NS
JOYCE

Miss Whichcote
June 22^d 1830

A COMPANION

TO THE

SCIENTIFIC DIALOGUES;

OR, THE

TUTOR'S ASSISTANT AND PUPIL'S MANUAL

IN

NATURAL AND EXPERIMENTAL PHILOSOPHY:

CONTAINING

A COMPLETE SET OF QUESTIONS, AND OTHER EXERCISES,

For the Examination of Pupils in the Six Volumes of

SCIENTIFIC DIALOGUES,

AND FORMING A SEVENTH VOLUME OF THAT WORK.

To which is added,

A COMPENDIUM OF THE PRINCIPAL FACTS UNDER EACH DEPARTMENT OF SCIENCE.

Published at the Request of many Persons engaged in the Education of the Young.

BY THE REV. J. JOYCE,

Author of Scientific Dialogues, Dialogues on Chemistry, &c.

A NEW EDITION

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PREFACE.

THE Author of the "Scientific Dialogues," at the particular request of several intelligent instructors of youth, who make use of that work in their different seminaries, has been induced to publish the following Questions for examination. The plan of giving Questions only, and requiring pupils to frame their own Answers, is a modern and capital improvement in the business of education. It is found by experience, that many will read and hear without giving themselves the trouble to understand; and that of those who understand, a great number will not be able, while they are preparing a lesson, to select the most material parts without some assistance. This assistance is here afforded. A number of leading questions are proposed upon every Conversation; and to these an intelligent Tutor may add as many more as he finds useful, or particularly adapted to the age and capacities of those whom he has to instruct. The Pupil, knowing beforehand what are the principal points to which he must bend his attention, will, it is presumed, prepare his answers with the greater facility and success. And the Tutor himself may find a convenience in having the substance of each lesson brought before his eye in another form.

To the Questions are subjoined a few additional elucidations of the more difficult branches of the subjects treated upon, and a list of such definitions and fundamental facts, as it will be proper for the Pupil to commit to memory.

MECHANICS.

Questions and other Exercises on the Science of MECHANICS, *formed from Vol. I of* "SCIENTIFIC DIALOGUES."

Conversation I.

WHAT is meant by the term philosophy?

What is an angle?

By what instrument can angles of different quantities be represented?

How many kinds of angles are there?

What is a *right* angle?

How do you call an angle?

What is an *acute* angle?

How do you define an *obtuse* angle?

For what purpose are letters used in the description of mathematical figures?

Can you tell me how to distinguish between an angle and a triangle?

Explain the figures 1 to 4.

Conversation II.——Of what is every thing, which we see and feel, composed?

How is *matter* defined?

How do you know it is extended and solid?

How is it proved that matter can be divided infinitely?

What is the reason, that, in practice, matter cannot be divided infinitely?

Do you recollect any remarkable instances of the minute division of matter?

What instances can you give of the minute divisions of matter in *nature?*

Do you recollect any examples with regard to marine animalculæ?

How do you compare the size of a particle of blood?

Are not the particles of light very small?

Repeat the lines descriptive of the minute size of insects.

Conversation III.——What instrument is used to discern very small objects?

What are the kinds of gravity which are applicable to the science of MECHANICS?

How do you define the *attraction of cohesion*?

What is the cause that some bodies are soft, others hard, &c.?

How is the power of cohesion exhibited in the case of leaden bullets?

What is the cause of things being broken?

Give me some instances in which the attraction of cohesion is overcome.

Is the principle of cohesion applicable to the operations of cookery?

Does heat, in some instances, weaken the power of the attraction, and, in others, make it act more powerfully?

Can you explain the reason of this?

Upon what principle is broth made?

How are bones dissolved?

Conversation IV.——Mention some instances in which the attraction of cohesion acts?

Upon what principle does water, or other liquids, ascend in sugar, sponge, &c.?

From whence does the term capillary attraction arise?

Does capillary attraction act in any tubes except those of exceedingly fine bores?

Explain the subject represented by Fig. 5.

What experiments will show capillary attraction?

Upon what principle do carpenters and others glue the several parts of their work together?

Do you recollect any other instances of the action of the principle of cohesion?

How does the principle of cohesion act?

What do you mean by *repulsion*?

Mention some instances in which the power of repulsion appears to act.

Why do cane, steel, and many other things, after being bent, recover their original form again?

How is elasticity accounted for?

Conversation V.——How is the attraction of gravitation defined?

Give some familiar instances in which the law of gravity or gravitation acts.

In what direction do bodies fall towards the earth?

Is this a general law without any exceptions?

By what power, and why, do bodies remain firm on the earth?

How is it that gravity acts alike on all bodies?

Do bodies, at equal distances from the earth, fall towards it with equal velocity?

Explain to me what is meant by velocity.*

Are velocity and swiftness synonymous terms?

How is the velocity of a body measured?

If a penny piece and a feather be let fall together, how is it that the penny reaches the ground first?

Suppose the penny and a piece of wood

* The tutor may turn to p. 44, 45, and examine his pupil on the examples given.

be let fall in a vessel of water, why does the copper go to the bottom, and the wood, after a short descent, rise again to the surface?

Conversation VI.——What is the meaning of the term *momentum*?

Can you show, by any familiar instance, that it does not mean weight?

Turn to Fig. 6 of the volume, and explain the difference between momentum and weight?

Which of two equal balls will have the greater momentum, the one that falls down an inclined plane, or the other that falls perpendicularly?

How can the momentum of a small body be made equal to that of a large one which has only a given velocity?

Why have cannon-balls superseded the use of battering-rams in the art of war? *

Why does a ball, or other body, falling upon the foot, occasion more pain than

* Here the pupil may be referred to the examples in p. 50, 51.

the mere pressure of a much heavier body?

Why do all bodies tend to the centre of the earth?

Why do not falling bodies, which happen to be near each other, approach still nearer by means of the attraction of gravitation?

If two bodies, very remote from each other, fall towards the earth, will they descend in parallel lines?

What would be the consequence if two bodies were placed in free space, and out of the sphere of the earth's attraction?

Where would they meet if the bodies were equal?

Does the earth move towards falling bodies?

If two bodies of unequal weights were falling towards each other, which of them would have the greater velocity?

Conversation VII.——By what law does the attraction of gravitation act?

Can you illustrate it by examples?

How much less light shall I receive from a candle at the distance of *six* feet, than I should if I were only *two* feet from it?

How much more warmth shall I feel at the distance of *three* feet from a fire, than you will being placed at *eight* feet from it?

Does the force of gravity act from the surface or centre of the earth?

Can the *difference* of the power of gravity be discerned at the small distances to which we can have access?

What would a piece of lead weigh at 4000 miles above the surface of the earth, that weighs a hundred weight on the surface?

Through what space does a heavy body fall on the surface of the earth in a second of time; and how far would it fall, in the same time, at the distance of 4000 miles above the surface of the earth?

At what distance is the moon from us,

in miles, and in semidiameters of the earth?

How much less is the attraction of the earth, at the distance of the moon, than it would be at 4000 miles from the surface of the earth?

What is the shape of the earth?

Would a body (as a block of stone, or a lump of lead) weigh heavier at the poles or the equator of the earth, and why?

Upon what does the descent of water down a hill depend?

Is the velocity of falling bodies continually the same: if not, by what proportion does it increase?

Conversation VIII.——How much less would a ball of 20lb. weigh on the top of a mountain three miles high than it does in this spot?

By what means could that be ascertained?

How could you find the height of any place?

If a penny-piece is four seconds in falling to the bottom of a well, how deep is that well?

How long would a stone be falling to the bottom of the well at Dover Castle, which is 360 feet deep?

By what law do bodies fall from a state of rest?

If a body takes eleven seconds in falling from a certain place, how high is that place?

Does the ascent of bodies follow a similar law, but in a contrary order to that of the descent?

How high does an arrow rise, the flight of which is perpendicular, and which takes ten seconds before it comes again to the ground?

If the flight of an arrow, in a perpendicular direction, take sixteen seconds before it come to the ground, how high does it go?

Does the rule with regard to falling bodies hold good in all cases?

By what law do you calculate the velocities of falling bodies?

How is the velocity of a body measured?

If the several seconds of time be taken separately, how are the spaces of falling bodies estimated?

What is the law of connection between the spaces and the *whole* times?

Conversation IX.——What do you mean by the *centre of gravity?*

Have all bodies a centre of gravity?

What is meant by the *line of direction?*

What should be the line of direction of a body to make it stand?

Look to Fig. 7, and explain the subject.

Why is it dangerous to rise up in a boat if the water should be rough?

In a case of danger in the water, what is the safest course to take?

Is the same principle applicable to carriages by land?

Is there any danger attaches to stage coaches, that are much loaded on the top, and why is it less than might be expected?

Why do not conical bodies stand firm if placed on the point?

What gives stability to bodies?

What is the reason that spherical bodies so easily roll along an horizontal plane?

Look to Fig. 8, and explain the object of it.

Why is it, that some high buildings, which lean very much, do not fall?

Explain this by means of Fig. 9.

Show me, by means of Fig. 10, how to find the centre of gravity of a body.

Conversation X.——Why is there danger attached to waggons, carts, &c. that are loaded very high?

What is the reason that children and others fall?

In what position will a man stand the firmest?

How do rope-dancers manage to balance themselves?

Give me some instances in which people in general, without knowing it, attend to the direction of the centre of gravity.

How is it, that a double cone appears to roll up an inclined plane?

Explain this by Fig. 13.

Is there any limit to the height of the planes?

Explain, by Fig. 11, how a cylinder is made to roll up a hill.

Tell me, with the assistance of Fig. 12, how a bucket is suspended by means of a stick, on the edge of a table.

Conversation XI.——What is the first law of motion?

Has a body in motion any power to destroy that motion, or to change its velocity?

What stops a body running on the ground?

And what brings to the earth one that passes through the air?

Is there any other cause, besides friction and gravitation, that destroys the motion of bodies?

How is the resistance of the air proved?

If a person walking fast is carrying a bason of water, and suddenly stops, what will be the consequence?

If a horse, from standing still, starts suddenly forward, what will happen to the rider?

Can you repeat the second law of motion?

Pray illustrate it by some familiar example.

What changes the direction of a cannon-ball?

Upon what does the distance passed depend?

Repeat the third law of motion, and give me an instance in proof of its truth.

How is action and re-action illustrated in the case of a horse drawing a heavy load?

How is this law applicable to the flight of a bird?

Conversation XII.——What is meant by a corollary?

If a body moves in a curve line, is it acted upon by more than one force?

What are the forces which act upon a stone whirled round in a sling?

Explain to me by what means the moon is carried about the earth?

What would be the consequence if the projectile force, or the power of gravity, were to cease to act upon the moon?

What do you mean by *centrifugal* and *centripetal* forces?

From what do these forces result?

What is meant by the term *vis inertiæ?*

If the projectile force that perpetually acts upon the moon were to cease, through what space would it fall in a minute?

How is the velocity of a body increased or diminished?

If a body at rest receive at the same instant two impulses, the directions of which do not coincide, in what line will that body move?

Explain this by Fig. 14.

Is it necessary for a body to move in the same line, in order that it should move in the same direction?

Conversation XIII.——If two equal forces act upon a body at right angles to one another, what line will be described by that body?

Suppose the forces are not equal, and do not act at right angles to one another, what will be the line described?

How do you know that two forces acting conjointly on a body do not produce so great an effect, as if they were to act separately?

In what cases is motion lost, and in what cases is it gained?

Why do the planetary bodies move in curves?

Explain this by means of the figure.

How is the third law of motion illustrated?

Explain the difference between elastic and non-elastic bodies.

Show me, by a reference to Fig. 15, how action and re-action are equal and in contrary directions.

How is it proved, that elastic bodies, as ivory balls, yield by percussion?

What would be the consequence of two non-elastic bodies, in motion, meeting each other?

What proof is there, that marbles are elastic?

Explain to me the intention of Fig. 16.

What curious circumstance is there resulting from the vis inertiæ of bodies and from the action and re-action of bodies?

Conversation XIV.——What do you mean by the momentum of a body?

Do you know how to make the *momenta* of unequal bodies equal?

What is meant by one body having a greater velocity than another?

What familiar example will illustrate it?

How much faster does the minute hand of a watch or clock travel than the hour hand?

What is meant by the centre of motion of a watch?

What parts of the vanes of a windmill move the faster?

Why are some parts of the vanes of a mill in quick motion more distinguishable than others?

Can you give me another instance or two on this subject?

Is it necessary to have clear ideas with regard to *time* and *space?*

How many mechanical powers are there?

Why are they so called?

What limits the assistance gained by these powers?

Explain what you mean by the phrase,

"that what we gain in power we lose in time."

How are the advantages of the mechanical powers set forth?

What is meant by a fulcrum?

What is the fulcrum of a watch?

Why is the pivot on which scissars move called a fulcrum?

When you move the fire with a poker, is the bar a fulcrum?

Conversation XV.——What is meant by a lever, and for what is it used?

Explain, by means of Fig. 17, its mode of action?

How many sorts of levers are there?

How is the fulcrum situated in the lever of the first kind?

How in that of the second?

How in the third?

Repeat the lines descriptive of the lever.

In what proportion are the spaces described by the arms of a lever?

Can you explain this by referring to Fig. 18?

What power does a lever gain, whose two arms are as 9 to 3?

How is it that an iron crow, in moving timber or stone, acts upon the principle of a lever?

Explain, by Fig. 19, how it is that the common steel-yard, made use of by the butcher, is a lever?

Conversation XVI.——In practice, is there any advantage in a steel-yard over a pair of scales?

How is the beam of a steel-yard divided?

How can fraud be practised in weighing out commodities, when the scales are even and the weights accurate?

What method would lead to a detection of this sort of cheat?

What is the rule to find the true weight of a body by means of a false balance?

Apply this rule, by supposing a body to weigh twenty ounces in one scale, and in the other only fifteen ounces.

What common instruments are to be referred to the lever of the first kind?

Why are they so referred?

Show me, by means of Fig. 20, the action of a lever of the second kind, and what advantage is gained by it.

What things in common use are to be referred to the lever of the second kind?

What causes the difficulty of moving a heavy door, when the hand is applied to that part next to the hinges?

Mention some other things, that act as a lever of the second kind.

Can the knowledge of this principle be made particularly useful in other instances?

How is the case of two men of unequal strength, carrying a burden, referrible to the principle of a lever of the second kind?

Is the same principle applicable to the horse's drawing a carriage?

Describe, by Fig. 21, the lever of the third kind.

What proportion must the power bear to the weight in levers of this kind?

Is any advantage gained by this lever as a moving power.

In what cases is it used?

What is the most important application of the principle of this lever?

Conversation XVII. —— Explain the general principles of the lever, and what the circumstances are, that will prevent you from forgetting the properties of each.

How does the principle of *momentum* apply to the lever?

What is the second mechanical power, and how does it gain power?

Look to Fig. 22, and show me how the *wheel and axis* is to be referred to the principle of the lever?

To what purpose is the wheel and axis applied?

Why, in deep wells, does the bucket appear heavier, as it approaches the top than lower down?

By what means is advantage gained?

What is the limit to the advantage to be gained?

Why are spikes fixed into the outer rim of these sorts of wheels?

Explain how time is lost as power is gained?

What machines are to be referred to the principle of the wheel and axis?

Repeat the lines from Falconer's shipwreck.

Explain the principles of those cranes in which a man or men walk, in order to raise and lower weights.

How is the action of these cranes explained?

What guard is there to prevent danger in these cranes?

How is the wheel and axis to be referred to the principle of the lever?—See Fig. 22 and 23.

Conversation XVIII.——Can the principle of the pulley be referred to that of the lever?—See Fig. 24.

Is any mechanical advantage gained from the *single fixed pulley?*

Why is it called a mechanical power?

Explain its action by Fig. 25.

In the lever, what must be the proportion of the momentum of the power to that of the lever?

How is the power estimated in a system of pulleys?

How much is to be allowed for friction and other imperfections in the mechanical powers?

What are the chief defects in the operation of pulleys?

Have these, or any of them, been obviated, and by what means?

What is the general rule for calculating the power of pulleys?

Explain, by Figs. 26 and 27, the nature of compound pulleys, or systems of pulleys.

Conversation XIX.——Do all writers on mechanical subjects reckon upon *six* mechanical powers?

How are we to estimate the advantage gained by the inclined plane?—See Fig. 28.

What power would be necessary to draw a given weight up such a plane as that described in the figure?

What is the reason that heavy packages are drawn up planks from the street to a warehouse, instead of being lifted perpendicularly up?

Why does a marble take longer in descending down an inclined plane than it would in falling perpendicularly by the force of gravity?

Explain this more particularly by the instance of a marble on horizontal and inclined planes.

How is the swiftness of a falling body to be estimated?

If a plane is three times as long as it is high, what will be the proportion of the perpendicular fall of a marble to its descent down the inclined plane? *

* In this place explain the note at page 181, vol. 1.

What instruments are to be referred to this mechanical power?

Conversation XX.——Of what is the wedge formed?

Refer to Fig. 29, and explain the principle of this mechanical power.

Is the principle of the wedge similar to that of the inclined plane?

Why is great force necessary in the use of the wedge?

How is the power of the wedge estimated?

What instruments are to be referred to the wedge?

To what particular purposes is the wedge applied?

How are mill-stones separated from the rocks?

Repeat the two lines from the Botanic Garden.

Conversation XXI.——What is the sixth mechanical power?

Is this a simple mechanical power?

Of what is the *screw* composed?

Show me by the figures the construction of the screw.

How is the advantage gained by the screw calculated?

Tell me why power is gained in the screw in proportion to the nearness of the threads.

What advantage is gained by a screw, the threads of which are a quarter of an inch apart, and the lever used six feet long?

By what methods can you increase the mechanical advantage of the screw?

Is the power gained by this mechanical power very great?

When several men are employed in turning a screw, how is the power to be estimated?

Is the principle of the screw of general use?

Repeat Dr. Darwin's lines on coining.

Do you recollect what operations Mr. Boulton's coining apparatus performs?

How many guineas can four boys coin in an hour?

Conversation XXII.——Does the time of vibration of a pendulum depend upon its length?

Do longer or shorter pendulums vibrate quickest?

What is the precise law which subsists between the lengths of pendulums and their times of vibrations through equal arcs?

What is the length of a second's pendulum in the latitude of London?

What is the length of a half second pendulum in the same latitude?

What is the length of a pendulum that shall vibrate in quarters of seconds?

What is the length of a three second pendulum?

If a thin cylinder be suspended at one end, and made to oscillate, how are its vibrations estimated by means of a simple pendulum?

If such a thin cylinder when suspended at one extremity vibrate *seconds*, what is its length?

If it be suspended at one-third of its length, what will happen then?

And what if it be suspended at the middle point?

Some of the leading DEFINITIONS *and* FACTS, *explained and illustrated in Vol. I, which it is recommended, that the Pupils should commit to Memory.*

MATTER.

1. The properties of matter are solidity, divisibility, mobility, and inertia.

2. All bodies seem to possess the properties of attraction.

3. Solidity is the property which prevents two bodies from occupying the same part of space at the same time.

4. Divisibility is that property by which matter is capable of being divided.

5. Mobility is that property of matter by which it is capable of being moved.

6. Inertia is the tendency which matter has to continue in the state into which it is put, whether of rest or motion.

7. SPACE is either absolute or relative.

8. Absolute space has no limits, and is itself immoveable.

9. Relative space is that part of absolute space which is occupied by any body.

10. Motion is either absolute or relative.

11. Absolute motion is the motion that bodies have independently of each other, and only with regard to the parts of space.

12. Relative motion is the degree and direction of the motion of any body, when compared with that of another.

13. Accelerated motion is that in which the velocity of the motion continually increases.

14. Retarded motion is when the velocity continually decreases.

15. The velocity of uniform motion is estimated by the space moved over in a certain time.

16. The velocity of a body is ascertained by dividing the space by the time.

17. The space is estimated by the time multiplied into the velocity.

18. In accelerated motion, the space passed over is in proportion to the square of the time.

19. A body acted upon by one force moves in a straight line.

20. A body acted upon by one uniform force, and also by another accelerating force in a different direction, will describe a curve.

21. The momentum of a body is the force with which it moves, and is estimated by the quantity of matter multiplied into its velocity.

22. The attraction of cohesion acts at only very small distances.

23. The attraction of gravitation is that which masses of matter exert on each other at all distances.

24. Gravitation decreases from the surface of the earth as the squares of the distances.

25. The centrifugal force is the tendency

which bodies, that revolve round a centre, have to fly off from it in a tangent to the curve they move in.

26. The centripetal force is that which prevents its flying off, by impelling it towards a centre; such is the attraction of gravitation.

27. The centre of gravity is that point in which the weight of a body is supposed to be collected.

28. A line drawn from the centre of gravity, perpendicular to the horizon, is called the line of direction.

29. When the line of direction falls within the base of any body, that body will stand; but when it falls without the base, the body will fall.

30. There are three kinds of levers: the *first* is, when the fulcrum is between the power and the weight: the *second* is, when the fulcrum is at one end of the lever, the power at the other, and the weight between them: the *third* is when the fulcrum is at one end, the

weight at the other, and the power between them.

31. In all kinds of levers, the power is to the weight as the distance of the weight from the fulcrum is to that of the power from the fulcrum.

32. A hammer is a bent lever, and differs only in form from a lever of the first kind.

33. A balance is a lever of the first kind, with equal arms.

34. The steel-yard is likewise a lever of the first kind with a moveable weight.

35. In the wheel and axis, to obtain an equilibrium, the power must be to the weight as the circumference of the wheel is to the circumference of the axis, or as the diameter of the wheel is to the diameter of the axis.

36. Pulleys are of two kinds, fixed and moveable.

37. In the fixed pulley, when the power and the weight are equal, there is no mechanical advantage obtained.

38. In the moveable pulley there will be an equilibrium, if the power is equal to half the weight only.

39. In the inclined plane there will be an equilibrium, when the power is to the weight as the height of the plane is to the length.

40. In the wedge, the power will be to the weight as half the thickness of the wedge on the back is to the length of one of the sides.

41. The screw is always used with a lever; and the power is to the weight as the distance from one thread or spiral to another is to the circumference of the circle described by the power.

ASTRONOMY.

Questions and other Exercises on the Science of ASTRONOMY, *formed from Vol. II of* "SCIENTIFIC DIALOGUES."

Conversation I.——How many stars are there supposed to be visible to the naked eye at one time and at one place?

By what means can we correct the errors into which we are liable to fall by depending on a single sense?

Illustrate this by experiment.

How are objects seen?

To what are the rays of light subject in their passage from the fixed stars to the earth?

From what does the fallacy arise, by which we are led to suppose the stars visible to the naked eye are innumerable?

By what means can a single object be made to appear like many?

In looking through a multiplying glass at a single object, how many images of that object will be seen?

What other experiment is there to prove, that the brilliancy of the heavens is chiefly owing to reflected and refracted light?

Conversation II.——Is it very difficult to distinguish the stars?

By whom were the stars divided into constellations, and for what purpose was this done?

Do you know how to find the cardinal points, by day and by night also?

What are the two stars called, through which, if a line were drawn and extended far enough, it would nearly touch the pole star?

Is the pole star always in the same part of the heavens?

To what other purpose, besides that of finding the cardinal points, is the pole star and those near it useful?

How should you be able by yourself to find out the name of any particular star in the heavens?

Do the fixed stars always keep their relative places in the heavens?

What is the difference between the fixed stars and planets?

Turn to Fig. 1 and explain it.

Conversation III.——Do the fixed stars keep a constant situation with regard to the heavens?

How are those stars distinguished to which there are no particular names?

Is there any good reason why particular characters should be used for the same stars by all nations?

Illustrate this by an instance.

What do you mean by the *ecliptic?*

What is that motion of the sun called, which it seems to describe every day?

What is the equator?

What is the celestial equator, or equa-noctial?

How would you trace the ecliptic in the heavens?

Is the moon always in the ecliptic?

How far distant from the ecliptic can the planets wander?

What method would you adopt in tracing out to a friend the ecliptic?

Through what two remarkable stars does the ecliptic pass?

How is *Regulus* or *Cor Leonis* situated?

From what particular stars is the moon's distance calculated?*

For what purpose are these calculations made?

Explain what the Nautical Almanac is, and to what purpose it is applied.

Conversation IV.——What book is ne-cessary in studying the heavens?

Of what use is an ephemeris, and whose is principally employed?

* Here refer to the globe.

Do you know the characters and names of the twelve signs of the zodiac?

What is the zodiac, and from whence is the term derived?

Repeat Dr. Watts's lines, in which the signs of the zodiac are enumerated.

What are the names of the planets, and draw the character belonging to each?

What do you mean by the declination of a heavenly body?

When do astronomers begin their day?

Which begins first, the common or the astronomical day?

When does the moon come to the meridian at the same time with the sun?

Can you repeat the lines descriptive of the moon?

How often does a well-regulated clock and the sun on the dial show the same time?

What are the four days in the year when the clock and dial are together?

Can you tell me how to regulate my

watch on any day by means of a good dial and the table contained in the ephemeris?

What is meant by the latitude of a heavenly body?

To what does the latitude of heavenly bodies refer?

Has the sun any latitude? and, if not, what is the reason?

What is the longitude of a heavenly body, and on what line is it measured?

Conversation V.——Of what does the solar system consist?

What was the system of Ptolemy?

How large is the sun?

Why do the heavenly bodies, which are so immensely large, appear so small?

At what distance is the sun from the earth?

Are the fixed stars further from us than the sun?

At what rate does a cannon-ball proceed from the mouth of a gun?

How long would a cannon-ball, with

the same velocity, be coming from the sun to the earth?

How is the sun situated?

Which way do the planets move, and how many are there?*

Can you repeat the lines from Thomson's Summer descriptive of the solar system?

What is the meaning of the term orbit?

Can you explain to me the various parts of Fig. 2?

To which of the planets are there satellites, or moons, and to which not?

By whom was this system first adopted in ancient and modern times?

Will you repeat the lines on the solar system by Chatterton?

Conversation VI.——How is it proved, that the earth is of a globular figure, and not a mere plane?

* The number mentioned in this place do not include the four smaller planetary bodies lately discovered.

Explain this by Fig. 3.

Why does not the sea appear to the eye to be curved?

How does the method adopted in cutting of canals prove the globular figure of the earth?

Is there any other proof that the earth is round?

How can it be known whether a ship sails round the earth?

Is the earth a perfect sphere, like the artificial globe?

How much do the two diameters of the earth differ from one another, and which is the longer of the two?

What are the extremities of the earth's axis called?

Point them out in Fig. 4.

What is the equator?

Why is the ecliptic marked on the terrestrial globe?

Conversation VII.—— Enumerate the reasons adduced in proof of the globular shape of the earth.

Has the earth any motion of its own?

What are the natural appearances with regard to the heavenly bodies?

Can you, by Fig. 2, show me, that the appearance will be the same to us, whether those bodies revolve round the earth, or the earth turn about on its axis?

Why do we not perceive the motion of the earth?

What will be the appearance of distant objects to a person standing in a ship while the vessel is turning about?

Why does not a particular spot of the earth appear to move from under a lark, which is apparently stationary in the air, or nearly so?

What are Milton's lines on the motion of the earth?

Do you recollect any deceptions in the sight with regard to moving objects?

With what velocity does the equator move in the diurnal motion of the earth?

If the sun went round the earth in 24 hours, at what rate must he travel?

What is the effect of the earth's turning on its axis?

Conversation VIII. —— Explain, by means of Fig. 5, how the rotation of the earth upon its axis produces day and night.

What is the sensible horizon, and upon what does its extent depend?

What is the rational horizon, and in what does it differ from the sensible horizon?

On which of these do the rising and setting of the stars depend, and why?

Why does the distance of the centre from the surface of the earth appear to vanish in comparison of its distance from the moon and other heavenly bodies?

Turn to the Figure and show, when the sun is at *z*, which part of the earth will be illuminated by its rays.

To what part of the earth will it be rising, and to what other part will it be setting?

Explain the reason of this.

What is the consequence of the earth's diurnal motion ?

Will the motion of the earth account for the apparent motion of the fixed stars ?

Round what points in the heavens do the fixed stars appear to move ?

What is the occasion of night ?

Are there stars in every part of the heavens ?

Repeat Dr. Young's lines on this subject.

Why are the stars above us invisible in day ?

Is there any mode of getting a glimpse of the stars by day ?

Conversation IX.——Has the earth any other motion besides that round its axis ?

How are the seasons of winter and summer to be accounted for ?

Repeat the lines by Hughes on this subject.

Can you tell me how it is ascertained that the earth makes this annual journey round the sun?

Can the same thing be proved by the mutual attraction of the earth and sun?

Do they turn round any common point, and what is that called?

Is the matter of the earth or sun the more dense, and in what proportion?

In what proportion is the quantity of matter greater in the sun than it is in the earth?

How much swifter then should the motion of the earth be than that of the sun?

Conversation X.——Upon what do the different seasons depend?

Why does not the earth enjoy equal days and nights all the year, and under what circumstances would that be the case?

Explain the subject by Fig. 6.

Why are the people at the poles excepted?

In what case would the rays of the sun fall vertically on a particular part of the earth?

Would that be advantageous or otherwise to the earth?

Repeat Milton's lines on the apparent course of the sun.

How much is the axis of the earth inclined from the perpendicular?

Explain this by Fig. 7.

Why are our days in summer sixteen hours long, and in winter only eight?

To whom is this difference still greater?

To what parts of the earth are there six months day and six months night?

To what parts of the earth are the days and nights always equal?

Upon what does the change in the seasons depend?

Show me, by Fig. 8, how the heat of the sun differs according to the mode of its falling upon any particular place.

Conversation XI.——Explain to me what is intended by Fig. 9.

Is the orbit of the earth circular?

How is the sun situated with regard to the earth's orbit?

Are we nearer to the sun in the summer or in the winter?

How is it proved?

Why is the winter colder than the summer?

Which is the hottest time of the year, and why is it so?

Refer to the Figure, and tell me the position of the earth in June, and what that occasions.

Do the same with regard to December, March, and September.

Why do the days lengthen and shorten every year from the equator?

Where are there two harvests in a year?

Why is there sometimes no day nor night for a certain number of days or weeks or months within the polar circle?

Why is there but one day and one night in a year at the poles?

Conversation XII.——State what the motions of the earth are.

What is meant by equal time, and what by apparent time?

What is understood by the equation of time?

Upon what does the difference between a well-regulated clock and a true dial depend?

How has the rotation of the earth any thing in common with the motion of a watch?

What occasions the difference between the solar and sidereal day?

Repeat the lines from the Botanical Garden on this subject.

What time do clocks and watches measure?

What time is that which is measured on the sun-dial?

How often is the equator of the earth directed towards the centre of the sun?

How often, and when do the clocks and sun-dials agree?

Explain this by means of Fig. 10.

When is the sun faster than the clocks, and when slower?

What is the cause of this difference?

What difference does the elliptic form of the earth's orbit occasion?

Does the earth travel faster in summer or in winter?

Conversation XIII.——Who fixed the length of the year to 365 days and a quarter?

What is leap-year?

What is the meaning of the word *bissextile*?

What new day is admitted in leap-year?

What is the rule for finding whether the present year is or is not leap-year?

Does the year consist of 365 days six hours exactly?

What is the error, and in how long will it amount to a day?

Who reformed the Julian year, and when did the alteration take place in the greater part of Europe?

When was new style adopted in England?

Is any method provided to maintain accuracy in this business?

Did the legal year always begin on the 1st of January in this country?

In the year 1824, there were five Sundays in the month of February; when will that happen again?

Conversation XIV.——Upon what does the division of time into days and years depend?

What other division of time is marked out by nature?

What do you mean by a month?

What is the difference between a periodical and synodical month?

What is the reason of this difference?

Explain this by Fig. 11.

By what light does the moon shine?

What is the length of the moon's diameter?

Explain, by the Figure, the changes of the moon.

Does the moon turn about on her axis, and in what time?

How many days are there in the moon's year?

Is there any other remarkable circumstance relating to the moon?

Can the earth be considered as a satellite to the moon?

How large will the earth appear to the inhabitants of the moon?

What reasons are there to prove that the moon is inhabited?

Conversation XV.——Upon what do eclipses depend?

When does an eclipse of the moon happen?

Show this by Fig. 12.

What is the reason that the eclipses of the moon do not always happen when the moon is full?

In what case will there be no eclipse at the time of full moon?

What is a central eclipse?

How long does an eclipse of the moon last?

Of what shape is the shadow of the earth?

What things are necessary to be known in calculating an eclipse of the moon?

How is it proved that the sun is larger than the earth?

Explain this by Figs. 13 and 14.

When does an eclipse of the sun happen?

Upon what does an eclipse of the sun depend?

When will there be a *total* and when a *partial* eclipse?

What is meant by an *annular* eclipse?

How long can a total eclipse of the sun last?

Are total eclipses common?

Explain, by Figs. 15 and 12, how an eclipse of the sun may be *total* to the inhabitants near the middle of the earth's disk, and annular to some others.

Repeat Milton's lines upon eclipses as ominous of impending evil.

Conversation XVI.——Upon what do the tides depend?

What is the daily difference in time in high water?

Explain to me by Fig. 16, how the tides are occasioned.

How often are there tides?

Why are there not two tides within 24 hours?

Is there any difference in the heights to which the tides rise with regard to the seasons of the year.

In what position are the earth and moon when the tides are highest?

Are there high tides in the Mediterranean?

Where do they rise 30 feet high?

Has the sun or the moon the greater effect in producing tides, and why?

What are the highest, and what the lowest tides called?

When are the tides highest?

Do the highest tides happen at the equi noxes?

Conversation XVII.——Why does the moon rise about three quarters of an hour later on each day than on that preceding?

At what season of the year is the difference in the rising of the moon but trifling for several successive evenings?

Why is not this necessary at the equator?

In what signs of the ecliptic is the difference in the time of the moon's rising the least, and how many minutes is this on an average?

Repeat the lines of Mr. Lofft on this subject.

In what signs is the full moon at the time of harvest?

Which is the harvest moon, and which the hunter's moon?

Why have the people at the equator no harvest moon?

To whom is the harvest moon most remarkable?

Why is there no harvest moon to those who live within the polar circles?

At what seasons does not the full moon rise, and at what time does she not set at the polar circles?

What happens remarkable at the poles with regard to the sun and moon?

Is there any substitute for the light of the moon to the inhabitants at the poles, when she is below the horizon?

Repeat Thomson's lines on this subject.

Conversation XVIII.——Which of the planets is nearest the sun?

Which are called inferior planets, and why are they so called?

How is it known that the orbits of Venus and Mercury are included within the orbit of the earth?

Why are they called attendants upon the sun?

Is Mercury frequently visible?

Does it, like the earth, turn on its axis?

At what distance is Mercury from the sun, and what is the length of his year?

At what rate does this planet travel in an hour?

How large is Mercury?

What degree of light and heat does he enjoy from the sun?

Repeat Mallet's description of this planet.

Is it probable that Mercury is inhabited?

Repeat the lines from Pope, and those from Prior.

Conversation XIX.——How is the planet Venus described in prose, and also in verse?

At what distance is Venus from the sun, and what is the length of her year?

How many miles does she travel in an hour?

What is the magnitude of this planet?

What proportion of light and heat does she enjoy?

Is there much difference in the seasons of this planet, and to what is that ascribed?

Explain to me, by means of Fig. 17, why Venus appears larger sometimes than she does at others.

Is Venus to be seen in different parts of her orbit with different phases like the moon?

Explain the different situations in which the motion of this planet is direct, when she seems to be *stationary*, and when her motion appears *retrograde*.

When is Venus an evening and when a morning star?

What does Mallet say on this subject?

What is meant by the transit of Venus?

How often does a transit happen, and when will the next occur?

What is Kepler's law?

What is meant by the periodical times?

Conversation XX.——What are the superior planets, and why are they so called?

At what distance is Mars from the sun, and what is the length of his year?

How was the diurnal rotation of this planet discovered?

What is the magnitude of Mars, and what proportion of light and heat does he enjoy from the sun?

Explain, by Fig. 18, the direct and apparently retrograde motions of the superior planets.

In what position is the motion of the superior planets retrograde?

Is that the case with regard to the in ferior planets also?

Tell me why the superior planets may be in the west in the morning, when the sun rises in the east, and the reverse.

How much nearer to the earth is Mars

and the other superior planets at one time than they are at another?

What is meant by the *heliocentric* longitude of a planet?

What is the *geocentric* place of a planet?

Explain, by Fig. 19, in what the difference between the heliocentric and geocentric longitude of the planets consists.

Conversation XXI.——How is Jupiter known?

What is the magnitude of Jupiter, and what is his distance from the sun?

What proportion of light and heat does he enjoy from that luminary?

What is the length of his days and nights?

Is there any thing remarkable with regard to this planet?

Is there any difference of seasons, or in the length of day and night, in Jupiter?

What is the length of Jupiter's year, and at what rate does he travel?

How many moons has Jupiter?

Repeat the lines from Mallet descriptive of this planet.

To what practical purpose have the eclipses of Jupiter's moons been applied?

Conversation XXII.——How is Saturn distinguished in the heavens?

How large is Saturn, and at what distance is he from the sun?

What is the length of his year, and at what rate does he travel?

What proportion of light and heat does he enjoy from the sun?

Do you recollect how much greater daylight is than the light of the moon at its full?

How many moons has Saturn?

What other peculiarities are noticed with regard to Saturn?

What were Herschel's conjectures with regard to Saturn's ring?

What does Fig. 20 represent?

Repeat Mallet's description of this planet.

Is the length of Saturn's day and night known?

Conversation XXIII.——Is the planet Herschel easily distinguished?

How large is this planet, and at what distance is he from the sun?

What is the length of his year, and at what rate does he travel?

How many moons has the Herschel?

What is the proportion of light and heat which this planet enjoys from the sun?

Conversation XXIV.——Do you remember the lines in Thomson in which he refers to comets?

In what respects do comets resemble the planets?

What is said of the comet seen by Sir Isaac Newton in 1680?

How long would such a body take to cool in?

Is there any thing known with certainty in regard to the periodical times of comets?

How is it shown, that all bodies move faster or slower in proportion as they are nearer to, or more distant from, their centre of motion?

What is said of the comets of 1807 and 1811?

Give an account of the head, the coma, and tail of comets.

Conversation XXV.——How is it known that the sun turns on its axis?

In what time is this revolution made?

What is the figure of the sun?

What is the size of this body?

Repeat Mallet's description of this luminary.

Conversation XXVI.——What proofs are there that the planets borrow their light from the sun?

How is it known that the fixed stars shine by their own light?

Is the distance of the fixed stars known?

How long would a ray of light be in passing from the nearest fixed star to us?

Whence does the apparent magnitude of the fixed stars seem to arise?

At what distance has Dr. Herschel been able to discover stars?

What does Huygens say of the distances of the fixed stars?

What has Dr. Halley advanced respecting these bodies?

In what lines has Dr. Young alluded to the opinions of Huygens?

For what important purposes can we suppose that the fixed stars were created?

In what situation would our sun appear as a fixed star?

To what tract of the heavens is our sun supposed to belong?

Of what does the milky-way consist?

Some of the leading DEFINITIONS *and* FACTS, *explained and illustrated in Vol. II, which it is recommended that the Pupils should commit to Memory.*

ASTRONOMY.

1. The heavenly bodies are either fixed stars or planets.

2. The fixed stars always remain in the same relative position with respect to each other; but the planets are continually changing their places, both with regard to the fixed stars and to themselves also.

3. The ecliptic is an imaginary great circle in the heavens, which the sun appears to describe in the course of a year.

4. The ecliptic runs along the middle of a certain tract in the heavens called the zodiac.

5. Within the zodiac the planets are always found.

6. The solar system consists of the sun as a centre, of seven primary planets and eighteen satellites, or secondary planets, besides four newly-discovered small bodies, called by Dr. Herschel asteroids.

7. The moon is a secondary planet moving round the earth.

8. The moon and the sun are on the meridian, at the same time, every new moon.

9. All the planets move in orbits that are nearly circular, but which are really elliptical, having the sun in one focus.

10. They are preserved in their orbits by the power of attraction and the centrifugal force, which exactly balance each other.

11. The earth is a spherical body, the diameter of which is nearly 8000 miles long. It is not a perfect sphere, but a spheroid, the diameter from pole

to pole being 38 miles shorter than that at the equator.

12. The earth turns on an imaginary axis once in 24 hours, thereby producing to its inhabitants a constant succession of day and night.

13. The axis of the earth is inclined about $23\frac{1}{2}°$ from the perpendicular.

14. The diurnal motion of the earth, which cannot be made sensible to those who live upon it, leads the uninformed to believe that the heavenly bodies rise every day in the east and set in the west.

15. The people on the equator travel, by the diurnal motion of the earth, at the rate of 1000 miles in an hour.

16. The sensible horizon differs from the rational horizon in this, that the former is seen from the surface of the earth, and the latter is supposed to be viewed from its centre.

17. The heavens are in every part adorned with stars, but those above the

horizon in the day cannot be seen, owing to the stronger light of the sun.

18. The earth has an annual motion round the sun, which it performs in about $365\frac{1}{4}$ days.

19. The annual motion of the earth, and the inclined position of its axis, are the causes of the different lengths of the days and nights, and of the different seasons.

20. Owing to the elliptical orbit of the earth, we are three millions of miles nearer to the sun in winter than in summer.

21. The heat of summer depends on the greater perpendicularity of the rays of the sun, and upon the time which he is above the horizon.

22. The hottest part of the day is two or three hours after noon: and the hottest part of the summer is a month or two after the longest day.

23. The rotation of the earth, that is, the space of time which any par-

ticular meridian takes in revolving from a fixed star to that star again, is 23 hours 56 minutes and 4 seconds. This is called the *sidereal* day.

24. The *solar* day is the time which any meridian of the earth takes in revolving from the sun to the sun again: that is about 24 hours, a little more or less.

25. Julius Cæsar divided the year into 365 days and a quarter, making one year in four to contain 366 days, and the other three 365.

26. The length of the year being only $365^d\ 5^h\ 48'\ 49''$, occasions the error of a whole day in 130 years.

27. The Julian year continued in general use till 1582, when the error, which amounted to 10 days, was corrected by pope Gregory. Hence the *New Style*, which was not adopted in England till the year 1752.

28. Till this period, the year began in England on the 25th of March; but

since, the commencement of each year has been on January 1.*

29. The periodical month, or the time which the moon takes in revolving from one point of the heavens to another, consists of $27^d\ 7^h\ 43'$.

30. The synodical month, or the time passed from new moon to new moon, is $29^d\ 12^h\ 44'$.

31. The moon shines with a light borrowed from the sun.

32. The diameter of the moon is nearly 2200 miles in length, and she is 240,000 miles distant from the earth.

33. At change or new moon, that body is between the earth and sun.

34. At full moon, the earth is between the sun and moon.

35. The length of a day and night in

* Hence, in many books, we find such dates as this, Feb. 2, 1759—60. Because the months of January, February, and part of March, were, according to the old style, in 1759; but according to the new regulations they were in 1760.

the moon is equal to rather more than twenty-nine days and a half of ours: the length of her year, which is measured by her journey round the sun, is equal to that of ours.

36. One hemisphere of the moon is never in darkness: to the other there is a fortnight's light and darkness by turns.

37. The earth may be regarded as a satellite to the moon, and will appear, to the inhabitants of that body, subject to all the changes which the moon undergoes.

38. All the planets probably revolve about an imaginary axis, in various periods of time, which revolution constitutes their day and night.

39. In every planet, its revolution about the sun forms its year.

40. In most of the planets, the axis is inclined to the orbit, which occasions the diversity of seasons.

41. Eclipses of the sun are occasioned

by the moon coming between the earth and the sun, and thus hiding its disc from our view.

42. Eclipses of the moon are owing to the shadow of the earth, projected by the sun, falling upon the moon.

43. The eclipses of the other satellites are caused by their coming into the shadows of their respective primaries.

44. The tides are occasioned by the attraction of the moon and sun upon the waters of the sea.

45. When the sun and moon act together they occasion *spring* tides; when they counteract each other's attraction, *neap* tides take place.

46. The moon in general rises about three quarters of an hour later every day than on the one preceding: but in the season of harvest, before and after full moon, it rises several nights together, within a few minutes of the same time. This is called the *harvest-moon.*

47. Mercury is the planet nearest the sun.

48. Mercury and Venus are called inferior planets, because they revolve in orbits included within that of the earth. They are called attendants upon the sun, because they are always so near that body, as never to be seen on the one side of the heavens when he is on the other.

49. Mercury revolves round the sun at the distance of 37 millions of miles, and his year is about 88 of our days. The heat which this planet enjoys is seven times greater than that experienced by the inhabitants of the earth.

50. Venus is 66 millions of miles from the sun, and her year is about 224¼ of our days.

51. The diameter of Venus is 7700 miles in length. She turns about her axis in 23 hours and 20 minutes. The light and heat experienced by this planet are about twice as great as those which we enjoy.

52. Venus is an evening star when she is east of the sun: and a morning star while she is seen west of him.

53. Transits of Venus will happen in 1874, 1882, 2004, and 2109.

54. From the transit of Venus the distances of the other planets, and of the sun, have been demonstrated.

55. Mars is 145 millions of miles distant from the sun; the length of his year is 687 of our days, and the rotation on his axis is performed in 24 hours 39 minutes.

56. The diameter of Mars is only 4189 miles, and he enjoys about half as much light and heat as we experience.

57. The diameter of Jupiter is 90,000 miles, and his distance from the sun is estimated at more than 490 millions of miles.

58. The year of Jupiter is equal to nearly 12 of ours, and a day and night in that planet are equal to ten of our hours. The inhabitants of Jupiter do not enjoy more than a twenty-fifth part as much heat and light as we do on the earth.

59. The equatorial diameter of Jupiter is 6000 miles greater than the polar diameter.

60. There is no inclination of the axis of Jupiter, and of course no variety of seasons.

61. Jupiter has four satellites, subject to be eclipsed like our moons. From these eclipses it has been found, that rays of light come from the sun to the earth in eight minutes; of course, light travels at the rate of 12 millions of miles in a minute.

62. The diameter of Saturn is nearly 80 thousand miles in length; his distance from the sun is more than 900 millions of miles, and his year is equal to about 30 of ours.

63. Saturn enjoys 90 times less light and heat than are experienced by the earth; nevertheless, the light of the sun at Saturn is equal to more than 500 times that which we enjoy from the full moon.

64. Saturn is attended by seven moons; and is encompassed with two broad rings, which are probably useful in reflecting light from the sun on the body of the planet.—See Fig. 20, vol. ii.

65. Saturn's day and night is about $12\frac{1}{4}$ hours, and his equatorial diameter is longer than his polar diameter in the proportion of 11 to 10.

66. The diameter of the Herschel is nearly 35 thousand miles in length, and his distance from the sun is estimated at 1800 millions of miles.

67. The year of the Herschel is equal to 82 of our years. He has six satellites; the light and heat enjoyed by this planet from the sun are 360 times less than we have; the light is however equal to what we should enjoy from 248 of our full moons.

68. Comets are a species of planets moving in very eccentric orbits: sometimes they are very near the sun, at other times at immense distances from him.

69. All the heavenly bodies move faster or slower, in proportion as they are nearer to or more distant from their centre of motion.

70. Comets are frequently accompanied with a luminous train called the tail.

71. The sun has a rotation on his axis from west to east, which he completes in about 25 days, which is two days less than his apparent revolution.

72. The sun's diameter is equal to 100 diameters of the earth; his bulk is accordingly about a million of times greater than that of the earth; but the density of the matter of which the sun is composed is four times less than the density of our globe.

73. The fixed stars are probably suns at immense distances from us and from each other; and our sun is only a fixed star much nearer to us, forming the centre of our system.

74. So distant is the nearest fixed star

from us, that a ray of light, which travels at the rate of 12 millions of miles in a minute, would be three years in passing from it to us.

HYDROSTATICS.

Questions and other Exercises on the Science of HYDROSTATICS, *formed from Vol. III. of* "SCIENTIFIC DIALOGUES."

Conversation I.——From what is the word *hydrostatics* derived?

As a branch of science, of what does it treat?

Into what parts is it divided?

To what does the science of hydraulics relate?

How is a fluid defined?

How do you distinguish between fluids and liquids?

Upon what does the perfection of a fluid depend?

Of what kind of particles are fluids supposed to be formed?

What are the reasons assigned why the particles of fluids should be spherical?

Explain this by Fig. 1.

How do you account for the composition of tinctures?

Can any thing be added to a fluid without increasing its bulk?

Give an instance in point: how do you account for this?

Are fluids compressible?

Who made the experiment with water, and what was the result?

Have any later experiments proved that fluids are capable of compression?

What reason is advanced to prove that the particles of water are hard?

Conversation II.——How do the particles of fluids act?

Give an instance to illustrate this.

Do the particles of water attract each other?

Why do the globules of dew on plants run off without seeming to wet them?

Explain the structure and uses of the level.—See Fig. 2.

To what purpose are levels applied?

In what directions do fluids press?

Can you, by Fig. 3, show how it is that fluids press upwards and sideways as well as downwards.

Is air easily compressible?

Can you exhibit this by an experiment?

Of two fluids of different densities, which will be uppermost?

Give an explanation of the subject illustrated by Fig. 5.

Can you show, by means of pasteboard or horn, that the upper pressure of fluids is equal to the pressure downwards?

Conversation III.——Why, in drawing up a bucket from a deep well, does it appear to have little or no weight while it ascends through the water?

On this subject explain the experiment illustrated by Fig. 6.

How is the fact accounted for?

What is meant by the specific gravity of a body?

Is the pressure of the water upward against the bottom of the bucket equal to the same force in the contrary direction?

Why will not the water in a glass tube of a small bore, open at both ends, run out, provided the upper part be kept closed?

Explain the experiment of the ale-glass filled with water.

How do you account for the operation of the instrument for tasting wine or beer?

Why are vent-holes made in casks?

Conversation IV.——How is the lateral or side pressure of fluids estimated?

Is the pressure of fluids equal in all directions?

Explain the experiment exhibited by Fig. 7.

What is necessary, in order that the pressure of fluids should be equal in all directions?

Look to Fig. 8, and with that let the subject be farther illustrated.

How much heavier is quicksilver than water?

How can lead or any other metal be made to swim in water?

How much heavier than water is lead?

How is it proved that the lead, made to swim, does not stick to the tube, instead of being acted upon by the upward pressure of the water?

Conversation V.——What do you mean by the hydrostatical paradox?

Can you explain Mr. Ferguson's experiment on this subject?—See Figs. 10, 11, and 12.

How is the upward pressure proved?

What do you mean by *homogeneous* fluids?

Conversation VI.——How is the pressure of fluids of the same kind estimated?

Explain the difference between weight and pressure.

Can you explain the construction and operation of the hydrostatical bellows?

Is there any means of making this small

quantity of water bear a still greater weight?

What will set limits to this experiment?

In what manner has a hogshead been burst, and how is the fact to be accounted for?

Explain to me, by Fig. 13, how this pressure acts.

Conversation VII.——What is the law of the pressure of fluids against the sides of any vessel?

Explain the subject by means of Fig. 16.

Can you tell me why the pressure against the whole side of a vessel must vary as the square of the depth of the vessel?

Suppose you have three vessels of equal width, whose depths are as 1, 2, and 3; what will be the proportional pressures against the several sides?

What will be the difference of pressure against the sides of two canals of equal width, the depth of one being five feet, and that of the other fifteen?

How is this proved by experiment?

How is the pressure against the bottom of a vessel estimated?

What is the pressure upon any side of a cubical vessel, and what is the reason of it?

What is the pressure upon the four sides equal to?

What is the difference between the weight and the pressure of a conical vessel of water standing on its base?

Conversation VIII.—— Explain, by Fig. 15, the motion of fluids through pipes.

By what law is the velocity of spouting fluids governed?

How is this practically applicable?

Why does water run slowly out of a cistern when almost empty?

In a barrel of porter standing on its head, having two cocks, one in the middle and the other near the bottom, which will give out the liquor the fastest, and in what proportion?

Point out the distinction which arises between the pressure against the side of a vessel, and the velocity of a spouting pipe.

Does the velocity of a running fluid continually decrease, and why?

How are water-clocks constructed?

How would you divide a vessel of this kind, that would require six hours to empty itself in?

Why are the flood-gates to locks made so thick as they are?

How are they opened when such a weight presses upon them?

What effect has the pressure of water on the banks of a river?

Can you explain this by the aid of Fig. 17?

How are leaks in the embankments of a river secured?

Conversation IX.——Can you explain the experiment represented by Fig. 18?

What general rule is deducible from this experiment?

In what part of the side of a vessel should a pipe be placed, in order that the fluid should spout the farthest possible?

Can you place two other pipes which shall spout to equal distances?

To what angle must a cannon be elevated to project a bullet the farthest possible?

Why will not water rise so high in a jet as a tube?

Will water in a pipe, or in the open air, as in a fountain, rise the highest?

Is there any other cause besides the resistance of the air that prevents a stream from a fountain rising so high as the head of the water from which it proceeds?

How is London supplied with water from the New River?

How must the reservoir, which is called the New River Head, be situated?

Can water be carried to any distance?

For what reason is it necessary that the pipes should be made very strong if they are carried down in deep vallies?

Conversation X.——Why do some bodies swim and others sink?

Do equal weights of different substances occupy equal spaces?

How would you get at the weights accurately of two equal quantities of fluid?

How do you find that quicksilver is 14 times heavier than water?

Compare now the weight of alcohol with that of water.

What are the comparative weights of bodies called?

Is rain water equally heavy everywhere, and how much does it weigh?

Conversation XI.——Upon what do the specific gravities of different bodies depend?

Make the comparison between equal bulks of lead, copper, and wood.

What then constitutes the difference in the specific gravities of bodies?

What is usually made a medium to compare the specific gravity of bodies?

Make the comparison in water with three pieces of wood.

What kind of pressure does a solid sustain when immersed in a fluid?

Make the experiment, as it is shown by Fig. 8, explain its principle, and the result.

Why does a stone sink in water if the pressure upward is equal to the downward pressure?

Repeat the lines on this subject by Browne.

How far will bodies, that are lighter than water, sink in that fluid?

Explain this more particularly.

If I place a piece of wood, the specific gravity of which is just equal to that of water, into a vessel of that fluid, what will be the consequence?

Explain what is meant by Fig. 19.

Conversation XII.——Explain the structure and uses of the hydrostatical balance. —Plate III, Fig. 20.

What is the rule for finding the specific gravity of bodies?

Explain this by the instance of a guinea.

Tell me the reason why boats, &c. swim, and to what extent they may safely be loaded.

Can iron be made to swim?

How does a copper ball act in turning off water when a cistern is full?

How would you find the specific gravity of a piece of silver?

What is the specific gravity of a piece of glass that weighs twelve ounces in the air, and only eight in water?

Does flint glass vary in its specific gravity?

How is the specific gravity of quicksilver to be found, and what is it if a given quantity weigh 480 penny-weights in air, and only 445 in water?

How can the specific gravity of precious stones and other small fragments of bodies be found?

Conversation XIII.——How can I find the specific gravity of bcdies that are lighter than water?

What is the specific gravity of a piece of beech-wood that weighs 660 penny-weights, to which, when a piece of metal weighing 480 penny-weights is annexed, it loses by being immersed in water 51 penny-weights?

Explain the mode adopted in finding the specific gravity of a piece of elm or other wood, by means of Fig. 22.

Make the experiment with cork.

What precautions are necessary in making the experiments upon porous bodies?

Is there any other rule for finding the specific gravity of fluids?

Explain this by an experiment in water and milk.

A piece of glass plunged in water loses of its weight 803 grains; but in spirit of wine it loses 699 grains: what are the specific gravities of the two fluids?

Can you with equal bulks of different bodies obtain their specific gravities, and how is it done?

Are the specific gravities in proportion to the weights lost by immersion in water?

What is the reason of the rule that you have now given me?

Conversation XIV.——By what means and by whom was the method of obtaining the specific gravities of bodies discovered?

What is the axiom deduced from the discovery of Archimedes?

To what practical purpose did he apply his discovery?

Can you, in your own words, briefly explain the mode adopted by Archimedes in detecting the roguery of the Sicilian jeweller?

Conversation XV.——How am I to know whether a suspected guinea, or other gold coin, be a counterfeit or not?

Is there any means of finding out the proportions of the base and pure metal?

Explain the same with regard to a guinea which is full weight.

What reasons are assigned why a person who has taken counterfeit money should not attempt to pass it?

How am I to ascertain the value of a counterfeit guinea, that is composed of copper and gold?

What are the methods of estimating its worth, if it were a compound of gold and silver?

Tell me what is the average allowance for every grain that base metal loses by immersion more than sterling gold?

How can I find whether this tablespoon is of fair marketable silver?

Conversation XVI.——Explain the experiments intended to be exhibited by Figs. 23 and 24.

By what means are the slaves in the West Indies said to plunder their masters of rum?

Can fluids of different specific gravities be placed one upon another without mixing?

For what purposes is the hydrometer used?

Explain its structure by means of Fig. 25.

How is it graduated?

What is the meaning of the word *inversely* when applied to this subject?

What is the difference between spirit of wine and alcohol?

Will a pint of water and a pint of alcohol make a quart? if not, what is the cause?

Conversation XVII.——In what trades is the hydrometer used?

Can you explain the theory of floating vessels?

Will a vessel sink deepest in salt water or in fresh?

Is there any danger of loading a vessel too heavily that rides in the sea, and which has to come into fresh water?

What is the difference of densities between sea and fresh water?

Is the human body lighter or heavier than fresh water?

What makes a person sink in water?

What method does Dr. Franklin recommend to a person to learn to swim *?

Why do all quadrupeds swim?

What risque do incautious bathers run, and from what cause?

How much deeper is a clear stream than it appears to be?

What is the cause of a person being drowned?

By what means is a person, who falls into the water, brought up again from the bottom?

Conversation XVIII.——What is the syphon intended for?

* It has lately been asserted, that, if a person unable to swim can so far command himself as not to lift his hands above water, it will be impossible that he should sink.

Explain the mode of its action by Fig. 26.

To what is the action of pumps and other hydraulic machines to be attributed?

How is the pressure of the air estimated?

By what means does the pressure of the air make the syphon act?

Explain this to me by the assistance of the Figure.

Explain the principle upon which a bottle of wine, &c. is decanted by the syphon.

How is the Tantalus's cup explained? —See Fig. 27.

Explain, by Fig. 29, in what manner the distiller's crane acts.

How is the nature of intermitting springs accounted for?

Can you explain the theory by a reference to Fig. 30?

Conversation XIX.——Upon what principle is the diver's bell made?

Explain the structure of that represented in Fig. 31.

In this machine how are divers supplied with air?

What sensations do divers feel under water?

How are divers brought up?

To what purpose is the diver's bell applied?

Conversation XX.——Has the diver's bell been attended with accidents?

What is the structure of Mr. Smeaton's diving machine, Fig. 32?

Explain the nature of the one invented by Mr. Adam Walker, Fig. 33.

Conversation XXI.——Can you show, by Fig. 34, how the pump acts?

To what depth is the action of the suction pump confined?

Why is a pump useless in wells more than 33 feet deep?

To be sure of the action of a pump, how far from the water should the piston be set?

Repeat Dr. Darwin's lines on the pump.

Conversation XXII.——Can you describe the action of the forcing-pump by Fig. 35?

In what does the forcing differ from the common sucking-pump?

Upon what principle were the London water-works constructed?

What is the rule to calculate the height to which an engine will throw water?

How are fire engines constructed?

Repeat the lines on this subject from Dr. Darwin's Botanical Garden.

Can you explain the structure and operations of the rope-pump by Fig. 36?

How much water will the rope-pump at Windsor raise in a minute, and from what depth?

Explain the nature of the water-press, as it is exhibited in the 14th Figure.

What can be done with it?

Some of the leading DEFINITIONS *and* FACTS, *explained and illustrated in Vol. III. which it is recommended that the Pupils should commit to Memory.*

HYDROSTATICS.

1. *Hydrostatics* is a branch of natural philosophy that treats of the nature, gravity, pressure, and motion of fluids in general.

2. This science is, by some authors, divided into two distinct parts, *viz. hydrostatics* and *hydraulics:* the latter relates particularly to the motion of water through pipes, conduits, &c.

3. A fluid is a body, the parts of which yield to any impression, and in yielding are easily moved among each other.

4. The air we breathe is a fluid, the parts of which yield to the least pressure.

5. The particles of which fluids are made up are supposed to be exceedingly small, round, and smooth.

6. They are likewise imagined to be exceedingly hard, and almost incapable of compression.

7. The particles of water have but a slight attraction for one another.

8. Fluids press in all directions equally.

9. A portion of any kind of fluid gravitates in another when surrounded by a larger portion, in the same way as if it were in the air.

10. A fluid presses in proportion to its perpendicular height, and the base of the vessel containing it, without any regard to the quantity.

11. The specific gravity of any body is its weight compared with any other body; or, more generally,

12. By specific gravities is meant the relative weights of equal bulks of different substances.

13. The lateral or side pressure of fluids is equal to the perpendicular pressure.

14. The hydrostatical paradox is, "That any quantity of water, however small, may be made to balance and support any quantity, however large."

15. The pressure of water and other fluids differs from its gravity or weight in this; that the weight is according to the quantity, but the pressure is according to the perpendicular height.

16. The pressure of fluids, against the separate parts of the side of any prismatic vessel taken horizontally, increases as the odd numbers 1, 3, 5, 7, &c.

17. The pressure against the whole side of a vessel must vary as the square of the depth of the vessel.

18. Of three vessels of equal width, whose depths are as 1, 2, and 3, the pressure against the side of the second will be four times greater than that against the first; and the pressure against the side of

the third will be nine times greater than that against the first.

19. In any cubical vessel the pressure against any one side is equal to half the pressure upon the bottom; and of course the pressure upon the four sides is equal to twice the pressure upon the bottom.

20. The pressure of any fluid upon the bottom and four sides of a cubical vessel is equal to three times the weight of the fluid.

21. The pressure of the fluid in any conical vessel is found by multiplying the base by the whole perpendicular height; therefore the pressure will be equal to three times its weight.

22. The velocity with which water spouts out at a hole in the side or bottom of a vessel is as the square root of the distance of the whole below the surface.

23. The pressure against the side of a vessel increases in proportion to the square of the depth; but the velocity of a spout-

ing pipe increases only as the square root of the depth.

24. The horizontal distance to which a fluid will spout from an horizontal pipe, in any part of an upright vessel below the surface of the fluid, is equal to twice the length of a perpendicular to the side of the vessel, drawn from the mouth of the pipe to a semicircle described upon the altitude of the vessel.

25. Of several pipes, placed horizontally in the side of an upright vessel, that in the centre will spout the farthest; and pipes, at equal distances from the centre, above and below, will spout to equal distances.

26. In pipes placed obliquely, that whose elevation is 45° will spout the farthest; and those placed at equal angles above and below 45°, will spout to the same point.

27. Water will not rise so high in a jet as it does in a tube.

28. Bodies heavier than water will

sink in it, and those that are lighter than the fluid will swim.

29. Pure rain water, which is the usual standard for comparing the specific weights, of bodies, is everywhere of the same weight, and a cubical foot weighs exactly a thousand ounces avoirdupoise.

30. The specific gravity of bodies is estimated by the quantities of matter when the bulks are the same.

31. A solid immersed in water sustains a pressure on all sides, which is increased in proportion to the height of the fluid above the solid.

32. A body, specifically lighter than water, will sink in it till so much of it is below the surface, that a bulk of water, equal to the bulk of the part of the body which is below the surface, is of a weight equal to the weight of the whole body.

33. The instrument for comparing the specific gravity of solids is called the hydrostatic balance.

34. The rule for obtaining the specific gravity of a body is this: "Weigh the body first in air, then in water: observe what it loses by being weighed in water; and by dividing the former weight by the loss sustained, the result is its specific gravity."

35. Every body, when immersed in water, loses as much of its weight as is equal to the weight of a bulk of water of the same magnitude.

36. If the same body be weighed in different fluids, the specific gravity of the fluids will be as the weights lost.

37. The specific gravity of bodies are to one another inversely as the weights lost by immersion in water.

38. The instrument for comparing the specific gravity of liquids is called the hydrometer.

39. The hydrometer is used in breweries and distilleries to ascertain the strength of their liquors, and by the excise officers to guage the spirits, in order to as-

certain the duties to be paid to the revenue.

40. All bodies that float on the surface of water displace as much fluid as is equal in weight to the weight of the bodies so floating.

41. Salt water is specifically heavier than fresh or river water.

42. The specific gravity of the human body is found to be one-ninth less than that of common river water.

43. People in danger of drowning should never raise their hands above the water, and then they cannot sink.

44. Clear water is always one-fourth part deeper than it appears to be.

45. A syphon is a bended tube with unequal legs. The cause of its action is owing to the pressure of the atmosphere, added to the preponderance of weight in the longest leg.

46. The diver's bell is an empty vessel inverted, and made sufficiently heavy to sink in water.

47. Pumps for raising water are of two kinds; the sucking and the forcing-pump.

48. The water in a sucking-pump is raised from the well by the pressure of the atmosphere; and it can be raised by this means about 33 feet.

49. A forcing-pump is unlimited in regard to the height to which it may raise water.

50. An air-vessel is added to a forcing-pump to give an equable stream.

51. A constant stream is produced by means of two barrels, with pistons moving up and down alternately.

52. Plungers are pistons that nearly fill the working barrel: these do not act by the pressure of the atmosphere.

53. Valves are of various kinds: the best are technically described as the clack valve, the button-and-tail valve, the conical valve, and the globular valve.

PNEUMATICS.

Questions and other Exercises on the Science of PNEUMATICS, *formed from Vol. IV of* "SCIENTIFIC DIALOGUES."

Conversation I.——What is meant by Pneumatics?

Will the definition given to a fluid comprehend the air?

Is air necessary to the existence of fish?

What is the air-bladder in fish, and what are its uses?

Conversation II.——Describe, by means of Fig. 1, the structure and use of the air-pump.

How is the air taken away from the receiver over the air-pump?

Can the whole of the air be exhausted?

What is the cause of the mist which appears on the inside of the receiver on the exhaustion of the air?

Repeat the lines by Dr. Darwin on this subject.

How will Fig. 2 enable you to describe the resistance of the air?

What facts are deducible from this experiment?

Can you describe the experiment of the guinea and feather, and tell me what it is calculated to teach?—See Fig. 3.

What do you mean by the philosophical hammer?—See Fig. 4.

Conversation III.——How is the air wholly excluded from a vessel, as a glass tube?

What is the pressure of a column of quicksilver about 29 or 30 inches long equal to?

Can you explain the structure and uses of a syringe?

How is it proved that the syringe does not act by means of suction?—See Fig. 5.

Who discovered the weight and pressure of the air?

Conversation IV.——Explain the experiment illustrated by Fig. 6.

What effect does the pressure of the air occasion in this instance?

How is the pressure explained by the experiments with Fig. 7?

Can you describe the experiment shown by Fig. 8?

Why is there a bubble left at the top of the glass?

What does the experiment exhibited by Fig. 9 prove?

Why can you not move the small glass?

Why could not suction produce the effect?

How will you loosen and get away the small glass, that you cannot lift up?

Conversation V.——Explain the action of the leather and stone.

Is it not by means of suction that

children sometimes draw water through a straw from a spring?

Explain the experiment made with the transferrer, Fig. 10.

Do the same with the brass hemispheres, Figs. 11, 12, and 13.

What is Fig. 14 meant to show?

What is Fig. 15 intended to demonstrate?

How is mercury made to pass through a piece of wood?—See Fig. 16.

Conversation VI.——How is the weight of the air ascertained?—See Fig. 17.

The air, in passing through a small orifice into a vacuum, makes a hissing noise: when the noise ceases, what does it prove?

How much does a quart of air weigh?

How is the weight of the air estimated?

How does the barometer show the weight of the air?

Upon what does the inaccuracy in the flask experiment depend?

To how great a degree of exactness can a vessel be exhausted of air by means of the air-pump?

How is that ascertained?

By how many turns of the handle of the air-pump will this degree of accuracy be obtained according to the relations given in the conversation?

What is the specific gravity of air, compared with that of water?

Is that always the weight?

Conversation VII.——What is the nature of elastic bodies?

How is elasticity defined?

Do many bodies possess this property?

How is the elasticity of the air demonstrated?

What will Fig. 8 show in proof of this?

Explain the experiment exhibited by Fig. 18.

Can a shrivelled apple be made to look plump and fair to the sight, and on what does it depend?

Why does ale that is merely warm put on the appearance of boiling under the exhausted receiver of the air-pump?

What effect is produced on beer and other liquids by taking from them the air?

By admitting the air again, does it produce the same lively taste in the liquids that they had before? and, if not, why so?

What air is that combined with beer?

How do you account for the pain felt by exhausting the air from under the hand?

How is *cupping* performed?

How do the small glasses that are used in the operation act?

Tell me what Fig. 15 is meant to show.

What experiment is shown with a new-laid egg?

Conversation VIII.——In what respect does air differ from other fluids?

Is air easily compressible?

Show me how it is done.

Explain the experiment exhibited by Fig. 18.

Why are the lower regions of the atmosphere more dense than those higher up?

How is the density of the air illustrated?

What does the artificial fountain prove?

Explain the action of the fountain by Fig. 19.

How is the rise of the water accounted for?

What is the construction of the condensing syringe?

In what respect does it differ from the common squirt?

To what extent can air be compressed?

Are there different kinds of fountains?

Why do the streams coming from artificial fountains continually diminish in height?

Conversation IX.——How is it proved, that various substances, as metals, stones, &c., contain air?

Show the same of vegetables.

What is inferred from this experiment?

What is the explanation of the experiment with cork?

Can the same be shown by a bladder?

Upon what does the ascent of smoke and vapours depend.

Why does the smoke of a chimney sometimes rise very high, and in a vertical direction?

What is Fig. 20 intended to show?

Explain the same by means of Figs. 21 and 22.

What is the experiment of lead and cork intended to prove?

How is this explained?

In what state is a pound of feathers heavier than a pound of lead?

Conversation X.——Upon what do the effects of the air-gun depend?

Will air-guns act like common guns?

What are the characteristics of air-guns?

Explain the construction of an air-gun, by Fig. 23.

Does all the air of an air-gun escape at a single discharge?

Does the strength of each discharge remain the same?

What is the magazine wind-gun?

Does air never lose its elastic power?

How is it proved that air is the medium of sound?

Why are sounds from a distance heard so much plainer at one time than another?

Is great strength required to condense air?

Upon what does the power required for condensing depend?

How may it be regulated to any given degree?

Is there any other body besides air that will convey sound?

Is the earth a good conductor?

What experiment is shown with a slip of flannel?

Conversation XI.——How is thunder produced?

Does gunpowder, when fired *in vacuo*, produce any sound?

Do you know what were Mr. Cotes's experiments on this subject?

Why do some bodies give out a better sound than others?

What is the cause of sound?

How is it known that the particles of the metal move when a bell is struck?

At what distance has sound been heard?

Can sound be conveyed further along a smooth or a rough surface?

Is water or land the better conductor of sound?

When a gun is fired at a distance, do you hear the sound, or see the flash first?

At what rate does light travel?

At what rate does sound travel?

Can this knowledge be applied to any useful purpose?

Upon what does the mischief occasioned by lightning depend?

Can you ascertain at what distance you are from a thunder-storm?

Can this be done by counting the beats of the pulse?

Conversation XII.——Upon what does sound depend?

What kind of a wave is made in the air by sound?

What circumstances are observable in the waves made by throwing a pebble into still water?

How do you describe the nature of sound?

Upon what principle does the speaking trumpet depend?

What is its construction?

Were speaking trumpets in use among the ancients?

What other name has been given to speaking trumpets, and why were they so called?

Can you explain, by a reference to Fig. 24, how speaking figures are constructed?

Conversation XIII.——Repeat Ovid's description of Echo?

What is the cause of an echo?

How must the ear be situated to hear an echo?

Explain to me what is meant by the lines of reflection and incidence.

In what case are they both the same?

In what case are they not?

How is this illustrated by means of a looking-glass?

Look to Fig. 25, and see if you can explain its meaning?

Explain the distinction between direct sound and echo?

What is the cause of an echo being repeated?

In what case will there be no echo?

What is the least distance at which a person must stand from the reflecting substance to hear an echo?

Must the distance be increased if more syllables than one are to be repeated?

Conversation XIV.——Can you enumerate some of the principal echoes?

Has the echo ever been applied to any practical purpose?

In what manner have inaccessible distances been measured by the echo?

What is the circumstance that attracts attention in the whispering gallery of St. Paul's?

How is that produced?

How must the persons be placed to hear the whisper in the best manner?

What is the best medium as a conductor of sound?

What instance is adduced by Dr. Hutton?

Next to water what is the best conductor of sound?

To what distance has a whisper been conveyed by means of a brick wall?

Upon what do musical instruments depend for their sounds?

What circumstance is observable if a long cord stretched out between two points be struck?

Upon what do the notes of a violin depend?

How are the various sounds on an Eolian harp explained?

If one of the strings of an Eolian harp is struck will they all vibrate?

How is this shown?

Is it necessary that the strings should be in unison to produce this effect?

If a vibrating cord make 118 vibrations in a second, what sound does it yield?

Conversation XV.——What is wind?

How are the effects of wind shown by experiment?

What puts the air in motion so as to produce winds?

How does heat produce wind?

Show me the experiment with a lighted taper at the door, and explain the reason of the appearances.

Upon what principle does the smoke-jack depend?

How is wind defined?

How is its direction denominated?

How many kinds of wind are there?

Does the wind blow in any part of the earth in one direction only?

What is the reason of this?

Explain this by the globe.

Do transparent media receive heat?

Tell me then how the constant winds are to be accounted for.

What other name have they?

Where do the periodical winds prevail?

On what do they depend?

What other names have they?

Why are they called trade-winds?

What experiment will illustrate the subject?

Upon what does the variableness of the wind in an island depend?

Has electricity any effect in producing wind?

Upon what may the suddenness and strength of a storm depend?

By what methods can the velocity of wind be measured?

What is supposed to be the greatest velocity of wind?

By what law does the force of the wind increase?

Conversation XVI. —— Why is the steam-engine called the most important of all machines?

In what cases is the steam-engine used to advantage?

When was the steam-engine invented?

To whom are we indebted for the discovery?

How is the experiment with the cup explained?

What is used in the steam-engine to make a vacuum?

Can you repeat the lines from Dr. Darwin's Botanical Garden on this subject?

Try to explain the structure and action of the engine from the Figures in Plate 4.

Show me the steam-pipe, and tell me its use.

Which are the steam-valves and what are the uses of them?

Show me the eduction valves and their uses.

What is that represented by *f*, and for what is it used?

How is the air-pump worked?

Is the great beam used for any thing else?

Tell me how the valves are opened and shut.

Now describe the action of the engine.

Conversation XVII.——[No questions can be formed on this Conversation better than those in the book.]

Conversation XVIII.——To what was the steam-engine first applied?

In what lines does Dr. Darwin allude to this?

Has Mr. Boulton applied this machine to any particular purpose?

How is the power of the steam-engine estimated?

To what uses is the steam-engine applied in Whitbread's brewery?

Can you repeat the lines by Dr. Darwin, in which he anticipates a still further extension of this useful power?

Is not steam sometimes productive of very dangerous consequences?

Can you recollect any instances of this kind?

For what is Papin's Digester used?

How is it made?

What kind of valve is used in the digester?

Can you, by Fig. 26, show how the water is raised to any degree of heat?

What additional pressure is required to

give water a heat double that of boiling water?

Conversation XIX.—— What is the construction of the barometer?

Explain how it is made by Fig. 27.

For what purpose is it used?

What is the reason that water stands in a tube open at one end, provided that end be plunged in a vessel of water?

Why does water stand 33 feet, but the mercury only 29 or 30 inches?

How much heavier is mercury than water?

Who discovered the principle of the barometer?

Did the inventor apply it to discover the changes in the state of the air?

How would you define a barometer?

When does the mercury rise and when does it fall?

What is meant by the standard altitude?

What is the scale of variation?

How much does the height of the mercury vary in this country?

In what parts of the world is the variation of the mercury the least, and in what is it the greatest?

Of what use is the *vernier*?

Can you explain its application by Fig. 28?*

Repeat Dr. Darwin's lines descriptive of the barometer?

Conversation XX.——How is the height of the atmosphere discovered?

What is the specific gravity of the air when the barometer stands at 30 inches?

Is the atmosphere equally dense at all heights?

What is the height of the atmosphere estimated at?

Is the barometer applied to any thing else besides that of showing the changes in the pressure of the atmosphere?

How much is it ascertained that the mercury of the barometer falls in ascending an eminence of 100 feet perpendicular?

* Here the best kind of examination will be found in the volume.

Can you repeat the lines from Lofft's Eudosia which describe the pressure of the atmosphere on the human body?

How much weight does a full grown person sustain from the pressure of the atmosphere?

Conversation XXI.——To what is the thermometer applied?

How is it constructed?

How were thermometers formerly made?

Upon what principle does the mercurial thermometer depend?

What does the thermometer indicate?

According to Fahrenheit's thermometer, what is the freezing-point and what the point of boiling water?

Is the heat of boiling water always the same?

Look to Fig. 29, and explain the construction and graduation of the thermometer.

What is the utmost extent of the mercurial thermometer, and why?

Conversation XXII.——Can quicksilver be compared with other metals?

Are all bodies in nature capable of existing in the solid, fluid, and aeriform state?

In what parts of the earth does it rarely if ever freeze?

Under what circumstances does it seldom freeze here?

What is the coldest and what is the warmest part of the 24 hours?

Does brass require a great heat to melt it?

Can heat higher than boiling mercury be ascertained by any mode?

What is the construction of Wedgewood's thermometer?

How is it used?

To how many degrees of Fahrenheit does one of Wedgewood answer?

What is the difference between Reaumur's and Fahrenheit's thermometer?

How many degrees of Fahrenheit make one of Reaumur's?

What is the rule for converting the

degrees of Fahrenheit to those of Reaumur?

How is the operation reversed, and how are the degrees on Reaumur converted to those of Fahrenheit?

Conversation XXIII.——What do you mean by a pyrometer?

Explain the structure and use of that represented by Fig. 30.

For what is the hygrometer used?

Upon what principle does the common weather-house act?

Can you tell how the hygrometer (Fig. 31) acts?

What effect has moisture on packthread, catgut, &c.?

Show me how the hygrometer (Fig. 32.) acts.

How can sponge be made into an hygrometer?

What else is mentioned as well adapted to the purpose of an hygrometer?

Conversation XXIV.——For what purpose is the rain-gauge used?

How does that act which is represented in Fig. 34?

What proportion do all plane surfaces bear to one another?

How is the rise of the water noted?

To what degree of accuracy can the quantity of rain be measured?

Can you explain the structure of the other rain-guage?

Name the different instruments used in comparing the changes of the atmosphere.

How should the rain-gauge be fixed?

Is there any difference in the quantity of rain collected, whether the gauge stand on the ground or on a building considerably above the surface of the earth?

What does the rising of the mercury presage?

What does its falling denote?

According as the mercury stands convex or concave what weather may be expected?

What does the falling of the mercury indicate in very hot weather?

What does its rising indicate in winter?

If the mercury rise in a continued frost, what may be expected?

When may bad, and when fair weather be expected?

When may a continuance of fair weather be expected?

When may much wet be expected?

In examining the scale, what is to be attended to?

When may high winds, and when heavy showers be expected?

What is the sign of fair weather?

On what occasions is the mercury the highest?

Questions made from the Appendix.

What causes determine the distribution of heat over the earth's surface?

Upon what do these depend?

How does that act which is represented in Fig. 34?

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On what occasions is the mercury the highest?

Questions made from the APPENDIX.

What causes determine the distribution of heat over the earth's surface?

Upon what do these depend?

Is the heat of the longest day greater at St. Petersburg or at Pavia, and in what degree?

How are the effects of the influence of the sun modified?

How does the sea preserve a moderate temperature?

What effects are produced by large continents and very high mountains?

What is the effect of evaporation?

At what rate is the diminution of heat, with respect to the elevation of places?

What are the varieties of temperature on the surface of the earth?

How have the climates of European countries been improved?

What effect has humidity on the air?

What is dew, and how is it formed?

What is the probable construction of the meteoric stones?

Some of the leading Definitions *and* Facts, *explained and illustrated in Vol. IV. which it is recommended that the Pupils should commit to Memory.*

Pneumatics.

1. The science of Pneumatics treats of the mechanical properties of air.

2. Air is a solid and material substance, as well as water and other fluids.

3. The invisibility of the air is owing to its transparency.

4. Air possesses weight, compressibility, and elasticity.

5. The pressure of the atmosphere is equal to the pressure of a column of water 32 or 33 feet high, or to a column of mercury about 30 inches high.

6. The Torricellian experiment proves there is no such a thing as suction.

7. The pressure of the air is shown by various experiments.

8. The weight of the air is demonstrated by experiments.

9. The density and elasticity of the air are in proportion to the force that compresses it.

10. The elasticity of the air in the human body is shown by experiments on the air-pump.

11. The operation of cupping depends on the elasticity of the air in the body.

12. The density of the air diminishes upwards.

13. The air-pump is a machine for exhausting the air from vessels.

14. A vacuum is a space emptied of air.

15. Artificial fountains are made by means of compression.

16. The height to which artificial fountains ascend depends on the quantity of air forced into the vessel.

17. The ascent of smoke and vapours depends on the density of the air.

18. A piece of cork and a piece of lead, exactly balanced in the air, being introduced under the receiver of an air-pump,

and the air taken away, the cork will appear the heaviest body.

19. The effects of the air-gun depend on the elasticity and compression of air.

20. Air-guns will answer the same purposes as fowling-pieces.

21. The air presses upon every body immersed in it, and on every side.

22. Air is the medium of sound; and sound is increased in proportion to the density of the air.

23. Thunder is produced by the concussion of two bodies of air.

24. All sonorous bodies are elastic, the parts of which are made to vibrate by percussion.

25. The vibrations of a bell are invisible.

26. Sound can be heard at a great distance when it passes over water.

27. Sound travels at the rate of 1142 feet * in a second of time: hence is easily

* Dr. Gregory has shown that the velocity of sound varies a little, in consequence of changes of temperature. See his edition of Hutton's Course, vol. ii. p. 281.

found the distance of a storm, when accompanied with thunder and lightning, or the distance of a ship in distress by the firing of her guns.

28. Sound is the effect produced on the ear by the undulations of the air.

29. When these undulations strike against any surface adapted to the purpose, and are reflected back, an echo is produced.

30. For an echo to be heard, the ear must be in the line of reflection.

31. There can be no echo unless the direct and reflected sounds follow one another at a sufficient interval of time.

32. For an echo to be distinct, the reflected sound must travel over, at least, 127 feet more than the direct.

33. If many syllables are to be repeated, the distance must be increased in proportion to the number of syllables.

34. The echo has been applied to the measuring of inaccessible distances.

35. Water is the best conductor of sound; and next to this is stone.

36. Wood is sonorous, and produces a

most agreeable tone, which renders it so well adapted for musical instruments.

37. The notes upon a violin depend upon the different lengths of the strings, which are varied by the fingers of the musicians.

38. All the strings of an Eolian harp will, if set to the same note, vibrate by striking one only.

39. Air in motion constitutes wind.

40. The principal cause of wind is heat communicated by the sun.

41. The smoke-jack acts by the force of the air of the room, which, being rarefied, ascends the chimney and strikes upon the vanes of the jack.

42. The direction of the wind is denominated from that quarter from which it blows.

43. There are three kinds of winds; the constant, the periodical, and the variable.

44. On the sea-coasts between the tropics, the wind blows towards the shore in the day, and towards the sea by night.

45. Machines used for measuring the force of the wind are called wind-gauges.

46. The force of the wind increases as the square of the velocity.

47. Barometers are instruments for measuring the weight or pressure of the atmosphere.

48. The Torricellian vacuum is the empty space in the upper part of the barometer tube.

49. The standard altitude of the mercury fluctuates in this country between 28 and 31 inches.

50. Within or near the tropics there is but little variation in the height of the mercury of the barometer in all weathers.

51. The vernier is an instrument to show the fluctuation of the mercury to the hundredth part of an inch.

52. Air is about 800 times lighter than water.

53. The barometer has been applied to the measuring of altitudes.

54. A common sized person bears from

the pressure of the air a weight equal to nearly 13 tons.

55. The thermometer is intended to mark the changes in the temperature of the atmosphere.

56. The mercury or other fluids used as thermometers expand by heat and contract by cold.

57. All bodies in nature are capable of existing in a solid, fluid, and aeriform state.

58. Wedgewood's Thermometer is intended to measure those degrees of heat which are above boiling mercury.

59. Each degree upon Reaumur's thermometer is equal to $2\frac{1}{4}$ of Fahrenheit's.

60. The pyrometer is a machine for measuring the expansion of solid substances by heat, and is contrived to mark the smallest expansions possible.

61. The hygrometer is an instrument contrived to measure different degrees of moisture in the atmosphere.

62. The rain-gauge measures the quantity of rain fallen on one particular spot.

OPTICS.

Questions and other Exercises on the Science of Optics, *formed from Vol. V. of* "Scientific Dialogues."

Conversation I.——Of what does light consist?

Are the particles of light very small?

From whence does light proceed?

Who discovered the velocity of light, and by what means was the discovery made?

How much faster does light travel than a cannon-ball?

What is Dr. Akenside's conjecture on this subject?

Repeat the lines in which it is contained, and also the lines by Dr. Young.

How is it proved that the particles of light move in all directions?

In what proportion is the intensity of light reckoned?

Explain what you mean by this?

How does light move?

What experiment proves this?

Conversation II.——How is a ray of light described?

By what means do we see objects?

To what is the angle of reflection equal?

What do you mean by incident rays?

What is meant by reflected rays?

Tell me how the nature of incident and reflected rays is illustrated by the looking-glass.—See Fig. 1; but the best illustration will be by means of a looking-glass, actually.

Conversation III.——Why does the glass in the window reflect the rays of light?

Does all glass reflect in some measure the rays of light?

In looking at a looking-glass where is the image of yourself formed?

What is meant by a medium?

What constitutes the excellence of a medium?

How do the rays of light pass through different media?

What is meant by refraction?

Explain this by Fig. 2.

When does refraction take place?

What is the rule when a ray of light passes from a rarer into a denser medium?

What is the rule when it passes from a denser into a rarer medium?

What experiment is exhibited in proof of this? Let it be explained by Fig. 2.

In what direction do we see any thing?

Explain the experiment shown by Fig. 3.

Conversation IV.——Show me, by Fig. 4, how the principle of refraction will make a straight stick in water appear crooked.

How much higher does an object in water appear than it really is?

If a river or other clear water be six feet deep, how deep will it appear to a common observer?

Prove this by experiment.

Can you judge of magnitudes as well in water as in air?

Can you tell how the deception of the appearance of two pieces of money, when there is but one, can be explained?

What has the principle of refraction to do with regard to the sun?

Explain this by means of Fig. 5.

Does the sun ever appear to be in that part of the heavens in which it is not?

To the inhabitants of any part of the earth is the true and apparent place of the sun the same?

Why does the moon appear larger when it is near the horizon than when it is higher up in the heavens?

Conversation V.——What do you mean by a pencil of rays?

What are parallel rays?

What is meant by diverging and converging rays?

Explain this by Fig. 6.

What is a lens?

How many kinds of lenses are there, and what are their names?

Point them out by Fig. 7.

What is the focus?

Point it out by Fig. 6.

Where do parallel rays falling upon a plane convex lens meet?

Where do they meet in a double convex?

What is the reason of it?

Can you tell me the rule for finding the focus, if the two sides of a double convex are of different curves?

Show this by Fig. 8.

What is the principle of the burning glass?

Do you know how to calculate the force of the heat collected in the focus of a burning glass?

What was the size of Mr. Parker's lens?

What effects were produced by it?

Are white substances and water easily affected by the lens?

Conversation VI.——Does the magnitude of the pupil of the eye make any difference with regard to the appearance of the object?—See Fig. 9.

What effect does the magnitude and brightness of an object produce?

As the rays passing through a double convex lens meet in the focus, what will happen if there is nothing to receive them there?—See Fig. 8.

What effect will be produced, if a candle is placed in the focus of a double convex lens?—See Fig. 10.

What will be the effect, if it be put nearer or farther from the lens than the focus?—See Fig. 11.

What is the cause of an inverted image?

Can you explain this by Fig. 12?

What is the rule for finding the distance of the picture from the glass?

Conversation VII.——How is it known that the image of a candle, when received through a convex lens, will be inverted?

What is the appearance of an object seen through a very small aperture, and what is the reason of it?

By looking at a small print through a pin-hole in brown paper, what is the effect produced?

What is the scioptric ball, and what does it represent?

Explain its structure.—See Fig. 13.

How is it compared to the eye?

What is the chief defect in the scioptric ball?

How is that remedied?

What is the virtual or imaginary focus?

Explain this by Fig. 14.

Is there any similarity in the refraction of the convex and concave lens?

Conversation VIII.——Do you recollect the lines of Milton deploring the loss of his sight?

How is the importance of light illustrated?

Of what advantage is the atmosphere?

Would not the sudden transitions from light to darkness, and the reverse, be very inconvenient?

How should we be benefited by the sun if there were no atmosphere?

Is light a simple or a compound substance?

Into how many colours can a ray of light be divided?

Repeat the lines from Thompson on this subject.

What is the oblong spectrum on which the colours are painted called?

Have all philosophers admitted of seven colours in the rays of light?

Can a white be produced by mixing the other colours?

In what manner is that done?

How is the rainbow caused?

Conversation IX.——What description does Hughes give of colours?

How are colours supposed to exist?

By what do we judge of the colour of objects?

How do you account for the whiteness of paper or snow?

From what does the whiteness of the sun's light arise?

How is that proved?

To what are we indebted for all the fine colours exhibited in nature?

Repeat Mallet's lines on this subject.

Are the vegetable and animal kingdoms indebted to the light for their various colours?

What is the theory of blanching lettuces, cabbages, &c.?

What makes the different parts of the same flower, as the heart's-ease, of different colours?

How does Mallet describe the sun?

Do all colours depend on the reflection of the several coloured rays of light?

Do some transparent media reflect one colour and transmit another?

What is Mr. Delaval's theory?

Of what colour are the original fibres of all substances?

Conversation X.——What is the scientific name of a looking-glass?

Of what are mirrors made?

How many kinds of mirrors are there?

What is the general rule with regard to the angle of reflection?

Is this rule applicable to mirrors of all kinds?

Of what length must a looking-glass be for a person to see his complete image?

In looking at your image in the glass, how much behind the glass does it appear to stand?

Can you explain for what Fig. 15 is intended?

What is the appearance if you walk towards a looking-glass?

What is the reason of the double image in the looking-glass?

How do you explain the expression, "An image formed behind a reflector?"

How much light does a plain mirror reflect?

Have not mirrors been applied as burning-glasses?

Conversation XI.——What are concave mirrors used for?

Do you know how to find the focus of parallel rays of a concave mirror?

Are all the rays that proceed from a celestial object to be deemed parallel?

Does the same hold with regard to terrestrial objects?

Explain this by Fig. 17.

Is the image formed by a concave mirror erect or inverted?

Conversation XII.——How and where is the image formed in a concave mirror?

Let this be explained by Fig. 16.

What is the rule for finding the distance at which the image of an object is formed from the mirror?

Can concave mirrors be applied as burning-glasses?

Is the image formed by a concave mirror always before it?

In what cases is the image behind the mirror?

What is the effect of a candle, if placed in the focus of a concave mirror?

Conversation XIII.——Look to Fig. 18,

and tell me how it is that the images of objects seen in convex mirrors are less than the objects themselves.*

Explain what is intended by Figs. 19, 20, and 21.

Conversation XIV.——Explain what is meant by Fig. 22.

What is the appearance, if a person walks towards a convex spherical reflector?

Does the distance of the image increase in proportion to the distance of the object?

What is the difference between convex and concave reflectors?

To what uses have convex reflectors been applied?

What are concave mirrors used for?

Explain Fig. 23.

Explain what is meant by Fig. 24.

How are anamorphoses produced?

Conversation XV.——Of what is the eye composed?—Let the pupil point out all the parts in the Figs. 25 and 26.

* The proper examinations on this Conversation, and in some other parts of the volume, can only be taken from the volume itself.

Which is the sclerotica?

Which is the cornea, and why is it so called?

Which is the choroides?

Which is the part called the iris?

Why is this larger at one time than at others?

Why do we feel uneasiness, if we are suddenly introduced to the light after having been some time in the dark?

Which is the retina, and what is its use?

For what are the humours of the eye intended?

What are the names given to them?

Which is the vitreous humour, and why is it so called?

What is the crystalline humour?

How is the aqueous humour situated?

What is the optic nerve for?

Describe the uses of the eye-brows, the eye-lids, and eye-lashes.

Conversation XVI.——How is the image of any object painted on the retina of the eye?

Show me, by Fig. 27, how the rays of light are refracted in passing through the different humours of the eye.

Do all the humours refract the rays of light, and which has the greatest effect upon them?

How is it that we see the images of objects in the proper erect position, since they are inverted on the retina?

Is there no difficulty in reconciling this theory to objects never seen before?

Why do we not generally see objects double?

By what means do we see objects double?

Conversation XVII.——In what way do spectacles assist the sight?

Of what form are spectacle-glasses?

Explain, by Fig. 28, how a person may have his sight assisted whose eye is too flat.

Why do the people try many pair of spectacles before they suit themselves?

Explain, by Fig. 29, how a person with eyes too round would meet with a remedy in spectacles?

Why do some old people, in examining small objects, hold them at a distance from the eye?

Why do short-sighted people bring objects close to their eyes?

Explain this by Fig. 30.

Why do people who were short-sighted while young see better as they advance in years?

Conversation XVIII. —— When are rainbows seen?

Repeat Mr. Thomson's description of one.

By what is a rainbow occasioned, and on what does it depend?

How many colours are there in the rainbow?

Do you know any artificial word, by which you can call to mind the colours in the rainbow?

Can you explain, by Fig. 31, how a ray of light is divided by the prism?

Why is the image oblong?

Show, by Fig. 32, how this is applicable to the rainbow?

At what particular angles are the colours formed?

Does the situation of the rainbow vary in proportion to the height of the sun?

Is the rainbow ever seen below the spectator?

How do you account for the upper bow?

Show how it happens, by Fig. 33.

By what means is the image of the rainbow preserved perfect and constant?

How are artificial rainbows produced?

Conversation XIX.——How many kinds of telescopes are there?

What is the principle of each?

Of what does the refracting telescope consist?

For what are tubes meant?

Explain the construction of that represented in Fig. 34.

What is the form of the object-glass?

Try and explain the several lines in the Figure.

Why is it necessary to draw out the

tubes of a telescope to adapt the telescope to the eyes of different people?

For what are refracting telescopes used, and what are the necessary requisites in them?

What is meant by the field of view?

Can you, by Fig. 35, show how the field of view is increased?

How is the magnifying power of a telescope calculated?

Do telescopes represent terrestrial objects *nearer* or *larger?*

How is the magnifying power of a telescope increased?

How are refracting telescopes, intended for viewing terrestrial objects, constructed?

Do you know how an opera-glass is constructed?

What is meant by a night-telescope?

Conversation XX.——What are the peculiar advantages of a reflecting telescope?

Can you point out the construction of one by referring to Fig. 36?

How is the magnifying power of the reflecting telescope estimated?

How is that done by experiment?

What is the size of Dr. Herschel's grand telescope, and how many times does it magnify?

In what lines does Dr. Darwin refer to the discoveries of this great astronomer?

Conversation XXI.——For what is the microscope used?

Why do minute objects appear magnified by viewing them through a small hole?

Why is not the object magnified if you look through the hole at some inches distant from the print?

Explain this by Figs. 37 and 38.

Of what does the single microscope consist?

What advantages are derived from this instrument, and why?

What is the rule for finding the magnifying power of a reading-glass?

To what extent has Dr. Hooke carried the powers of these lenses?

Describe the mode of making small lenses.

Describe the microscope represented by Fig. 39.

How many glasses are there in a compound microscope?

Can you explain the construction by Fig. 40?

How is the magnifying power of the compound microscope calculated?

Explain the structure of the solar microscope.—Fig. 42.

Upon what does the magnifying power of this instrument depend?

For what purpose is it calculated?

Give me Mr. Browne's description of the miscroscope.

Conversation XXII.——Can you describe the structure and uses of a camera obscura?

What things are necessary to obtain an interesting picture?

How is the portable camera obscura constructed?

Of what does the magic lanthorn consist?

How are the figures placed for the images to be erect?

In what does the magic lanthorn differ from the phantasmagoria?

In the latter the images appear sometimes to be receding and at others approaching; what is the cause of this?

Illustrate the nature of the multiplying glass by Fig. 41.

Some of the leading Definitions *and* Facts, *explained and illustrated in Vol. V, which it is recommended that the Pupils should commit to Memory.*

Optics.

1. Light is supposed to consist of inconceivably small particles, projected from a luminous body.

2. Light proceeds in straight lines from the luminous body. It travels at the rate of about 200,000 miles in a second of time.

3. The intensity of light decreases as the square of the distance from the luminous body increases.

4. When light strikes obliquely upon a surface, it is so reflected, that the angle of reflection is equal to the angle of incidence.

5. The properties of mirrors depend on reflected light.

6. Whatever suffers the rays of light to pass through it is called a medium.

7. All transparent fluids are called media; and the more transparent the body, the more perfect is the medium.

8. When rays of light are bent out of their course, on entering a denser or rarer medium, they are said to be refracted.

9. When light passes out of a rarer into a denser medium, it is drawn *to* the perpendicular.

10. When light passes from a rarer to a denser medium, it moves in a direction farther *from* the perpendicular.

11. We see every thing in the direction of that line in which the rays approach us last.

12. Refraction takes place in all kinds of glass; but in glass that is thin it is generally overlooked.

13. The image of an object seen in water always appears higher than the object really is.

14. We cannot judge of distances or of magnitudes so well in water as in air.

15. By means of refraction the sun is

seen every clear morning several minutes before he comes to the horizon, and as long after he sinks beneath it in the evening.

16. The sun is never seen in that place in the heavens in which he appears to be.

17. A pencil of rays is any number of rays that proceed from a point.

18. Parallel rays are such as move always at the same distance from each other.

19. A lens is a glass ground into a certain form to collect or disperse the rays of light.

20. The force of the heat collected in the focus is in proportion to the common heat of the sun as the area of the glass is to the area of the focus.

21. As an object approaches a convex lens, its image departs from it.

22. Convex lenses collect the rays of light, or make them converge to a focus.

23. Concave lenses disperse the rays of light.

24. The focus of a double convex lens is at the distance of the radius of

convexity; and so is the imaginary focus of the double concave lens.

25. The focus of the plane convex is at the distance of the diameter of the convexity.

26. The images of objects placed beyond the focus of a convex lens are inverted, and real.

27. Light is composed of seven colours.

28. The rainbow is owing to the separation of the rays of light into its primitive colours, by the drops of falling rain.

29. All colours are supposed to exist only in the light of luminous bodies.

30. We judge of the colour of objects from the reflected rays.

31. The whiteness of paper is occasioned by its reflecting the greatest part of all the rays that fall upon it.

32. Many transparent media reflect one colour and transmit another.

33. In all mirrors the angle of reflection is equal to the angle of incidence.

34. In a concave mirror the image is less than the object, when the object

is more remote from the mirror than the centre of concavity, and the image is between the object and mirror.

35. If the object is in the centre, then the image and object will coincide:—if nearer the glass than the centre, the image will be more remote and bigger than the object.

36. The image formed by a concave mirror is always before it, except when the object is nearer the mirror than the principal focus.

37. The human eye is an optical instrument, consisting of three coats and three humours.

38. The humours of the eye refract the rays of light like glass lenses.

39. The retina receives the images of objects produced by refraction.

40. The optic nerve conveys to the brain the sensations produced on the retina.

41. Spectacles are intended to collect the light and bring it to a proper degree of convergency.

42. Convex glasses are used when the eyes are too flat; and concave glasses are used when the eyes are too round.

43. There are generally two rainbows seen at the same time. The bright one is produced by one reflection and one refraction: the faint one is occasioned by two reflections and two refractions.

44. There are two kinds of telescopes, the refracting and the reflecting: the former depends on lenses for its operation, the latter chiefly upon mirrors.

45. Refracting telescopes are used principally for viewing terrestrial objects; but the reflecting telescope is used for astronomical purposes.

46. Telescopes, in general, represent objects to be nearer, not larger.

47. Acromatic telescopes are such as have the glasses so contrived as to correct the unequal refraction of the rays of light.

48. Microscopes are instruments for viewing very small objects. They apparently magnify objects, because they enable

us to see them nearer without destroying the distinctness of vision.

49. The single microscope consists of only one lens.

50. The camera obscura is contrived to exhibit, in a room, a picture of a landscape or other objects without.

51. The magic lanthorn is a small machine intended for the amusement of young persons, by magnifying paintings on glass and throwing their images on a white screen in a darkened room.

52. The phantasmagoria is a kind of magic lanthorn, which causes the images to be thrown upon a thin screen of silk placed between the lanthorn and spectator.

MAGNETISM.

Questions and other Exercises on MAGNETISM, *formed from Vol. V. of* "SCIENTIFIC DIALOGUES."

Conversation I.——What is the principal property of the magnet?

How were voyages made before the magnet and its properties were known?

When was it discovered?

In what does the directive power consist?

How are the north and south poles of a magnet distinguished?

In what way would a mariner be directed by the magnet if he wished to sail from any port in a direction due west?

Would not the pole star be sufficient for the guidance of ships?

What is a compass?

What do you mean by artificial magnets?

Tell me what are the leading properties of the magnet?

Conversation II.——In what parts of the magnet is the attraction the strongest?

Does the needle attract the magnet, as well as the magnet attract the needle?

What experiment will prove this?

Do poles of the same name attract each other?

Is the magnetic attraction destroyed or diminished by the interposition of other bodies?

Does iron or steel retain the magnetic power the longest?

Explain the nature of magnetic attraction by Fig. 28, Vol. VI.

To what does Fig. 29 refer?

What is the axis of the magnet?

Conversation III.——Why are artificial magnets generally used in preference to the real magnet?

Can you describe the method of making magnets?

By communicating its properties to other bodies, is the power of the magnet diminished?

Do iron bars in any position ever become magnetic?

What is the reason that an artificial magnet is more powerful than a real one?

Can you, by means of Figs. 25, 26, and 27, describe the method made use of in forming magnets?

What advantage is there attaching to the horse-shoe magnet?

In what manner is magnetism communicated to compass needles?

Of what does the mariner's compass consist?

Conversation IV.——What is meant by the variation of the compass?

Is this different at different times and places?

How is a globe, having a compass attached to it, to be set due north and south?

What is meant by the dipping of the needle?

Does this vary in different places?

What experiment shows this property?

Do you recollect in what particulars electricity and magnetism agree?

In what particulars do the magnetic and electric powers differ?

Some of the leading DEFINITIONS *and* FACTS, *explained and illustrated in Vol. V. which it is recommended that the Pupils should commit to Memory.*

MAGNETISM.

1. The magnet is a mineral body of a dark brown colour, and has the property of attracting needles and other small iron or steel substances.

2. The cause of magnetism is unknown.

3. The directive property of the magnet is that by which mariners are able to conduct vessels through the seas.

4. The magnet, or a needle rubbed with a magnet, freely suspended, always points nearly north and south.

5. Every magnet has two poles.

6. Iron and steel can be rendered magnetic; and bars thus prepared are called artificial magnets.

7. When two magnets are brought near each other, their poles of the same name repel each other; but poles of different names attract each other.

8. The attraction is strongest at the poles, and it diminishes in proportion to the distance of any part from the poles.

9. The attraction between the magnet and iron is mutual.

10. Magnetic attraction is not diminished, or any way affected, by the interposition of any kind of bodies, except iron.

11. The earth itself is supposed to be a great magnet, having its poles near to but not coinciding with the ends of the imaginary axis on which it turns.

12. The magnet by communicating its properties to other bodies has not its own power diminished.

13. The magnet rarely points due north and south, and its deviation from that line is called the variation of the compass.

14. The variation of the compass is different in different parts of the world, at

different periods of time, and even at different hours of the day.

15. The dip of the needle was discovered by Robert Norman: in this country it is reckoned about 72°.

16. Pure iron most easily receives and loses magnetism.

17. Steel, or iron combined with carbon, retains the magnetic properties when communicated to it.

ELECTRICITY.

Qnestions and other Exercises on the Science of ELECTRICITY, *formed from Vol. VI. of* "SCIENTIFIC DIALOGUES."

Conversation I.——Mention some instances of electrical attraction.

Is the electrical fluid generally diffused and readily collected?

Who discovered the electric fluid, and on what bodies was it first observed?

When did it first excite attention?

What is meant by an electric?

Who was the first person that saw the electrical light?

What discovery did Sir Isaac Newton make on this subject?

To what is this analogous?

Who wrote a history of this science?

Conversation II.——What fact is supposed by persons who treat on electricity?

Can substances contain more than a certain quantity of the electric fluid?

Does every substance possess a certain quantity of the electric fluid?

In what cases are sparks obtained from any bodies?

For what is a glass tube used in this science?

What is meant by attraction and repulsion in this science?

In what way is the electric fluid collected?

Explain the distinction between electrics and conductors.

What other name is there for electrics?

Explain the experiment shown by Fig. 1.

Examine the Table, page 20.

Conversation III.——For what is the electrical machine used?

Explain the parts as represented in Fig. 2.

How does the cushion act?

What connects the machine with the surrounding bodies?

What is the grand reservoir of the electric fluid?

How is the electric fluid collected from the cylinder?

What proof is there that the electrical fluid is a very powerful agent?

How are electrical sparks taken from the human body?

What prevents it from running to the earth?

What is meant by insulating a body?

Conversation IV.——What is the composition of amalgam, and for what is it used?

Explain the mode in which sparks are conveyed from one to another.

How is a person said to be electrified who has *less* of the fluid than his natural share?

How is he electrified when he has more?

Explain the experiment of the pith-balls, Fig. 3.

For what are two conductors used in some machines?

Conversation V.——Explain the nature of vitreous and resinous electricity, and why they are so called.

How are the two kinds of electricity explained?

Can the course of the electric spark be traced?

Is it the more natural theory that there should be one or two electric fluids?

On the supposition of one fluid only can the facts be accounted for?

Illustrate this with the pith-balls.

How is the experiment of the tuft of feathers explained?

How is the hair on the head affected by electricity?

What particular sensation does an electrified person usually feel?

What is the general rule on this subject?

How do you show, that, when a body has received as much electricity as it can contain, it will be repelled by another electrified body?

How is the experiment of the dancing figures explained?

What will happen, if two insulated pith balls be brought near the electrified conductor of a machine?

In what case will pith balls repel each other.

In what cases will there be an attraction between them?

What will be the result, if one pith ball be electrified with wax and another with glass?

Will the result be the same, if the balls be electrified one with smooth and another with rough glass?

Conversation VI.——Explain the experiment of the bells, Fig. 4.

What do you mean by the electric fish?

For what is an electrometer used?

Look to Fig. 5, and explain the nature of the instrument.

How is it discovered whether the electricity is negative or positive?

When do electrified bodies repel each other?

Under what circumstances do they attract each other?

Conversation VII.——How is it known that the ends of an electrified conductor possess the plus and minus electricity?

Is it known which is positive and which negative?

Suppose more electricity than its natural share is thrown into the inside of a glass tumbler, in what state will the outside be?

Where and how was the Leyden phial discovered?

How does M. Muschenbroeck describe the electrical shock?

How is it described by Mr. Ninkler?

How is the Leyden phial constructed, and how are its effects explained?—See Fig. 6.

How is the equilibrium restored?

For what is the instrument, represented by Fig. 7, used?

How would the shock be conveyed through the body?

What do you mean by a discharging rod?—See Fig. 8.

Why have discharging rods glass handles?

Would an electrified body ever discharge itself?

Conversation VIII.——What is meant in electricity by the word residuum?

Explain the nature and uses of the electrometer, Fig. 10.

Who invented it, and for what purpose is it usually applied?

Explain the construction of an electrical battery, Fig. 9.

How is it charged?

May not the charge of a battery be attended with dangerous effects?

For what is the quadrant electrometer used?

When do you know that the battery is properly charged?

In what case will not a battery act, and how are accidents prevented?

What precautions are necessary in using the battery?

Conversation IX.——Explain the experiment of piercing through a quire of paper?

Why is a hole made through the paper?

Will it tear or break other non-conducting substances?

What is the second experiment mentioned?

How is spirit of wine inflamed?

How can glass be stained with gold leaf?

Can gold leaf be melted into electric fluid?

Explain, by Fig. 11, the structure and uses of the universal discharger.

By what electric means can a piece of paper be torn in pieces?

Can gunpowder be inflamed by the electric fluid?

How is wire fused by electricity?

How is it known that the superabundant electricity of the inside of the electric jar passes to the outside?

Can wood be rent asunder by electricity?

Explain the reason of the twelfth experiment.

Conversation X.——Does the size of the electric spark depend on the conductor?

What reasons are there for supposing that the electric fluid partakes of the nature of fire?

Is the spark different according to the substance from which it is taken?

How is an ivory ball made luminous?

Explain the experiment of the spiral tube, Figs. 13 and 14.

Upon what does its brilliancy depend?

What appearances are exhibited by a wet spunge attached to a conductor?

What effect has the electric fluid on a drop of water?

What is the experiment with sealing-wax?

How is cotton wool set on fire?

What course does the electric fluid always take?

Explain this by Fig. 15.

How is a hole made through a glass phial?

How is the course of the fluid shown with a lighted taper?

Explain the difference between the positive and negative electricity.

Conversation XI.——How is the thumb illuminated by the electrical fluid, and what may be seen during the experiment?

How is water illuminated?

What experiment is Fig. 16 intended to show?

Explain the construction of an electrophorus, Fig. 17.

What is an electrophorus?

Show me the construction of a very sensible electrometer, and how it is used, and explain its use.—Fig. 18.

How is electricity exhibited by evaporation?

Conversation XII.——Who discovered that electricity and lightning were the same?

How was this ascertained?

In what lines does Dr. Darwin allude to this fact?

Can lightning be obtained by a kite?

In what way do conductors save buildings from danger?

How are they formed?

What church has been injured by lightning?

Explain, by Fig. 19, the structure of the thunder-house.

What do the experiments on it teach?

Give me some account of Dr. Watson's description of the injury done to St. Bride's Church.

What does Thomson say of thunder?

Conversation XIII.——What atmospherical phenomena does electricity account for?

What are falling stars?

Describe that mentioned by Beccaria.

How did he ascertain it was an electrical appearance?

Are the masts of ships ever injured by lightning?

What is the *aurora borealis?*

How is it imitated?

In what lines does Thomson refer to this phenomenon?

What is the Jack-o'-Lantern?

What is the cause of water-spouts?

How do sailors disperse them?

How is the resemblance between water-spouts and electricity shown?

Upon what principles are rain, hail, and snow accounted for?

What intention do thunder-clouds answer, and to what may they be compared?

What are earthquakes?

Repeat the lines by Mallet.

Conversation XIV.——Has electricity been applied to any important purposes?

In medicine, can the shock be regulated and passed through any part of the body?

Explain the mode of operation.

What are the directors?

Is it necessary that a person should be insulated to receive a shock?

For what disorders are shocks and sparks chiefly used?

How is electricity applied to the eye?

For what disorders is it chiefly employed?

Conversation XV.——How many species of fish show signs of electricity, and what are their names?

How is the torpedo described?

How is the shock received from this fish?

Are the opposite electricities shown by this fish?

Do the same substances conduct the

electricity of the torpedo, by which artificial electricity is conducted?

Does this fish give out the electrical spark, or exhibit the effects of attraction and repulsion?

Does the power seem to depend on the will of the animal?

Does the gymnotus possess similar properties to those of the torpedo?

How does the gymnotus act upon other fish?

What is peculiar to this fish?

Mention the experiment on this subject.

How was the property of this fish discovered?

Is there much known of the silurus electricus?

Conversation XVI.——Explain the experiment depending on Fig. 30.*

* The questions to the remainder of this Conversation, as well as to the former part of it, cannot be better given than as they stand in the volume.

Some of the leading DEFINITIONS *and* FACTS, *explained and illustrated in Vol. VI, which it is recommended that the Pupils should commit to Memory.*

ELECTRICITY.

1. The electric fluid is supposed to pervade almost all substances, and when undisturbed it remains in a state of equilibrium.

2. That portion which every substance is supposed to contain is called its natural share.

3. Its properties were first observed in amber, by Thales, six hundred years before the birth of Christ.

4. They were noticed in the tourmalin by Theophrastus.

5. Mr. Boyle is supposed to have been the first person who saw the electric light.

6. Sir Isaac Newton first observed the electrical attractions of excited glass.

7. Bodies through which the electric fluid passes freely are called conductors.

8. Those which oppose the passage of electricity are called electrics.

9. When a body possesses *more* or *less* than its natural share of the electric fluid, it is said to be electrified or *charged*. In the former case it is said to be positively electrified, in the latter it is said to be negatively electrified.

10. Electricity is excited in the greatest quantities by the friction of conductors and electrics against each other.

11. A body prevented from touching the earth, or communicating with it by means of glass, or other non-conducting substances, is said to be insulated.

12. Two bodies, both positively or both negatively electrified, repel each other.

13. If, of two bodies electrified, the one be electrified positively and the other negatively, they will attract each other.

14. Upon the principle of attraction and repulsion electrometers are formed.

15. If a body containing only its natural share of electricity be presented sufficiently near to a body electrified either plus or minus, a quantity of the electric fluid will pass from the latter to the former in the shape of a spark.

16. When two electrified bodies, one plus and the other minus, approach each other sufficiently near, the superabundant electricity rushes violently from one to the other to restore the equilibrium.

17. If an animal be so placed as to form part of this circuit, the electricity, in passing, produces a certain effect, called an electric shock.

18. The motion of the electric fluid, in passing from a positive to a negative body, is so rapid, that it appears to be instantaneous.

19. When the outside of a glass jar is presented to a body electrified plus,

that side of the jar will be electrified minus; but the inside of the jar will be electrified plus; and *vice versa*.

20. The electric fluid communicated to glass does not spread, on account of the non-conducting quality of glass.

21. Electrical, or, as they are usually called, Leyden jars are partly covered with tin-foil and partly bare: the tin-foil accelerates the communication of the electric fluid, and the bare part of the jar prevents it from passing from the one side to the other. A jar so covered is said to be coated.

22. If a communication by a conducting substance be made between the inside and outside of a coated and charged jar, a discharge takes place.

23. Several Leyden jars connected together, both with respect to the insides and outsides, are called an electrical battery.

24. Electricity by means of a battery is capable of firing inflammable sub-

stances; of fusing some metals, of oxidating others, and even of killing small animals.

25. Metallic points attract the electric fluid from bodies, and discharge them silently: hence the use of conductors in preserving buildings from the effects of lightning.

26. When electricity enters a point, it appears in the form of a star; when it issues from a point, it puts on the form of a brush.

27. It is demonstrated, that lightning and the electric fluid are the same substance.

28. Lightning may be drawn from the clouds by a common kite.

29. Thunder is the noise produced by the motion of lightning through the atmosphere.

30. When the electric fluid passes through highly rarefied air, it constitutes the aurora borealis: this phenomenon may be imitated by experiment.

31. Earthquakes, whirlwinds, and waterspouts, are probably the effects of electrical agency.

32. The electric fluid has been applied with great success to many medical cases.

33. There are several fish that exhibit strong electrical powers.

GALVANISM.

Questions and other Exercises on the Science of GALVANISM, *formed from the second Part of Vol. VI, of* "SCIENTIFIC DIALOGUES."

Conversation I.——How is the fact explained, that porter is better tasted when drunk from pewter than glass?

Can you give some account of the rise and progress of Galvanism?

Can the experiments on Galvanism be made on animals generally?

What experiment is made with the zinc and silver?

Can it be made with other substances?

How is the principle of Galvanism explained?

What substances are those that conduct the Galvanic fluid?

How is the taste excited by Galvanism accounted for?

In this case what change does the metal undergo?

What do you mean by oxidation?

Illustrate this in the case of mercury and lead.

Conversation II.——How can the Galvanic fluid be made visible?

Can you explain the structure and use of the Galvanic battery?

How is it made to operate?

Explain the use of the glasses represented by Fig. 21.

Can the Galvanic shock be made to pass through several persons, and by what means?

In what way are metallic wires fused by Galvanism?

How is gunpowder inflamed by it?

Can other substances be melted?

Under what circumstances does the Galvanic battery act the best?

Conversation III.——Into what classes are conductors of Galvanism divided?

To make a complete combination, how many conductors must there be?

When is the Galvanic combination said to be of the first order?

What is meant by a simple Galvanic circle?

Illustrate, by an example, what is meant by a combination of the second order.

How has the discolouration of a silver spoon by the act of eating eggs been accounted for by Galvanism?

Which are the most powerful Galvanic circles?

Examine and explain the Tables, pages 205, 206.

Describe the experiment exhibited by Figs. 22 and 23.

How is it accounted for?

What circumstance occurs if wires not oxidable are used?

How are the two gases obtained separately?

What effect has hydrogen gas on the oxides of metals?

What experiment is there in proof of this?

Conversation IV.——What parts of the animal are most affected by the electric fluid?

How are the limbs of animals affected by it?

Are conducting substances necessary for these experiments?

Tell me the method of making an experiment of this kind.

How are living animals, as a frog, or a flounder, excited by Galvanic experiments?

Why are amputated limbs convulsed during the operation?

Why is amalgam soon oxidated?

Will Galvanism account for the preservation of ancient inscriptions upon pure metals, while those on mixed metals are quickly corroded?

How have some persons pretended to find out the seams in brass and copper vessels?

Why is the copper sheathing on ships so soon corroded?

Under what circumstances is zinc quickly oxidated?

What experiment is made with a cup composed of tin and zinc?

What is that made with soap-suds?

What is Galvanism?

How is the Galvanic electricity produced?

What yields this fluid in great quantities?

What powerful effects does it produce?

What parts of animals are chiefly affected by Galvanism?

By what substances is this fluid conducted?

How does it affect the animal frame?
To what is it likened?

Proper Answers to the last Eight or Ten Questions will supersede the Recital of the general Facts on this Science.

THE END.

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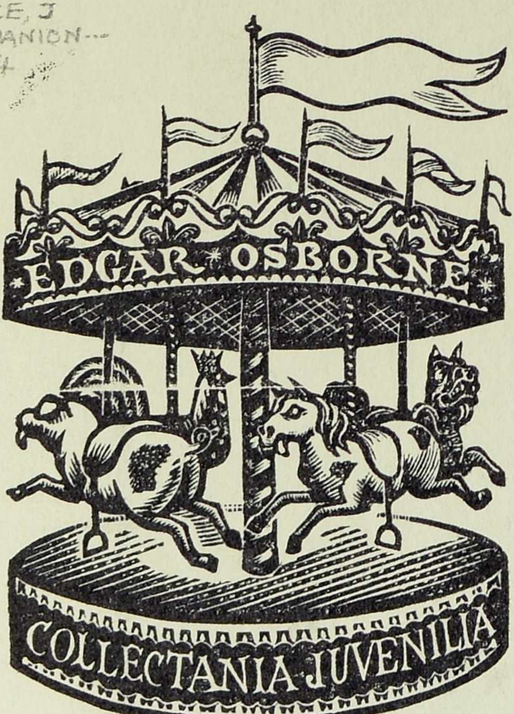
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