order that it may be converted into *solid ice*; and as much *heat is liberated* from the water into the air, we feel warmer.

Q. *Why does* SALT DISSOLVE ICE*?*

A. Water freezes at 32°, but salt and water will not freeze *till the air is 25° colder*: if, therefore, salt be added to frozen water it becomes *liquid*, unless the thermometer stands below 7°, (which it never does in our island).

Q. *Will any thing do* INSTEAD *of* SALT*?*

A. Yes; any *acid*, such as sulphuric, nitric, &c.

Q. *Why are* SALT *and* SNOW *mixed together, colder than* SNOW*?*

A. When *salt* is mixed with snow, it *dissolves the crystals* into a fluid; and whenever a solid is

converted to a liquid, *heat is absorbed*, and the cold made more intense.

Q. *Why does* FROST *make the* EARTH CRACK*?*

A. During the warm weather the earth *absorbed abundance of moisture*, which the winter *freezes*: and (as water *expands* by frost) the expanding water *thrusts the particles of earth apart from each other*, and leaves a chink or crack behind.

Q. *Show the* WISDOM *of* GOD *in this arrangement.*

A. These *cracks* in the earth let in the air, the dew and rain, and many gases favourable to vegetation.

Q. *Why does the* EARTH CRUMBLE *in* SPRING*?*

A. In spring the *ice* of the clods *dissolves*, and the particles of earth (which had been held apart by the expanded ice) are left *unsupported*, and tumble into minute parts (because their *cement is dissolved*).

Q. *Why does* MORTAR CRUMBLE *away in* FROST*?*

A. If the mortar was not *dried in the warm weather*, its moisture *freezes*, *expands*, and thrusts the particles of the mortar away from each other; but (as soon as the frost goes) the *water condenses* and leaves the mortar full of cracks and chinks.

Q. *Why does* STUCCO PEEL *from a* WALL *in* FROSTY *weather?*

A. If the stucco was not *dried in the warm weather*, its moisture *freezes*, *expands*, and thrusts its particles away from the wall; but as soon as the water condenses again by the thaw, the stucco (being unsupported) *falls by its own weight*.

Q. *Why cannot* BRICKLAYERS *and* PLASTERERS *work in* FROSTY *weather?*

A. Because the bricks and plaster would *start from their position* as soon as the *frost* came and expanded the mortar.

Q. *Why do* BRICKLAYERS COVER *their work with* STRAW *in spring and autumn?*

A. Because straw is a non-conductor, and prevents the mortar of their new work from *freezing* during the cold nights of spring and autumn.

Q. *Why are* WATER-PIPES *often covered with* STALL-LITTER *in winter time?*

A. Because straw (being a non-conductor) prevents the *water of the pipes from freezing*, and the *pipes from bursting*.

Q. *Why are delicate trees covered with straw in WINTER?*

A. Because straw (being a non-conductor) prevents the *sap of the tree* from being frozen.

Q. *Can water be frozen in any way besides by frosty weather?*

A. Yes; in very many ways. For example—a bottle of water wrapped in *cotton*, and frequently *wetted with ether*, will soon freeze.

Q. *Why would water freeze if the bottle were kept constantly wetted with ether?*

A. Because *evaporation* would carry off the heat of the water, and reduce it to *freezing point*.

Q. *Why does ether freeze under the receiver of an air-pump, when the air is exhausted?*

A. Because *evaporation* is very greatly increased by the *diminution of atmospheric pressure*; and the ether freezes by evaporation.

FREEZING MIXTURES.

1. If nitre be dissolved in water, the heat of the liquid will be reduced 16 degrees.

2. If 5 oz. of nitre, and 5 of sal-ammoniac (both finely powdered) be dissolved in 19 oz. of water, the heat of the liquid will be reduced 40 degrees.

3. If 3 lbs. of snow be added to 1 lb. of salt, the mixture will fall to 0° (or 32 degrees below freezing point).

The two following are the coldest mixtures yet known:—

1. Mix 3 lbs. of muriate of lime with 1 lb. of snow.

2. Mix 5 lbs. of diluted sulphuric acid with 4 lbs. of snow.

Q. *Why is it more easy to swim in the sea than in a river?*

A. Because the *specific gravity* of salt water is *greater than that of fresh*, and therefore it *buoys* up the swimmer better.

Q. *How do cooks ascertain if their brine be salt enough for pickling?*

A. They put an *egg into their brine*. If the egg *sinks* the brine is *not strong enough*, if the egg *floats* it *is*.

Q. *Why will the egg sink if the brine be not strong enough for pickling?*

A. As an egg is *heavier than water*, it will *sink* if immersed therein; but if as much *salt* be added as the water can dissolve, the egg will *float*.

Q. *Why will the* EGG FLOAT *in strong* BRINE*?*

A. Because the specific gravity of *salt and water* is greater than that of water *only*.

Q. *Why do persons* SINK *in water when they are* UNSKILFUL SWIMMERS*?*

A. 1st—Because (in their floundering about) they *take in water* at their nose and mouth, which makes them *heavier*:

2ndly—FEAR *contracts the body*; and as the body is compressed by fear into a smaller compass, it becomes *heavier*: and

3rdly—The water and fear *take away the breath*; and when the breath is taken from the body, its *bulk is reduced*, and it becomes *heavier*.

Q. *Why can* QUADRUPEDS *swim* MORE EASILY *than* MAN*?*

A. 1st—Because the *trunk* of a quadruped is *lighter than water*, and this is the greatest part of them:

2ndly—The *position* of a beast in water is a *natural* one.

Q. *Why is it* MORE DIFFICULT *for a* MAN *to swim than for a* BEAST*?*

A. Because the *head and limbs* of a man (like those of a beast) are *heavier* than water, and these compose more than *half his body*:

2ndly—The *position* of a man in water is *unnatural* to him.

Q. *Why can* FAT *men* SWIM *more* EASILY *than* SPARE *men?*

A. *Fat is lighter than water*; and the *fatter* a man is, the more *buoyant* will he be.

Q. *How are* FISHES *able to* ASCEND *to the* SURFACE *of water?*

A. Fishes have an *air-bladder* near their abdomen: when this bladder is *filled with air*, the fish increases in size; and (being lighter) ascends through the water to its surface.

Q. *How are fishes able to* DIVE *in a minute to the* BOTTOM *of a stream?*

A. They *expel the air* from their air-bladder; in consequence of which, their *size is diminished*, and they sink instantly.

CHAPTER XXVII.

LIGHT.

Q. *What is* LIGHT*?*

A. Rapid undulations of a fluid called ether, striking on the optic nerve of the eye. (*See p.46.*)

The *heat* of fire or of the sun sets the atoms of *matter* in motion; and these atoms, striking against the fluid *ether*, cause it to undulate.

Q. *How* FAST *does* LIGHT TRAVEL*?*

A. Light travels so fast, that it would go eight times round the earth, while a person counts "ONE."

Q. *Does* ALL *light travel equally fast?*

A. Yes; the light of the sun, or the light of a candle, or the light from houses, trees, and fields.

Q. *Where does the* LIGHT *of* HOUSES, TREES, *and* FIELDS *come from?*

A. The light of the *sun* (or of some lamp or candle) is *reflected from their surfaces*.

Q. *Why are* SOME *surfaces* BRILLIANT *like glass and steel, and* OTHERS DULL *like lead?*

A. Those surfaces which *reflect the most light*, are the most *brilliant*; and those which *absorb* light are *dull*.

Q. *What is meant by* REFLECTING LIGHT*?*

A. Throwing the rays of light *back again*, from the surface on which they light.

Q. *What is meant by* ABSORBING LIGHT*?*

A. Letting the rays of light *sink below the surface* which they touch, so as not to be seen.

Q. *Why can a* THOUSAND *persons* SEE *the* SAME OBJECT *at the same time?*

A. Because it throws off from its surface *an infinite number of rays in all directions*; and one person sees *one* portion of these rays, and another person *another*.

Q. *Why is the* EYE PAINED *by a* SUDDEN *light?*

A. Because the pupil of the eye is *burdened with rays*, before it has had time to contract.

Q. *Why does it give us PAIN, if a CANDLE be brought suddenly towards our BED at night time?*

A. In the dark *the pupils of the eyes dilate* very much, in order to *admit more rays*. When a candle is brought before them, the enlarged pupil is *overladen with rays*, and feels pained.

Q. *Why CAN we BEAR the candle-light after a few moments?*

A, Because the pupil *contracts again* almost instantly, and adjusts itself to the quantity of light which falls upon it.

Q. *Why can we SEE NOTHING, when we leave a WELL-LIGHTED room, and go into the DARK ROAD or street?*

A. Because the pupil (which *contracted* in the bright room) does not *dilate instantaneously*; and the contracted pupil is not able to *collect rays enough* (from the dark road or street) to enable us to see before us.

Q. *Why do we SEE BETTER, when we get USED to the dark?*

A. Because the pupil *dilates* again, and is able to gather together more rays; in consequence of which, we see more distinctly.

Q. *If we look at the SUN for a few moments, why do all OTHER things appear DARK?*

A. Because the pupil of the eye (which was *very much contracted* by looking at the sun) is *too small* to collect sufficient rays from *other objects*, to enable us to distinguish their colours. (*See* "accidental colours.")

Q. *If we watch a bright FIRE for a few moments, why does the ROOM seem DARK?*

A. Because the pupil of the eye (which was very much *contracted* by looking at the fire) is *too small* to collect sufficient rays from the objects around, to enable us to distinguish their colours.

Q. *Why can we see the PROPER COLOUR of every object again, after a few minutes?*

A. Because the pupil *dilates* again, and accommodates itself to the light around.

Q. *Why can TIGERS, CATS, and OWLS see in the DARK?*

A. Because they have the power of *enlarging the pupil of their eyes*, so as to collect several scattered rays of light; in consequence of which, they can *see distinctly* when it is not light enough for us to see *any thing at all*.

Q. *Why do CATS and OWLS SLEEP almost all DAY?*

A. As the pupil of their eyes is *very broad*, daylight *fatigues* them; so they close their eyes for relief.

Q. *Why do* CATS *keep* WINKING, *when they sit before a* FIRE?

A. As the pupil of their eyes is *very broad*, the light of the fire *pains* them; and they keep shutting their eyes to relieve the sensation of too much light.

Q. *Why do* TIGERS, CATS, OWLS, *&c.* PROWL *by* NIGHT *for prey?*

A. As these animals cannot see distinctly in *strong daylight*, they *sleep* during the *day*: and as they can see clearly in the *dark*, they prowl then for prey.

Q. *Why do* GLOW-WORMS *glisten by* NIGHT *only?*

A. Because the light of day is *so much stronger*, that it *eclipses* the feeble light of a glow-worm; in consequence of which, glow-worms are *invisible by day*.

Q. *Why can we not see the* STARS *in the* DAY-TIME?

A. Because the light of day is so powerful, that it *eclipses the feeble light of the stars*: in consequence of which, they are invisible by day.

Q. *Why can we see the* STARS *even at* MID-DAY, *from the bottom of a deep* WELL?

A. As the rays of the sun never come *directly over a well*, but the rays of the *stars* do; therefore the light from those stars (in such a situation) is more clear than the light of the *sun*.

Q. *What is the* USE *of* TWO EYES, *since they present only one image of any object?*

A. The use of two eyes is to *increase the light*, or take in *more rays of light* from the object looked at, in order that it may appear *more distinct*.

Q. *Why do we* NOT *see things* DOUBLE, *with* TWO EYES?

A. 1st—Because the *axis of both eyes is turned to one object*; and, therefore, the *same impression* is made on the ret´ina of *each eye*.

2ndly—The nerves (which receive the impression) have *one point of union*, before they reach the brain.

Q. *Why do we* SEE OURSELVES *in a* GLASS?

A. The rays of light from our face *strike against the surface of the glass*, and (instead of being absorbed) *are reflected*, or sent back again to our eye.

Q. *Why are the rays of light* REFLECTED *by a* MIRROR*?*

A. Because they cannot *pass through the impenetrable metal* with which the back of the glass is covered; so they *rebound back*, just as a *marble* would do if it struck against a wall.

Q. *When a marble is rolled towards a wall, what is that path* THROUGH WHICH IT RUNS *called?*

A. The line of the *angle of incidence*.

Q. *When a marble* REBOUNDS *back again, what is the path it* THEN *describes called?*

A. The line of the *angle of reflection*.

Q. *When the light of our face goes* TO *the* GLASS*, what is the path through which it goes* CALLED*?*

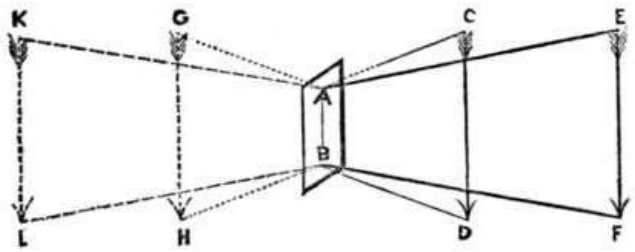
A. The line of the *angle of incidence*.

Q. *When the light of our face is reflected* BACK *again from the mirror, what is this* RETURNING *path called?*

A. The line of the *angle of reflection*.

Q. *Why does our reflection in a mirror seem to* APPROACH *us as we walk* TOWARDS *it, and to* RETIRE FROM *us as* WE *retire?*

A. Because the line *of the angle of incidence* is always *equal* to the *line and angle of reflection*.



Here CA, EA and DB, FB are the lines of the angle of incidence; and GA, KA and HB, LB are the lines of the angle of reflection. When the arrow is at CD, its shadow will appear at GH, because the line CA=GA and the angle CAB=angle GAB, &c.; and the same may be said about the point D.

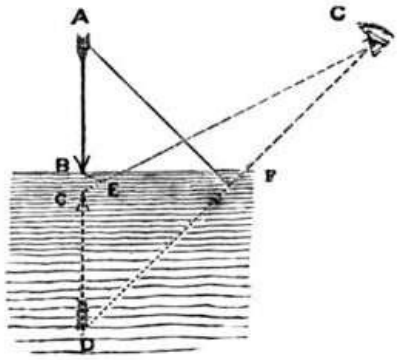
Q. *Why can a man see his* WHOLE PERSON *reflected in a* LITTLE MIRROR *not 6 inches in length?*

A. Because the *line of the angle of incidence* is always equal to the *line and angle of reflection*.

Take the last figure—CD is much larger than the mirror AB; but the head of the arrow C is reflected obliquely behind the mirror to G; and the barb D appears at H.—Why? Because the line CA=AG and the angle CAB=angle GAB, &c. The same may be said of the point D.

Q. *Why does a* SHADOW *in* WATER *always appear* TOPSY-TURVY*?*

A. Because the *line of the angle of incidence* is always equal to the *line and angle of reflection*.



Here the arrow-head A strikes the water at F, and is reflected to D; and the barb B strikes the water at E, and is reflected to C.

If a spectator stands at G, he will see the reflected lines CE and DF, produced as far as G.

It is very plain that the more elevated object A will strike the water, and be projected from it more perpendicularly than the point B, and therefore the shadow will seem inverted.

Q. *When we see our* SHADOW *in* WATER*, why do we seem to* STAND *on our* HEAD*?*

A. Because the *line of the angle of incidence* is always equal to the *line and angle of reflection*.

Suppose our head to be at A, and our feet at B; then the shadow of our head will be seen at D, and the shadow of our feet at C. (*See last figure.*)

Q. *Why do* WINDOWS *seem to* BLAZE *at* SUN-RISE *and* SUN-SET*?*

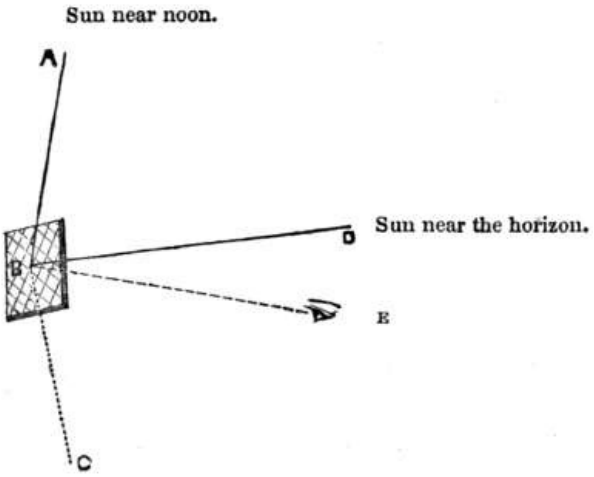
A. Because glass is a good *reflector of light*; and the rays of the sun (striking against the window glass) *are reflected*, or thrown back.

Q. *Why do* NOT *windows reflect the* NOON-DAY *rays also?*

A. They do, but the *reflection is not seen*.

Q. *Why is the reflection of the* RISING *and* SETTING *sun seen in the window, and* NOT *that of the* NOON-DAY *sun?*

A. As the angle of *incidence* always equals the *angle of reflection*, therefore the rays of the noon-day sun enter the glass *too perpendicularly* for their reflection to be seen.

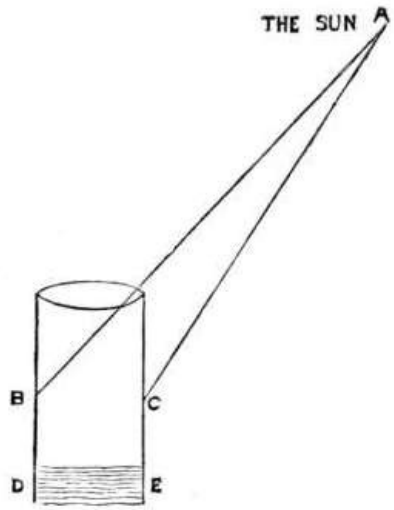


Here AB represents a ray of the noon-day sun striking the window at B; its reflection will be at C:

But DB (a ray of the rising or setting sun) will be reflected to E (the eye of the spectator).

Q. *Why can we not see the* REFLECTION *of the* SUN *in a* WELL, *during the day-time?*

A. Because the rays of the SUN *fall so obliquely*, that they *never reach the surface of the water* at all, but strike against the brick sides.



Let BDEC be the well, and DE the water.

The ray AB strikes against the brick-work *inside* the well; and

The ray AC strikes against the brick-work *outside* the well.

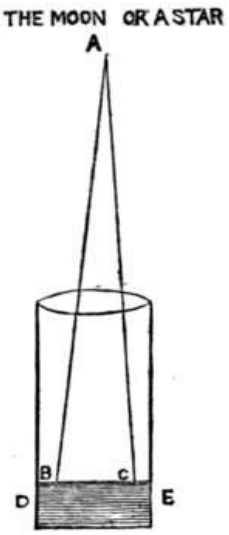
None will ever touch the water DE.

Q. *Why do we see the* MOON *reflected in a* WELL *very* OFTEN*?*

A. As the rays of the MOON are not so *oblique* as those of the sun, they will often reach the water. *(See next figure.)*

Q. *Why are the* STARS REFLECTED *in a* WELL, *although the* SUN *is* NOT*?*

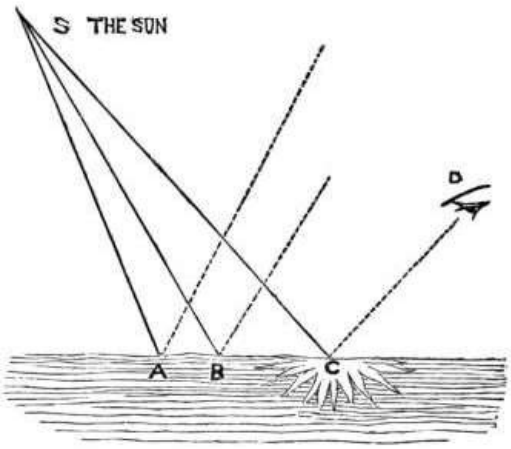
A. As the rays of the STARS are not so *oblique* as those of the sun, they will often reach the water.



Here the moon's rays AB, AC, both strike the water DE, and are reflected by it.

Q. *In a sheet of water at noon, the sun appears to shine upon only* ONE *spot, and all the* REST *of the water seems* DARK,—WHY *is this?*

A. Because the rays (which fall at various degrees of obliquity on the water) are *reflected at similar angles*; but as only those which *meet the eye of the spectator* are visible, all the sea will appear dark but *that one spot*.



Here of the rays SA, SB, and SC, only the ray SC meets the eye of the spectator D.

The spot C, therefore, will appear luminous to the spectator D, but no other spot of the water ABC.

Q. *At night the* MOON *seems to be reflected from only* ONE SPOT *of a lake of water, while all the* REST *seems* DARK,—WHY *is this?*

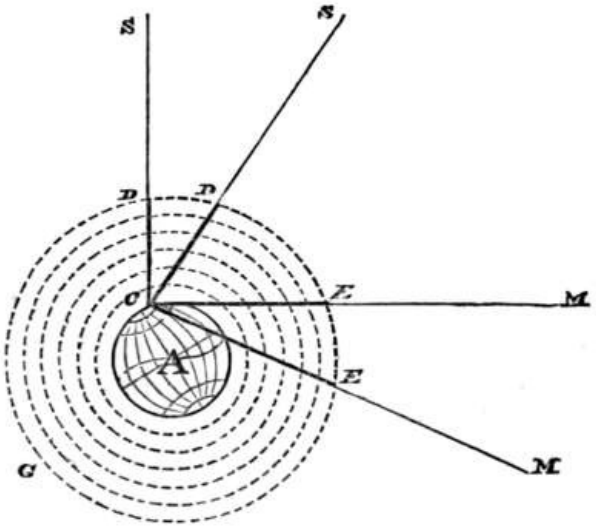
A. Because the rays (which fall at various degrees of obliquity on the lake) *are reflected at similar angles*; but as only those which *enter the eye of the spectator* will be visible, all the water will appear dark *but that one spot. (See last figure.)*

Q. *Why are* MORE STARS *visible from a* MOUNTAIN, *than from a* PLAIN?

A. As the air *absorbs and diminishes light*, the *higher we ascend*, the *less light will be absorbed*.

Q. *Why does the* SUN *seem* LARGER *at his* RISE *and* SET, *than it does at* NOON?

A. Because the earth is surrounded by air, which acts like a *magnifying glass*; and when the sun is near the horizon (as its rays *pass through more of this air*), it is more magnified.



Here SC represents a ray of the sun at noon, and MC a ray of the sun near the horizon. DEG represents the air or atmosphere around the earth.

Because EC is longer than DC, therefore the rays of the sun at M pass through *more air* than the rays of the sun at S, and the sun is more magnified.

Q. *Why does the* RISING *and* SETTING MOON *appear so much* LARGER, *than after it is risen higher above our heads?*

A. Because the earth is surrounded by air, which acts *like a magnifying glass*; and when the moon is near the horizon (as its rays pass through more of this air) it is more magnified. *(See last figure.)*

Q. *When* CANDLES *are* LIGHTED, *we* CANNOT SEE *into the* STREET *or road,—*WHY *is this?*

A. 1st—Because glass is a *reflector*, and throws the candle-light *back into the room again*; and

2ndly—The pupil of the eye (which has become *contracted* by the light of the room) is *too small* to collect rays enough from the dark street, to enable us to *see into it*.

Q. *Why can't persons in the street* SEE *into a* WELL-LIGHTED ROOM?

A. Because the pupil of their eyes is *much dilated by the dark*, and cannot collect from the window sufficient rays to enable them to *see into the room*.

Q. *Why do we often see the* FIRE REFLECTED *in our parlour* WINDOW *in winter time?*

A. Because glass is a *good reflector*; and the rays of the fire (striking against the window-glass) *are reflected back into the room again*.

Q. *Why do we often see the shadow of our* CANDLES *in the window, while we are sitting in our parlour?*

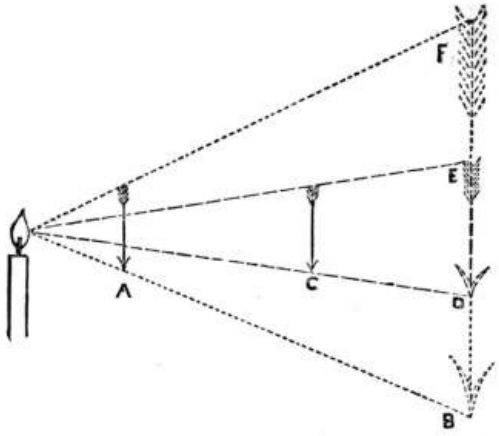
A. Because the rays of the candle (striking against the glass) are *reflected back into the room*: and the *darker* the night, the *clearer* the reflection.

Q. *Why is this reflection more clear, if the external* AIR *be* DARK*?*

A. Because the reflection is not then *eclipsed* by the brighter rays of the sun *striking on the other side of the window*.

Q. *Why is the* SHADOW *of an object (thrown on the wall)* LARGER *and larger, the* CLOSER *any object be held to the* CANDLE*?*

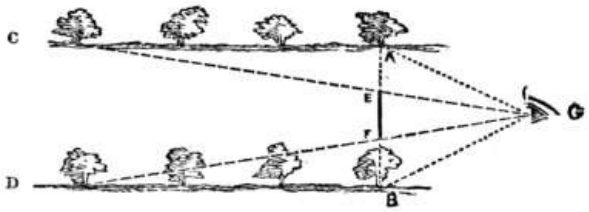
A. Because the rays of light *diverge* (from the flame of a candle) *in straight lines*, like lines drawn from the centre of a circle.



Here the arrow A held close to the candle, will cast the shadow BF on the wall: while the same arrow held at C, would cast only the little shadow D E.

Q. *When we enter a long* AVENUE *of* TREES, WHY *does the avenue seem to get* NARROWER *and narrower till it appears to* MEET*?*

A. Because the *further the trees are off*, the more *acute will be the angle* that any two will make with our eye.



Here the width between the trees A and B will seem to be as great as the line AB: But the width between the trees C and D will seem to be no more than EF.

Q. *In a long straight* STREET, WHY *do the houses seem to* APPROACH NEARER *and nearer as they are more* DISTANT*?*

A. Because the more *distant the houses* are, the more *acute will be the angle* which any two make with our eye.

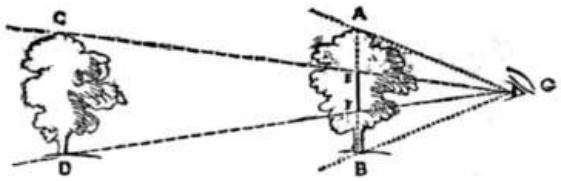
Thus in the last figure—

If A and B were two houses at the top of the street, the street would seem to be as wide as the line A B:

And if C and D were two houses at the bottom of the street, the street at the bottom would seem to be no wider than E F.

Q. *In an* AVENUE *of* TREES, WHY *do they seem to be* SMALLER *as their distance increases?*

A. Because the *further the trees are off*, the more *acute will be the angle* made by their perpendicular height with our eye.



Here the first tree A B will appear the height of the line A B; but the last tree C D will appear only as high as the line E F.

Q. *In a long straight* STREET, WHY *do the houses seem to be* SMALLER *and smaller the* FURTHER *they are* OFF*?*

A. Because the *further any house is off*, the more *acute will be the angle* made by its perpendicular height with our eye.

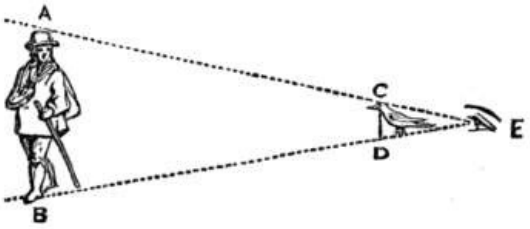
Thus in the last figure—

If A B be a house at the top of the street, its perpendicular height will be that of the line A B.

If C D be a house at the bottom of the street, its perpendicular height will appear to be that of E F.

Q. *Why does a man on the* TOP *of a* MOUNTAIN *or church spire seem to be no* BIGGER *than a* CROW*?*

A. Because the angle made by the *perpendicular height of the man* (at that distance) *with our eye*, is no bigger than the perpendicular height of a *crow close by*.



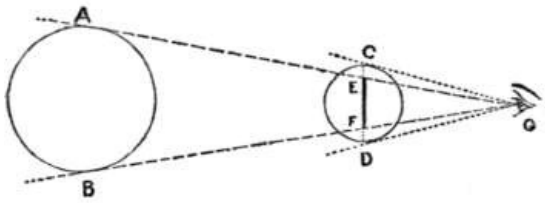
Let AB be a man on a distant mountain or spire, and CD a crow close by:

The man will appear only as high as the line CD, which is the height of the crow.

Q. *Why does the* MOON *appear to us so much* BIGGER *than the* STARS*, though in fact it is a great deal*

SMALLER?

A. Because the moon is *very much nearer to us* than any of the stars.



Let AB represent a fixed star, and CD the moon.

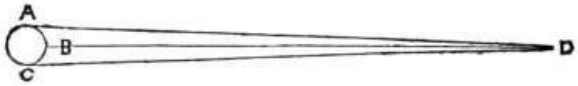
AB, though much the larger body, will appear no bigger than EF; whereas the moon (CD) will appear as big as the line CD to the spectator G.

The moon is 240,000 miles from the earth, not quite a quarter of a *million* of miles. The nearest fixed stars are 20,000,000,000,000. (i. e.. 20 billions.)

If a ball went 500 miles an hour, it would reach the moon in twenty days: but it would not reach the nearest fixed star in 4,500,000 years. Had it begun, therefore, when Adam was created, it would be no further on its journey than a coach (which has to go from the bottom of Cornwall to the top of Scotland) after it has past about three-quarters of a mile.

Q. *Why does the MOON (which is a sphere) APPEAR to be a FLAT surface?*

A. It is *so far off*, that we cannot distinguish any difference between the *length of the rays* which issue from the *edge*, and those which issue from the *centre*.



The rays AD and CD appear to be no longer than the ray BD; but if all the rays seem of the same length, the part B will not seem to be nearer to us than A and C, and therefore ABC will look like a flat or straight line.

The rays AD and CD are 240,000 miles long.

The ray BD is 238,910 miles long.

Q. *Why do the SUN and STARS (which are spheres) appear to be FLAT surfaces?*

A. Because they are such an *immense way off*, that we can discern *no difference of length* between the rays which issue from the *edge*, and those which issue from the *centre* of these bodies.

The rays AD and CD appear no longer than BD; and as B appears to be no nearer than A or C, therefore ABC must all seem equally distant; and ABC will seem a flat or straight line. (See last figure.)

Q. *Why does DISTANCE make an object INVISIBLE?*

A. Because the angle (made by the *perpendicular height* of the distant object *with our eye*) is so very *acute*, that *one* line of the angle *merges in the other*.

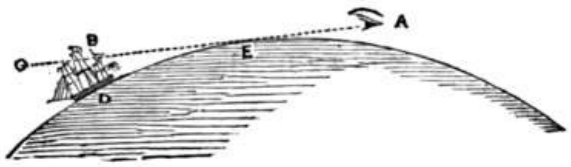
Here the tree AD would not be visible to the spectator C, even if he were to approach as far as B; because no visible perpendicular can be inserted between the two lines AC, DC, till after the point B is past; when the tree will appear like a very little speck.

Q. *Why do* TELESCOPES *enable us to* SEE *objects* INVISIBLE *to the naked eye?*

A. Because they *concentrate several rays* within the tube of the telescope, and *bend them upon the mirror or lens*, which acts as a *magnifying glass*.

Q. *When a* SHIP *(out at sea) is approaching the shore, why do we* SEE *the small* MASTS *before we see the bulky* HULL*?*

A. Because the *earth is round*, and the *curve* of the sea *hides the hull* from our eyes, after the tall *masts* have become visible.



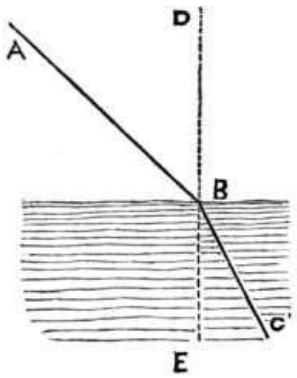
Here only that part of the ship above the line AC can be seen by the spectator A; the rest of the ship is hidden by the swell of the curve DE.

Q. *What is meant by* REFRACTION*?*

A. The *bending of a ray of light*, as it passes from one medium to another.

Q. *How is a ray of light* BENT*, as it passes from one medium to another?*

A. When a ray of light passes into a *denser* medium, it is bent *towards the perpendicular*. When it passes into a *rarer* medium, it is bent *from* the perpendicular.



Suppose DE to be a perpendicular line.

If AB (a ray of light,) enters the water, it will be bent *towards* the perpendicular to C.

If (on the other hand) CB (a ray of light) emerges *from* the water, it would be bent *away from* the perpendicular towards A.

Q. *Why does a* SPOON *(in a glass of water) always appear* BENT*?*

A. Because as the light of the spoon *emerges from the water*, it is *refracted*.

And the spoon looks like ABC. (See the last figure.)

Q. *Why does a river always appear more shallow than it really is?*

A. Because the light of the bottom of the river is REFRACTED as it emerges out of the water: and (as a stick is not so long when it is *bent*, as it is when it is *straight*) so the river seems less deep than it really is.

Q. *How much deeper is a river than it seems to be?*

A. One-third. If, therefore, a river seems only 4 feet deep, it is really 6 feet deep.

N. B. Many boys get out of their depth in bathing, in consequence of this deception. Remember, a river is always one-third deeper than it appears to be:—thus, if a river seems to be 4 feet deep, it is in reality 6 feet deep, and so on.

Q. *Why do fishes always seem to be nearer the surface of a river than they really are?*

A. Because the rays of light from the fish are *refracted* as they emerge from the eye: and (as a bent stick is not so far from end to end as a straight one) so the fishes appear nearer our eye than they really are.

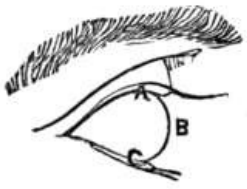
Q. *Why are some persons NEAR-SIGHTED?*

A. Because the COR´NEA of their eye is so *prominent*, that the image of distant objects is reflected *before it reaches the* RET'INA; and, therefore, is not distinctly seen.

N.B. The cor´nea shields the CRYSTALLINE LENS, and is more or less convex according to the lens which it covers.

Q. *What is meant by the "COR'NEA of the EYE?"*

A. All the *outside* of the visible part of the *eye-ball*.



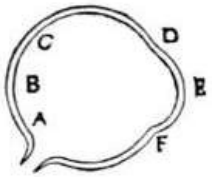
The curve A B C is called the COR'NEA.

If this curve be too prominent (or convex), the eye is near-sighted.

If too flat (or concave), the eye is far-sighted.

Q. *What is meant by the "RET'INA of the EYE?"*

A. The net-work which lines the *back of the eye*, is so called.



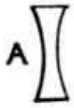
The net-work ABC is called the ret'ina, and the projecting part DEF is called the cor'nea.

Q. *What sort of GLASSES do NEAR-SIGHTED persons wear?*

A. If the cor'nea be *too convex* (or projecting), the person must wear double *concave glasses*, to counteract it.

Q. *What is meant by "DOUBLE CONCAVE GLASSES?"*

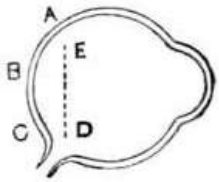
A. Glasses hollowed in *on both sides*.



The figure A is double concave, or concave on both sides.

Q. *What is meant by the "IMAGE of objects being reflected BEFORE it reaches the RET'INA?"*

A. If the cor'nea be *too convex*, the image of a distant object is reflected (on the vitreous humours of the eye) *before it reaches the ret'ina*.



Thus the image is reflected at DE, instead of on ABC (the ret'ina).

Q. *What is the use of DOUBLE CONCAVE SPECTACLE glasses?*

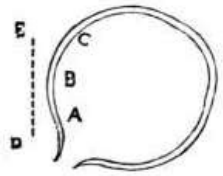
A. Near-sighted spectacles *cast the reflection further back;* and the image (being *thrown upon the ret'ina*) becomes visible.

Q. *Why are OLD people FAR-SIGHTED?*

A. Because the humours of their eyes *are dried up by age*, and the COR'NEA *sinks in*, or becomes flattened.

Q. *Why does the FLATTENING of the COR'NEA prevent persons seeing objects which are NEAR?*

A. As the cor'nea *is too flat*, the image of any near object is formed *behind the* RET'INA *of the eye*, and is not seen at all.



The reflection is made at DE, instead of at ABC (the retina).

Q. *What sort of* GLASSES *do* OLD *people* WEAR*?*

A. As their cor'nea is *not sufficiently convex*, they must use *double convex glasses*, to enable them to see objects near at hand.

Q. *What sort of glasses are* DOUBLE CONVEX SPECTACLE-GLASSES*?*

A. Glasses which *curve outwards* on both sides.

The figure A is double convex, or convex on both sides.

Q. *What is the* USE *of* DOUBLE CONVEX *spectacle-glasses?*

A. As the image of near objects is reflected *behind the* RET'INA, these double convex glasses *shorten the focus of the eye*, and bring the image *into the eye* (upon the ret'ina).

Q. *Why do* NEAR-SIGHTED *persons bring objects* CLOSE *to the eye, in order to* SEE THEM*?*

A. As the distance between the *front and back of their eye is too great*, distant objects are reflected *before they reach the ret'ina*; therefore, near-sighted persons bring the objects *closer*, in order that the reflection *may be cast further back*, (to reach the ret'ina).

Q. *Why do* OLD *people* HOLD *objects* FURTHER OFF*, in order to see them better?*

A. As the distance between the *front and back of their eye is not great enough*, the reflection of near objects is thrown *beyond the ret'ina*; therefore, they hold objects *a long way off*, in order to bring their images *forward* (so as to cast it on the ret'ina).

Q. *Why are* HAWKS *able to see such an* IMMENSE *way off?*

A. Because they have a muscle in the eye which enables them to *flatten their cor'nea*, by drawing back the crystalline lens.

This muscle is called the "marsupium."

Q. *Why can* HAWKS *not only see such a long way off, but also objects within half-an-inch of their eye?*

A. Because their eyes are furnished with a broad circular rim which *confines the action of this muscle*, and throws the *cor'nea forward*.

Q. *Into how many* PARTS *may a* RAY *of* LIGHT *be* DIVIDED*?*

A. Into three parts: BLUE, YELLOW, and RED.

N.B. These 3 colours, by combination, make seven. 1.—RED. 2.—Red and yellow form ORANGE. 3.—YELLOW. 4.—Yellow and blue make GREEN. 5.—BLUE. 6 and 7.—Shades of blue called INDIGO and VIOLET.

Q. *How is it* KNOWN*, that a ray of light consists of several different colours?*

A. Because, if a ray of light be cast upon a triangular piece of glass (called a prism), it will be distinctly divided into seven colours: 1.—Red; 2.—Orange; 3.—Yellow; 4.—Green; 5.—Blue; 6.—Indigo; and 7.—Violet.

Q. *Why does a* PRISM DIVIDE *a ray of light into* VARIOUS COLOURS*?*

A. Because all these colours have *different refractive powers*. Red is refracted *least*, and blue the *most*; therefore, the *blue* colour of the ray will be bent to the *top* of the prism, and the *red* will remain at the *bottom*.

Here the ray AB received on a prism, would have the blue part bent up to C; the yellow part to D; and the red part no further than E.

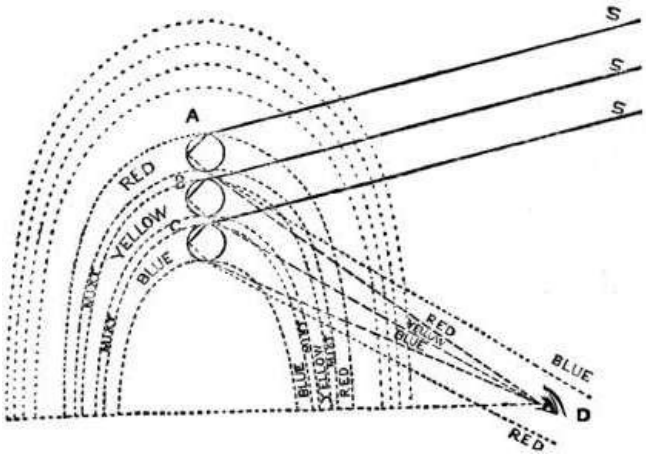
Q. *What is meant by the* REFRACTION *of a ray?*

A. *Bending it* from its straight line.

Thus the ray AB of the last figure is refracted at B into three courses, C, D, and E.

Q. *What is the cause of a* RAINBOW*?*

A. When the clouds opposite the sun *are very dark*, and rain is *still falling* from them, the rays of the bright sun *are divided by the rain-drops*, as they would be by a prism.



Let A, B, and C be three drops of rain; SA, SB, and SC three rays of the sun. SA is divided into the 3 colours; the blue and yellow are bent *above* the eye D, and the *red* enters it.
br /> The ray SB is divided into the three colours; the blue is bent *above* the eye, and the red falls *below* the eye D; but the *yellow* enters it.

The ray SC is also divided into the three colours. The blue (which is bent most) enters the eye; and the other two fall below it. Thus the eye sees the blue of C, and all drops in the position of C; the yellow of B, and of all drops in the position of B; and the red of A, &c.; and thus it sees a rainbow.

Q. *Does* EVERY *person see the* SAME *colours from the* SAME DROPS*?*

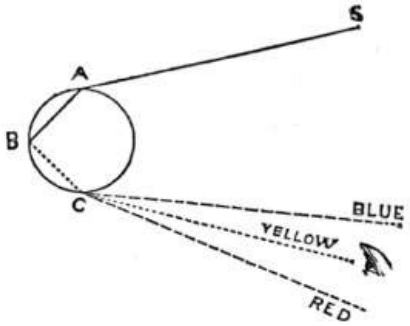
A. No; *no two persons* see the *same rainbow*.

To another spectator the rays from SB might be *red* instead of yellow; the ray from SC, yellow; and the blue might be reflected from some drop below C. To a *third* person the red may issue from a drop above A, and then A would reflect the yellow, and B the blue, and so on.

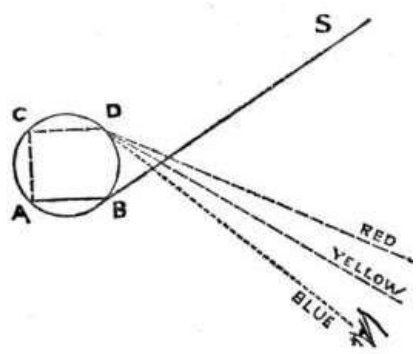
Q. *Why are there often* TWO RAINBOWS *at one and the same time?*

A. In *one* rainbow we see the rays of the sun *entering the rain-drops at the top*, and reflected to the eye *from the bottom*.

In the *other* rainbow, we see the rays of the sun *entering the rain-drops at the bottom*, and reflected to the top, whence they reach the eye.



Here the ray SA strikes the drop at A,—is refracted or bent to B,—is then reflected to C, where it is refracted again, and reaches the eye of the spectator.

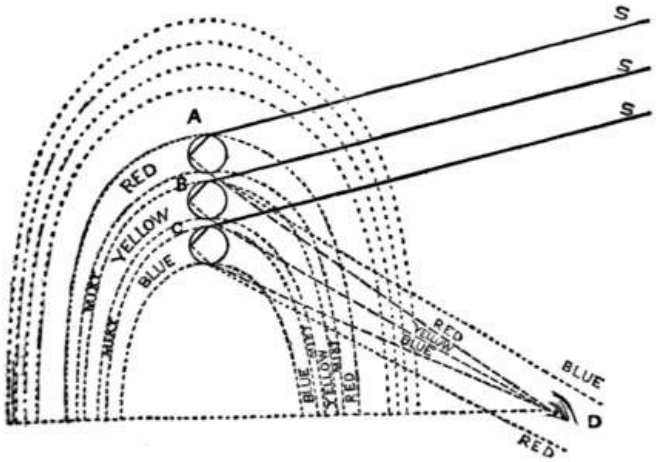


Here the ray SB strikes the drop at B,—is refracted to A,—is then reflected to C,—is again reflected to D, when it is again refracted or bent till it reaches the eye of the spectator.

Q. *Why are the* COLOURS *of the* SECOND *bow all* REVERSED*?*

A. Because in *one* bow we see the rays which enter at the *top* of the raindrops, *refracted from the bottom*:

But in the *other* bow we see the rays which enter at the *bottom* of the raindrops (after two reflections), *refracted from the top*.

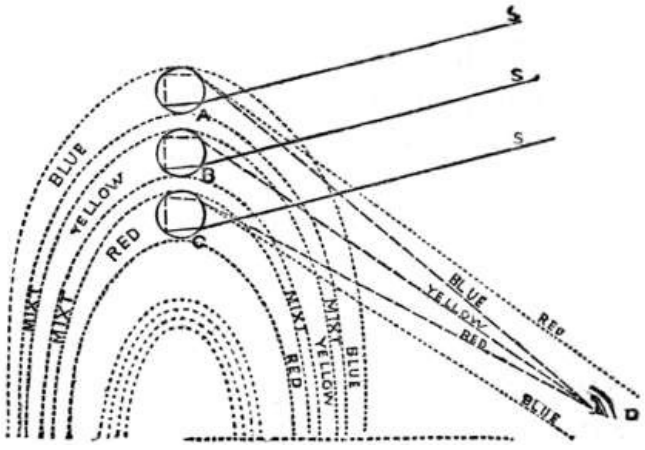


Here A, B, C, represent three drops of rain in the PRIMARY (or inner) RAINBOW.

The *least* refracted line is RED, and BLUE the *most*.

So the RED (or *least* refracted rays) of all the drops in the position of A,—the YELLOW of those in the position of B,—and the BLUE (or the *most* refracted rays) of the lowest drops, all meet the eye D, and form a rainbow to the spectator.

The reason why the primary bow exhibits the stronger colours is this—because the colours are seen after *one* reflection and *two* refractions; but the colours of the secondary (or upper) rainbow undergo *two* reflections and *three* refractions.



Here also the *least* refracted ray is RED, and the *most* refracted BLUE (as in the former case); but the position of each is reversed.

Q. *Why does a SOAP BUBBLE exhibit such VARIETY of COLOURS?*

A. The changing colour of the bubble depends upon the changing *thickness of the film* through which the ray passes.

Q. *How does the THICKNESS of the FILM affect the COLOUR of the soap bubble?*

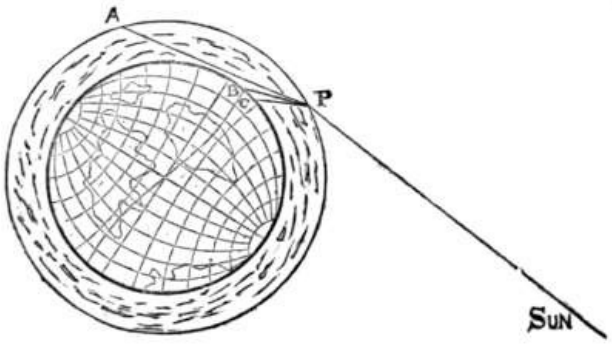
A. Because different *degrees of thickness* produce different *angles of refraction*, and, therefore, different colours reach the eye.

Q. *Why is the SOAP BUBBLE so constantly CHANGING its THICKNESS?*

A. As the bubble is *suspended*, the water keeps *running down from the top* to the bottom of the bubble, till the crown becomes so *thin* as to burst.

Q. *Why are the late EVENING CLOUDS RED?*

A. Because RED rays (being the *least refrangible*) are the *last to disappear*.



Here it will be seen that the red ray PA, being reflected on the horizon at A, will be visible to us; but the YELLOW and BLUE rays will be hidden by the curve of the earth.

Q. *Why are the early MORNING clouds RED?*

A. Because RED rays (being the *least refrangible*) are the *first to appear*.

See last figure.—It is evident that PA (the red rays) will be reflected on the horizon before either the yellow or blue ones.

Q. *What becomes of the BLUE and YELLOW rays?*

A. They are refracted *below the horizon*, and are soon made invisible by the *curve of the earth*. (*See last figure.*)

Q. *Why are the* EDGES *of* CLOUDS *more* LUMINOUS *than their* CENTRES*?*

A. Because the *body of vapour is thinnest* at the edges of the clouds.

Q. *What is the cause of morning and evening* TWILIGHT*?*

A. When the sun is below the horizon, the rays (which strike upon the atmosphere or clouds) *are bent down towards the earth*, and produce a little light called twilight.

See figure on p. 399.—Here the rays of PA will give *some* light.

Q. *Why is a ray of* LIGHT *composed of* VARIOUS COLOURS*?*

A. If solar light were of *one colour only*, all objects would appear of *that one colour* (or else black.)

Q. *Why are some things of* ONE COLOUR*, and some of* ANOTHER*?*

A. As every ray of light is composed of all the colours of the rainbow, *some* things reflect *one of these colours*, and some *another*.

Q. *Why do some things reflect* ONE COLOUR*, and some* ANOTHER*?*

A. Because the *surface* of things is so *differently constructed*, both physically and chemically; and, therefore, *some* things reflect *one* ray; some *two rays*; some *all* the rays; and some *none*.

Q. *What mainly determines the* COLOUR *of any object?*

A. The fluid or gas either *in* the body, or on its *surface*.

N. B. Nitrogen gives green,—Oxygen gives red,—Hydrogen gives blue colours.

Q. *Why does* DYING *a silk, &c.* CHANGE *its* COLOUR*?*

A. Because the materials used in dyeing *alter the chemical construction* of the substance dyed.

Q. *Why is a* ROSE RED*?*

A. Because the surface of a rose *absorbs the blue and yellow* rays of light, and *reflects* only the *red* ones.

Q. *Why does a rose absorb the yellow and blue rays, and reflect the* RED*?*

A. Because the action of the sun's rays on the oxygen (accumulated in the petals) produces an *acid* which turns them *red*.

The leaves which compose a flower, are called PETALS.

Q. *Why is a VIOLET BLUE?*

A. Because the surface of the violet *absorbs the red and yellow* rays of the sun, and *reflects* the *blue* only.

Q. *Why do violets absorb the red and yellow rays, and reflect the BLUE?*

A. Because the petals of the violet contain an *alkali*, which gives them a *purple tinge*.

Q. *Why is a PRIMROSE YELLOW?*

A. Because the surface of the primrose *absorbs the blue and red* rays of solar light, and *reflects* the *yellow* ones.

All plants which have much alkali in their ash, have blue or yellow flowers.

Those which have acid in their ash, have orange, pink, or red flowers.

N. B. Anti-acids (like soda) are called ALKALIS.

Q. *Why are some things BLACK?*

A. Because they *absorb all the rays of light*, and reflect *none*.

Q. *Why are some things WHITE?*

A. Because they *absorb none of the rays of light*, but reflect them *all*.

Q. *Why are COALS BLACK?*

A. Because they *absorb all the rays of the sun* which impinge upon them, and stifle their reflection.

Q. *Why is SNOW WHITE?*

A. Snow consists of a vast number of crystals (or small prisms), which separate the rays into their elemental colours; but as these crystals are very numerous, the colours *unite again* before they meet the eye, and *appear white*.

N. B. The combination of *all* colours makes WHITE.

Q. *Why is SUGAR WHITE?*

A. Sugar consists of a vast number of small crystals, which separate the rays into their elemental colours; but as these crystals are very numerous, the colours *unite again* before they meet the

eye, and appear *white*.

Q. *Why is* SALT WHITE*?*

A. Salt consists of a vast number of small crystals, which reflect the various rays of light from different points of the salt; and as these colours *unite* before they meet the eye, the salt appears to be *white*.

N. B. The combination of *all* colours makes WHITE.

Q. *Why are the* LEAVES *of plants* GREEN*?*

A. Because the *carbon* of the leaves is a *bluish olive*, and the *sap* and *tissue of the cells*, YELLOW; when, therefore, the *yellow sap* flows into the *blue carbon*, it produces a *green leaf*.

Q. *Why are leaves a* LIGHT *green in* SPRING*?*

A. Because the young leaves of spring have *more sap* than *carbon*; and, therefore, the *yellow* of the green prevails.

Q. *Why are leaves a* YELLOWISH BROWN *in* AUTUMN*?*

A. Because the *carbon* of the leaves is *dying away*, and the yellow tinge of the *tissue* and *falling sap* prevails over the blue.

Q. *Why are plants a* PALE YELLOW *when kept in the* DARK*?*

A. Solar light is essential for the production of *carbon*; and as plants kept in the dark *lose their carbon*, they lose the *blue colour* which should convert their yellow sap to *green*.

Q. *Why are* POTATOES YELLOW*?*

A. Potatoes are grown *underground*, and, therefore, contain very little *carbon* (or blue colour); hence the *yellow sap* of the potato is not converted to green by carbon.

Q. *Why are potatoes (which grow* EXPOSED *to the air and light)* GREEN*?*

A. Because the sun-light *increases their carbon*; which (mingling with the yellow sap) turns the potato *green*.

Q. *Why is it* DANGEROUS *to* SLEEP *in a room which contains* LIVING PLANTS*?*

A. Because they *exhale carbon in the dark* in the form of CARBONIC ACID GAS, which is destructive to animal life.

Q. *Why are some things (like glass) transparent?*

A. In transparent bodies (like glass) all the rays of light *emerge on the opposite side*.

Q. *Why are some things shining and splendid?*

A. Those objects which *reflect the most rays* are the most *splendid*; and those which *absorb* them most, are *dull*.

Q. *Why are deserts so dazzling in summer time?*

A. Because each separate grain of sand *reflects the rays of the sun* like a mirror.

Q. *If you move a stick (burnt at one end) round pretty briskly, it seems to make a circle of fire,—Why is this?*

A. Because the eye *retains the image* of any bright object, *after the object itself is withdrawn*; and as the spark of the stick returns *before the image has faded* from the eye, therefore, it seems to form a *complete circle*.

Q. *If separate figures (as a man and a horse) be drawn on separate sides of a card, and the card twisted quickly, the man seems to be seated on the horse,—Why is this?*

A. Because the image of the horse *remains upon the eye* till the *man* appears.

The Thaumatrope is constructed on this principle.

Q. *Why do the stars twinkle?*

A. Fixed stars are *so far off*, that their rays of light do not strike upon the eye *in a continuous flow*, but at *intervals*: when their rays *reach the eye*, the star becomes *visible*, and then is obscured *till the next batch of rays arrive*; and this *perpetually* occurring, makes a kind of *twinkling*.

Q. *If we look at a red-hot fire for a few minutes, why does every thing seem tinged with a bluish green colour?*

A. Because bluish green is the "accidental colour" of red: and if we fix our eye upon *any colour whatsoever*, when we turn aside, we see every object tinged with *its accidental colour*.

Q. *If we wear blue glasses, (when we take them off,) every thing appears tinged with orange,—Why is this?*

A. Because *orange* is the "*accidental colour*" of blue: and if we look through *blue glasses*, we shall see its "*accidental colour*," when we lay our glasses aside.

Q. *If we look at the* SUN *for a few moments, every thing seems tinged with a* VIOLET *colour,—*WHY *is this?*

A. Because *violet* is the "accidental colour" of *yellow* light; and as the sun is *yellow*, we shall see its "accidental colour" *blue*, when we turn from gazing at it.

Q. *Does not the* DARK SHADOW *(which seems to hang over every thing after we turn from looking at the sun) arise from our eyes being* DAZZLED*?*

A. Partly so: the pupil of the eye is *very much contracted* by the brilliant light of the sun, and does not adjust itself immediately to the feebler light of terrestrial objects; but, independent of this, the "ACCIDENTAL COLOUR" of the sun being *dark violet*, would tend to throw a shadow upon all things. (*See p. 366.*)

Q. *Why is* BLACK *glass for spectacles the* BEST *for wear?*

A. Because *white* is the accidental colour of *black*; and if we wear *black glasses*, every thing will appear *in white light*, when we take them off.

Q. *Why does every thing seem shadowed with a* BLACK MIST, *when we take off our common* SPECTACLES*?*

A. Because the glasses are *white*, and black being its "accidental colour," every thing appears in a *black shade*, when we lay our glasses down.

The accidental colour of red is bluish green.
The accidental colour of orange is blue.
The accidental colour of violet is yellow.
The accidental colour of of black is white.

And the converse of this is true:—

The accidental colour of bluish green is red.
The accidental colour of of blue is orange.
The accidental colour of of yellow is violet.
The accidental colour of of white is black.

(The law of an accidental colour is this—The accidental colour is always half the spectrum. Thus, if we take half the length of the spectrum by a pair of compasses, and fix one leg in any colour, the other leg will hit upon its accidental colour.)

N. B. The spectrum means the seven colours—Red, orange, yellow, green, blue, indigo, and violet, divided into seven equal bands, and placed side by side in the order just mentioned.

CHAPTER XXVIII.
SOUND.

Q. *What is* SOUND*?*

A. The vibration of some sonorous substance produces motion in the air called SOUND WAVES, which strike upon the *drum of the ear*, and give the sensation of sound.

Q. *What are* MUSICAL SOUNDS*?*

A. Regular and uniform successions of vibrations, which are always pleasing to the ear.

Q. *How* FAST *does* SOUND TRAVEL*?*

A. About 13 miles in a minute, or 1142 feet in a second of time.

Q. *How fast does* LIGHT TRAVEL*?*

A. Light would go 8 times round the whole earth, while sound is going its 13 miles.

Q. *Why are* SOME *things* SONOROUS*, and others* NOT*?*

A. The sonorous quality of any substance depends upon its *hardness and elasticity*.

Q. *Why are* COPPER *and* IRON SONOROUS*, and not* LEAD*?*

A. Copper and iron are *hard and elastic*; but as lead is neither hard nor yet elastic, it is *not sonorous*.

Q. *Of what is* BELL-METAL *made?*

A. Of *copper and tin* in the following proportions:—In every 5 pounds of bell-metal, there should be 1 lb. of tin, and 4 lbs. of copper.

Q. *Why is this mixture of tin and copper used for* BELL-METAL*?*

A. Because it is much *harder* and more *elastic* than either of the pure metals.

Q. *Why is the* SOUND *of a bell* STOPPED *by* TOUCHING *the bell with our finger?*

A. The weight of the finger *stops the vibrations* of the bell; and as soon as the bell *ceases to vibrate*, it ceases to make sound-waves in the air.

Q. *Why does a* SPLIT BELL *make a* HOARSE *disagreeable sound?*

A. The *split* of the bell causes a *double vibration*; and as the sound-waves *clash and jar*, they impede each other's motion, and produce discordant sounds.

Q. *Why does a* FIDDLE-STRING *give a musical sound?*

A. The bow drawn across the string *causes it to vibrate*, and this vibration of the string *sets in motion the sound-waves of the air*, and produces musical notes.

Q. *Why does a* DRUM *sound?*

A. The parchment head of the drum *vibrates* from the blow of the drum-stick, and sets in motion the sound-waves of the air.

Q. *Why do* MUSICAL GLASSES *give sounds?*

A. Because the glasses *vibrate* as soon as they are struck, and set in motion the sound-waves of the air.

Q. *Why do* FLUTES, *&c. produce musical sounds?*

A. The breath of the performer causes the *air in the flute to vibrate*, and sets in motion the sound-waves of the air.

Q. *Why do* PIANO-FORTES *produce musical sounds?*

A. The *keys of the piano* (being struck with the finger) lift up a little hammer which *knocks against a string*; and the vibration thus produced, sets in motion the sound-waves of the air.

Q. *Why are* SOME *notes* BASS *and some* TREBLE*?*

A. *Slow* vibrations produce *bass or deep sounds*; whereas, *quick* vibrations produce *shrill or treble sounds*.

Q. *Why is an instrument* FLAT *when the* STRINGS *are* UNSTRUNG*?*

A. Because the vibrations are *too slow*; in consequence of which, the sounds produced are not *shrill* or *sharp* enough.

Q. *Why can persons living a mile or two from*

a town HEAR *the* BELLS *of the town-church* SOME TIMES, *and not at* OTHERS*?*

A. Fogs, rain, and snow, obstruct the passage of sound; but when the air is *cold and clear*, sound is propagated more easily.

Q. *Why can we* NOT *hear sounds (as distant church bells) in* RAINY *weather, so well as in* FINE *weather?*

A. Because the falling rain *interferes with the undulations of the sound-waves*, and breaks them up.

Q. *Why can we not hear sounds (as distant church bells) in* SNOWY *weather, so well as in* FINE *weather?*

A. Because the falling snow *interferes with the undulations of the sound-waves*, and stops their progress.

Q. *Why can we* HEAR *distant clocks* MOST *distinctly in* CLEAR COLD *weather?*

A. Because the air is most *uniform* then: there are not *two currents of air* (one up and one down) to interrupt the sound-waves.

Q. *Why can persons hear the* VOICES *of men in conversation for a* MILE *distant, near the* POLES, *in winter time?*

A. Because the air is very *cold and very clear*; in consequence of which, there are not *two currents of air* (one up and one down) to interrupt the sound-waves.

Captain Ross heard the voices of his men in conversation, a mile and a half from the spot where they stood.

Q. *Why are not* SOUNDS *(such as distant church bells) heard so distinctly on a* HOT DAY *as in* FROSTY *weather?*

A. Because there are *two currents of air*; the current of *hot* air *ascending from the earth*, and the current of *colder* air *falling towards* the earth; and these two currents *break up the sound-waves*.

Q. *Why can we not hear* SOUNDS *(such as distant clocks) so distinctly in a thick* MIST *or* HAZE, *as in a* CLEAR *night?*

A. Because the mist *diminishes the velocity* of the sound-waves, and (by overburdening them with vapour) *limits their length*.

Q. *Why do we hear* SOUNDS *better by* NIGHT *than by* DAY*?*

A. 1st—Night air is *more uniform*, because the ascending currents of air (raised by the action of the sun's rays) *cease* as the evening advances; and

2ndly—Night is more *still* from the suspension of business, and the cessation of the hum of men.

Q. *How should* PARTITION WALLS *be made to* PREVENT *the voices in adjoining rooms from being* HEARD*?*

A. The space between the laths (or canvass) should be filled with *shavings or saw-dust*; and then no sound would ever pass from one room to another.

Q. *Why would* SHAVINGS *or saw-dust* PREVENT *the transmission of sound from room to room?*

A. Because there would be *several different media* for the sound to pass through: 1st—the air;

2ndly—the laths and paper;

3rdly—the saw-dust or shavings;

4thly—the air again: and every *variety* diminishes the *strength of the sound-waves*.

Q. *Why can* DEAF *people hear through an* EAR TRUMPET*?*

A. The ear trumpet restrains *the spread of the voice*, and limits the *diameter of the sound-waves*; in consequence of which, their *strength* is increased.

Q. *Why are* MOUNTAINS *so* NOISELESS *and quiet?*

A. Because the air of mountains is *very rarefied*; and as the air becomes *rarefied*, sound becomes less *intense*.

Q. *How do you know that the* RARETY *of air* DIMINISHES *the intensity of* SOUND*?*

A. If a bell be rung in the receiver of an air-pump, the sound becomes *fainter and fainter* as the air is exhausted, till at last it is quite *inaudible*.

Q. *What is the cause of* ECHO*?*

A. Whenever a sound-wave strikes against any *obstacle* (such as a wall or hill), *it is reflected* (or thrown back); and this *reflected sound* is called an ECHO.

The same laws govern echo as light. (*See p. 370.*)

Q. *What places are most* FAMOUS *for* ECHOES*?*

A. Caverns, grottoes, and ruined abbeys; the areas of antique halls; the windings of long passages; the aisles of cathedral churches; mountains, and ice-bergs.

Q. *Why are caverns, grottoes, and ruined abbeys* FAMOUS *for* ECHOES*?*

A. 1st—Because the sound-waves cannot pass *beyond* the cavern or grotto, and *must flow back*:

2ndly—The *return waves* (being entangled by the cavern) are *detained* for a short time, and come *deliberately* to the ear.

Q. *Why are antique halls, winding passages, and cathedral aisles* FAMOUS *for* ECHOES*?*

A. Because the sound-waves *cannot flow freely forward*, but strike against the winding walls perpetually, and are beaten *back*.

Q. *Why are* MOUNTAINS *and ice-bergs* FAMOUS *for* ECHOES*?*

A. Because they present a *barrier* to the sound-waves *which they cannot pass*; and are sufficiently elastic to *throw them back*.

Q. *Why do not the walls of a* ROOM *or church produce* ECHO*?*

A. Because sound travels with such *velocity*, that the echo is *blended with the original sound*, and produce but *one impression* on the ear.

Sound travels 13 miles in a minute.

Q. *Why do very* LARGE *buildings (as cathedrals), often* REVERBERATE *the voice of the speaker?*

A. Because the walls are *so far off from the speaker*, that the echo does not *get back in time* to blend with the original sound; and, therefore, *each* is heard separately.

Q. *Why do* SOME *echoes repeat only* ONE *syllable?*

A. The *further* the echoing body is *distant*, the *more sound* it will *reflect*. If, therefore, the echoing body be *near*, it will repeat but one syllable.

Q. *Why does an* ECHO *sometimes repeat* TWO *or more syllables?*

A. Because the echoing body is *far off*; and, therefore, there is time for one reflection *to pass away* before *another* reaches the ear.

Q. *Why do* WINDOWS RATTLE *when* CARTS *pass by a house?*

A. 1st—Glass is *sonorous*; and the air communicates its vibrations to the glass, which echoes the same sound: and

2ndly—The *window-frame is shaken* by the sound-waves *impinging against the window*, and contributes to the noise.

CHAPTER XXIX.
MISCELLANEOUS.

Q. *Why do the* BUBBLES *in a* CUP OF TEA *range round the* SIDES *of the* CUP*?*

A. Because the cup *attracts them*.

Q. *Why do all the* LITTLE BUBBLES *tend towards the* LARGE *ones?*

A. Because the large bubbles (being the superior masses) *attract them*.

Q. *Why do the* BUBBLES *of a* CUP OF TEA FOLLOW *a* TEA-SPOON*?*

A. Because the tea-spoon *attracts them*.

Q. *Why are the* SIDES *of a pond covered with* LEAVES*, while the* MIDDLE *of the pond is quite* CLEAR*?*

A. Because the shore *attracts* the leaves to itself.

Q. *Why do all fruits, &c. (when severed from the tree)* FALL *to the* EARTH*?*

A. Because the earth *attracts them*.

Q. *Why do persons (who water* PLANTS*) very often pour the water into the* SAUCER*, and not* OVER *the* PLANTS*?*

A. Because the water in the saucer is *supped up* by the mould (through the hole at the bottom of the flower-pot), and is transferred to the stem and leaves of the plant by CAPILLARY ATTRACTION, (*See p. 84*).

Q. *Why is vegetation on the* MARGIN *of a* RIVER *more* LUXURIANT *than in an open* FIELD*?*

A. Because the porous earth on the bank *sups up water* to the roots of the plants by CAPILLARY ATTRACTION.

Q. *Why is a* LUMP *of* SUGAR *(left at the bottom of a cup) so* LONG *in* MELTING*?*

A. Because *as it melts*, it makes the tea above it *heavier*; and (so long as it remains at the bottom) is surrounded by tea fully *saturated* with sugar; in consequence of which, the *same* portions of liquid will hold *no more sugar in solution*.

Q. *Why does the* LUMP *of* SUGAR MELT *more* QUICKLY *when* STIRRED ABOUT*?*

A. Because *fresh portions of unsaturated tea* keep coming in contact with the lump, and soon dissolve it.

Q. *Why does a* PIECE OF SUGAR *(held in a spoon at the* TOP *of our tea) melt very* RAPIDLY*?*

A. Because as the tea becomes *sweetened*, it *descends to the bottom of the cup* by its own gravity; and *fresh* portions of unsweetened tea are brought constantly into contact with the sugar, till the lump is entirely dissolved.

Q. *How can a* SICK ROOM *be kept* FREE *from unhealthy* EFFLUVIA*?*

A. Vinegar boiled with myrrh, or camphor, sprinkled in a sick room, will *entirely correct*

putridity.

Q. *Why does* LIME *destroy the offensive smells of* BINS, SEWERS, *&c.?*

A. Because it combines with the *carbonic acid* of these places, and converts it into CARBONATE OF LIME, which is entirely *free from smell*.

Q. *Why does* CHLORIDE *of* LIME *fumigate a sick room?*

A. Because the chlorine absorbs the *hydrogen of the stale air*, and by this means removes both the *offensive smell* and the *infection* of a sick room.

Q. *How can the* TAINT *of* MEAT *be removed?*

A. Either by washing with PYROLIGNEOUS ACID,—covering it for a few hours with common CHARCOAL,—or by putting a *few lumps of charcoal* into the *water in which it is boiled*.

Q. *Why do these things* DESTROY *the* TAINT *of meat?*

A. Because they *combine* with the *putrescent particles*, and neutralize their offensive taste and smell.

Q. *Why should* BED-ROOMS, COTTAGES, HOSPITALS, *and* STABLES, *be washed occasionally with* LIME-WHITE*?*

A. Because the lime *is very caustic*, and removes all organic matters adhering to the walls.

Q. *How can* MOULDINESS *be prevented?*

A. The perfume of *any essential oil* will prevent mouldiness from ink, paste, preserves, &c.

Alum, salt of amber, borax, nitre, salt, camphor, charcoal, and pyroligneous acid, are all excellent antiseptics.

Salt, corrosive sublimates, copperas, and alum, all arrest the decay of timber. (*See p.* 426.)

Q. *Why will strong* SOUCHONG TEA POISON FLIES*?*

A. Because it produces *prussic acid*, which destroys their *nervous system*.

Q. *Why is strong* GREEN TEA UNWHOLESOME*?*

A. Because it contains *prussic acid*, which destroys the *nervous system*.

Q. *Why is a* DEAD *man* TALLER *than a living man?*

A. Because at death the CARTILAGES are *relaxed*. So, also, after a night's rest, a man is *taller* than when he went to bed.

Q. *What is* SLEEP*?*

A. Sleep is the *rest of the brain* and *nervous system*.

Q. *Why can we not* SEE*, when we are asleep with our* EYES OPEN*?*

A. Because the "RET´INA of the eye" is *inactive* and at rest.

Q. *Why can we not* HEAR *in sleep?*

A. Because the drum or "TYMPANUM of the ear" is placid and at rest.

Q. *Why can we not* TASTE *when we are asleep?*

A. Because the nerves *at the end of the tongue* (called papillæ) are inactive and at rest.

Q. *Why can we not* FEEL *when we are asleep?*

A. Because the *ends of the nerves* (called papillæ), situated in the skin, are inactive and at rest.

Q. *Why have persons in sleep no* WILL *of their own, but may be moved at the will of* ANY *one?*

A. Because the "CEREBELLUM" (or *posterior* part of the brain) is inactive and at rest.

Q. *Why have* DREAMERS *no power of* JUDGMENT *or* REASON*?*

A. Because the "CEREBRUM" (or *front* of the brain) is inactive and at rest.

Q. *Why are* DREAMS *such* FOOLISH *and* INCONSISTENT *things?*

A. Because the "PINEAL GLAND" is acting *without the brain*; and the *faculty of thinking* exists in the "PINEAL GLAND," but the *faculty of judgment* in the "CEREBRUM of the brain."

The cerebrum of the brain occupies the top and front of the skull. The PINEAL GLAND is a small conical gland (about the size of a pea) *in the brain*.

Q. *Why do some persons* LOSE *all* POWER *of* SENSATION*?*

A. Because the "CEREBRUM" (or *front* of their brain) *has been injured*.

Q. *Why are many persons* IDIOTS*?*

A. Because the "CEREBELLUM of the brain" *has been removed* by some accident, or *injured by some disease*.

The cerebellum is all the posterior part of the brain.

Q. *Why does a person* FEEL *when he is* TOUCHED*?*

A. The ends of certain nerves (called PAPILLÆ) situated in the skin *erect themselves* when touched, and produce a nervous sensation called FEELING.

Q. *Why are persons able to* TASTE DIFFERENT FLAVOURS*?*

A. Because the "PAPILLÆ" of the tongue and palate *erect themselves* when food touches them, and produce a nervous sensation called TASTE.

Q. *Why do very* OLD *people* LOSE *the power of* VOLITION, SENSATION, *and* THOUGHT*?*

A. Because their *brain ossifies*; and as the "*cerebrum*" (or *front* of the brain) goes, they lose the power of *sensation and reason*; and as the "*cerebellum*" (or *posterior* part of the brain) goes, they lose the power of *volition*.

Q. *Why are* OLD *people* UNABLE *to* WALK*?*

A. Because their *muscles become rigid*.

GLOSSARY.

ACETIC ACID, commonly called Distilled Vinegar.

CITRIC commonly called Juice of Lemons.

NITRIC commonly called Aqua Fortis.

OXALIC commonly called Salt of Lemons.

SULPHURIC commonly called Oil of Vitriol.

SULPHATE OF LIME called Plaster of Paris.

SULPHATE OF MAGNESIA called Epsom Salts.

Sulphate of Soda called Glauber Salts.

Sulphate ofZinc called White Vitriol.

Nitrate of Silver called Lunar Caustic.

Acetate of Copper called Verdigris.

Muriate of Soda called Table Salt.

Tartrate of Potash called Tartar Emetic.

Carbonate of Ammonia called Smelling Salts.

Carbonate of Lime called Chalk, Marble, &c.

Super-acetate of Lead called Sugar of Lead.

Oxide of Lead called Goulard.

Sublimates are chemical preparations, the basis of which is quicksilver. In corrosive sublimates, the quicksilver is *extinguished*, either by vitriol, potter's clay, or some other ingredient.

Sublimation is a similar process to distillation; only *solids* (such as metals) are employed, instead of *liquids*.

Thus the fine *blue* used by painters is a sublimate, and made thus:—Take 2 parts of quicksilver, 3 flower of brimstone, 8 sal ammoniac; and (having ground them) put them with the quicksilver into a glass retort, luted at the bottom; place the retort in a sand-heat; and (when the moisture is given off) you will have a splendid blue sublimate for painting.

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FINIS

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Transcriber's Notes:

Archaic and inconsistent punctuation and spelling retained.

Inconsistent question formats were regularized.

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