CHAPTER II.

PROPERTIES OF MATTER.

9. Every distinct portion of matter possesses certain properties. Some of these belong in common to all bodies, solid, liquid, and aëriform, and are called Universal Properties of matter. Others, again, are found only in certain substances, and these are known as Accessory Properties.

The Universal Properties of matter are Extension, Figure, Impenetrability, Indestructibility, Inertia [*in-er'-sha*], Divisibility, Porosity, Compressibility, Expansibility, Mobility, and Gravitation.

The principal Accessory Properties are Cohesion, Adhesion, Hardness, Tenacity, Elasticity, Brittleness, Malleability, and Ductility.

We proceed to consider these properties in turn.

10. Extension.—Extension is that property by which a body occupies a certain portion of space. The portion of space thus occupied is called its Place.

In other words, every body, however small, must have some size, or a certain length, breadth, and thickness, which are called its Dimensions. The greatest of these three dimensions is its Length; the next greatest, its Breadth, or Width; the least, its Thickness. But, instead of any of these terms, we use the word *height* to denote distance from bottom to top in the case of objects towering above us, and *depth* to denote distance from top to bottom in the case of objects extending below us.

11. Figure.—Figure is that property by which a body has a certain shape.

This property necessarily follows from Extension; for since every body must have length, breadth, and thickness, it must also have some definite

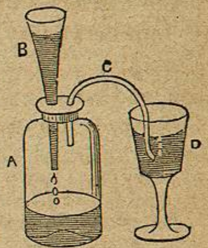
9. What is meant by Universal Properties of matter? What is meant by Accessory Properties? Enumerate the universal properties. Mention the principal accessory properties. 10. What is Extension? What is meant by the dimensions of a body? What is Length? Breadth? Thickness? When are the terms *height* and *depth* used? 11. What is Figure? From what does figure follow? What is the

shape. While this is true of all bodies, it must be remembered that the form of solids is permanent, while that of fluids varies, to adapt itself to every new surface with which it comes in contact. A bullet keeps the same shape, wherever it is placed; whereas a quantity of water, poured from a tumbler into a pail, visibly changes its form.

12. Impenetrability.—Impenetrability is that property by which a body occupies a certain portion of space, to the exclusion for the time of all other bodies.

Impenetrability may be illustrated with a variety of simple experiments. Fill a tumbler to the brim with water, and drop in a bullet; the water will at once overflow. Fill a bottle with water, and try to put the cork in; the cork will not enter till it has displaced some of the water: if it fit so closely that the water can not escape, and a hard pressure be exerted, the bottle will burst.

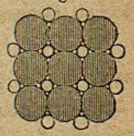
Fig. 1.



The impenetrability of air is shown with the apparatus represented in Figure 1. A is a glass jar fitted with an air-tight cork, through which a funnel, B, enters the jar. C is a bent tube, one end of which also passes through the cork into the jar, while the other is received in a glass of water, D. Let water be poured into the funnel; as it descends, drop by drop, into the jar, air passes out through the bent tube, and escapes through the water in D in the form of bubbles. Thus it is shown that water and air can not occupy the same space at the same time.

13. Impenetrability belongs to all substances, though in some cases it may appear to be wanting. A nail, for instance, is driven into a piece of wood without increasing its size; but it effects an entrance by forcing together the fibres of the wood, not by occupying their space at the same time with them. In like manner, a certain amount of salt and sugar may be successively dropped into a tumbler brim-full of water without causing it to overflow. The particles of water, which are supposed to be globular, do not everywhere touch each other, and the particles of salt are accommodated in the interstices between them. These in turn leave minute spaces, into which the still smaller particles of sugar find their way. Fig. 2 exhibits such an arrangement. To illustrate it familiarly, we may fill a vessel with as many oranges as it will hold, and then pour on a quantity of peas, shaking the vessel slightly so that they may settle in the empty spaces.

Fig. 2.



difference between solids and fluids as regards figure? 12. What is Impenetrability? Give some familiar illustrations of this property. Describe the experiment with the apparatus represented in Fig. 1. 13. What is said of those cases in which impenetrability appears to be wanting? Illustrate this with the nail. Explain how salt and sugar may be dropped into a tumbler full of water without causing it to over-

When the vessel will receive no more peas, repeat the process with fine gravel, and it will be found that a considerable quantity will lodge between the oranges and peas.

14. Indestructibility.—Indestructibility is that property which renders a body incapable of being destroyed.

Matter may be made to assume a new form and new properties, but it can not cease to exist. The quantity of matter now in the world is precisely the same as when it was first called into being, and it will continue undiminished till the end of time. The Deity alone created, and it is only He that can destroy.

15. To this universal law we have some apparent exceptions; but, when closely examined, it will be found that they are exceptions in appearance only. Water, for instance, exposed to the air in a shallow dish, will at length disappear by evaporation; but it is not destroyed. Assuming the form of vapor, it ascends, becomes incorporated with clouds, is condensed into rain, and falls,—to go through the same process again.—The oil in a burning lamp gradually gets lower and lower till at last it is all gone, and we say it is *burned up;* but the process of combustion, or burning, only changes it into invisible gases,—not one particle of its substance is lost. In like manner, when fuel of any kind is consumed, there is only a change of form, not a destruction of the least portion of matter.

Such changes are constantly going on in the operations of nature. One body perishes, and of the materials that composed it another is formed. Our own frames may contain particles that were in the bodies of Adam, Noah, or Socrates; or, if they do not now, may do so to-morrow, for they are constantly parting with portions of their substance, the place of which is as constantly supplied by new matter. It is supposed that the whole body, including even the innermost parts of its hardest bones, is completely renewed every seven years. Yet, amid all the countless transitions of nature, not a single particle of matter is destroyed or lost.

16. It was by a knowledge of the indestructibility of matter that Sir Walter Raleigh is said to have won a wager of Queen Elizabeth. Having weighed out a sufficient quantity of tobacco to fill his pipe, he came into the queen's presence, and as the wreaths of smoke curled up offered to bet her Majesty that he could tell their weight. Elizabeth accepted the bet, and Sir Walter quietly finished his pipe; then, having shaken out the ashes, he weighed them, and, subtracting the amount from that of the tobacco originally put

flow. 14. What is Indestructibility? What can be done to matter, and what not? 15. What is said of the apparent exceptions to this law? What becomes of water exposed to the air? What becomes of the oil in a burning lamp? What is said of the changes of nature? What is said of the changes in the human body? 16. How did Sir Walter Raleigh teach Queen Elizabeth that matter is indestructible? 17. What

in, told the queen the exact weight of the smoke. Elizabeth paid the wager, and thus learned to her cost that *matter is indestructible.*

17. Inertia.—Inertia is that property which renders a body incapable of putting itself in motion when at rest, or coming to rest when in motion.

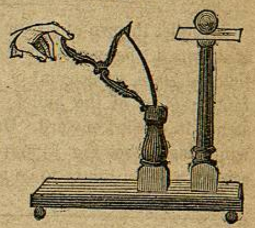
When a stationary body begins to move, or a moving body comes to rest, it is not through any power of its own, but because it is acted on by some external agency, which we call a Force.

That no inanimate body can put itself in motion, is evident from our daily experience. The rocks that we saw on the earth's surface ten years ago are to-day in precisely the same place as they then were, and there they will remain forever unless some force removes them.

It is equally true, though not so obvious, that a body once in motion can not of itself cease to move. The earth revolves on its axis, the heavenly bodies move in their orbits, just as they did at the time of the Creation; they have no power to stop. It is true that on the surface of the earth a moving body gradually comes to rest, when the force which put it in motion ceases to act; but this is owing to the resistance of the air and a force which draws it towards the centre of the earth—not to any agency of its own. Remove all external forces, and its inertia would keep it moving on in a straight line forever.

18. *Familiar Examples.*—It is in consequence of inertia that a horse has to strain hard at first to move a load, which, when it is once in motion, he can draw with ease. A car, through its inertia, continues moving after the locomotive is detached. Through inertia, a person standing erect in a stationary boat or wagon is thrown backward if it suddenly starts: his feet, touching the bottom, are carried forward with it, while his body by its inertia does not partake of the onward motion and falls backward. So, a person standing erect in a boat or wagon that is moving rapidly, is thrown forward if it suddenly stops; his feet cease to move at once, while his body continues in motion in consequence of its inertia, and falls forward.

Fig. 3.



19. An interesting experiment to illustrate inertia may be performed with the apparatus represented in Fig. 3. On the top of a short pillar is placed a card, and on the card a brass ball. Beside the pillar is fixed a steel spring, with an apparatus for drawing it back. If the

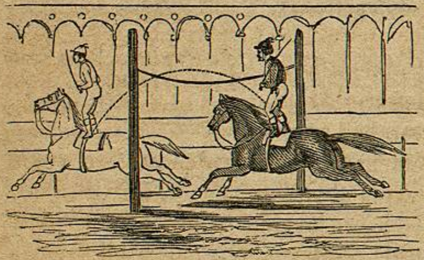
is Inertia? What is a Force? What evidences of the inertia of matter have we in nature? If inertia is one of the properties of matter, why does a moving body come to rest on the earth's surface? 18. Give some familiar examples of inertia and its consequences. 19. Describe the experiment with the inertia apparatus. Describe spring is drawn back and then suddenly released, it will drive the card from the top of the pillar, while the ball in consequence of its inertia will retain its place.

Those who have not the above apparatus may balance a card with a penny placed upon it on the tip of one of the fingers of the left hand, and strike it suddenly with the middle finger of the right hand, as represented in Fig. 4. If properly balanced and evenly struck, the card will fly away, and the penny will be left on the finger.

Fig. 4.

In these cases, there is not sufficient time for the card to overcome the inertia of the ball and the penny, and impart to them its own motion. When, however, motion has once been communicated by one body to another resting on it, the inertia of the latter keeps it in motion. A person riding in a carriage partakes of its motion, and if he jumps from it runs the risk of being thrown down, because his feet cease to move the instant they strike the ground, while the inertia of his body carries it forward. The circus-rider takes advantage of this fact. While his horse is going at full speed, he jumps over a rope extended across the ring (see Fig. 5), and regains his footing on the saddle without difficulty. To do this, he has only to leap straight up as he comes to the rope, for his inertia bears him along in the same direction as his horse.

Fig. 5.



A bullet thrown at a pane of glass breaks it into many pieces, but, fired at it from a rifle, merely makes a circular hole. In the latter case, all the particles of glass, on account of their inertia, can not immediately acquire the rapid motion of the bullet; and consequently only that portion which is struck is carried onward. On the same principle, a thin stick resting on two wine-glasses (see Fig. 6) may be broken by a quick blow with a poker in its centre, without injury to its brittle supports.

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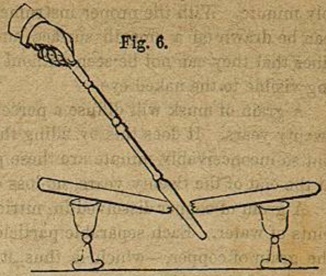
the experiment with the card and penny. What is the effect of inertia, when motion has once been communicated to a body? Why is a person who jumps from a carriage in motion thrown down? Explain the leap of the circus-rider. What is the effect of throwing a bullet against a pane of glass, and what of firing it? What causes the difference? What experiment may be performed to illustrate this point? 20. To

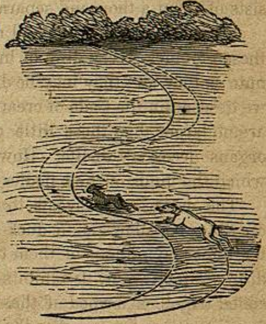
20. The heavier a body is, the greater is its inertia; the more strongly does it resist forces that would set it in motion, change its motion, or stop its motion.

Fig. 6.



Instinct teaches this fact. A child, when nearly overtaken by a man, will suddenly turn, or "dodge" as he calls it, thus gaining ground, inasmuch as the greater weight and inertia of the man compel him to make a longer turn. So a hare, in making for a cover, often escapes a hound by making a number of quick turns. The greater inertia of the hound carries him too far, and thus obliges him to pass over a greater space, as seen in Fig. 7, in which the continuous line shows the hare's path and the dotted line the hound's.

Fig. 7.



21. Divisibility. — Divisibility is that property which renders a body capable of being divided.

Atomic Theory. — Practically, there is no limit to the divisibility of matter. Most philosophers, however, hold what is called the Atomic Theory,—that if we had more acute senses and instruments sufficiently delicate, we would at last, in dividing and subdividing matter, arrive at exceedingly small particles, incapable of further division. Such particles they call Atoms, a term derived from a Greek word meaning *indivisible.*

According to this theory, different kinds of matter are made up of different kinds of atoms; but in the same substance the atoms are always the same in shape and nature. It must be remembered, however, that no particle has yet been arrived at that can not be divided.

22. *Instances of Divisibility.*—Matter has been divided into parts incredi-

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what is a body's inertia proportioned? How do children turn this fact to account? How does the hare apply this principle? 21. What is Divisibility? Is there any limit to the divisibility of matter? Give the chief points of the Atomic Theory.

bly minute. With the proper instrument, ten thousand distinct parallel lines can be drawn on a smooth surface an inch in width. So minute are these lines that they can not be seen without a microscope, not even a scratch being visible to the naked eye.

A grain of musk will diffuse a perceptible odor through an apartment for twenty years. It does this by filling the air with particles of its substance; but so inconceivably minute are these particles, that, if the musk is weighed at the end of the twenty years, no loss of weight can be detected.

A grain of copper dissolved in nitric acid will impart a blue color to three pints of water. Each separable particle of water must contain a portion of the grain of copper,—which is thus, it has been computed, divided into no less than 100,000,000 parts.

23. Nature affords many striking examples of the divisibility of matter. The spider's web is so attenuated that a sufficient quantity of it to go around the earth would weigh only eight ounces; and yet this minute thread consists of about a thousand separate filaments.

Blood is composed of small red globules floating in a colorless liquid. Of these globules, every drop of human blood contains at least a million. Minute as they are, they may be divided into globules much more minute. As we descend in the scale of creation, we come to animals whose whole bodies are no larger than these little globules of human blood, yet possess all the organs necessary to life. How inconceivably small are the vessels through which the fluids of their bodies must circulate!

The microscope reveals to us wonders of animal life that are almost incredible. It shows us in duck-weed animalcules so small that it would take ten thousand millions of them to equal the size of a hemp-seed. In a single drop of ditch-water, it exhibits myriads of moving creatures. The mineral called tripoli is formed of these animalcules fossilized or turned into stone; and it has been shown that the fortieth part of a cubic inch of this mineral contains the bodies of no less than a thousand million animalcules—or more than all the human beings on the globe.

24. Porosity.—What shape the atoms of different bodies are, we have no means of determining. By reason of their shape, however, or from some other cause, they do not everywhere touch each other, but are separated by interstices, to which we give the name of Pores. Pores are often visible to the naked eye, as in sponge and pumice-stone; in other cases, as in gold and granite, they are too minute to be detected even with the microscope.

22. How has the divisibility of matter been illustrated with a smooth surface an inch in width? How does a grain of musk prove divisibility? How, a grain of copper? 23. What is said of the spider's web? Mention some examples of the divisibility of matter afforded by nature. What does the microscope reveal to us? Mention some of these wonders. 24. What are Pores? What is said of the difference in the size

25. Porosity is the property of having pores. It belongs to all bodies.

26. That water is porous, is proved by the fact that a vessel filled with it will receive considerable quantities of salt and sugar without overflowing. What can become of these substances, unless, as shown in Fig. 2, their particles lodge in the interstices between the particles of water? It is on this principle that hot water receives more salt and sugar without overflowing than cold. Heat expands water,—that is, forces its particles further apart,—and thus enables a greater quantity of salt and sugar to lodge between them.

That granite is porous, is shown by placing a piece of it in a vessel of water under the receiver of an air-pump (described on page 178), and removing the air. Little bubbles will soon be seen rising through the water. These bubbles are the air contained in the invisible pores of the granite.

A piece of iron is made smaller by hammering. This proves its porosity. Its particles could not be brought into closer contact, if there were no interstices between them.

27. An experiment performed some years ago at Florence, Italy, to ascertain whether water could be compressed, proved that gold is porous. A violent pressure was brought to bear on a hollow sphere of gold filled with water. The water made its way through the gold and appeared on the outside of the sphere. Water will thus pass through pores not more than one half of the millionth of an inch in diameter.

28. *Density and Rarity.*—The fewer and smaller the pores in a body, the more compact are its particles, and the greater is the weight of a given bulk. Bodies whose particles are close together are called *Dense;* those with large or numerous pores are called *Rare.*

29. Compressibility and Expansibility.—These two properties are the opposites of each other. Compressibility is that property which renders a body capable of being reduced in size. Expansibility is that property which renders a body capable of being increased in size.

Compressibility and Expansibility follow from porosity. Since the particles of bodies do not everywhere touch each other, the application of a sufficient force will bring them closer together, and the size of the bodies will thus be re-

of the pores? 25. What is Porosity? 26. How is water proved to be porous? Why does hot water receive more salt and sugar than cold? How may it be proved that granite is porous? How is the porosity of iron proved? 27. Give an account of the experiment by which the porosity of gold was proved. How small pores will water pass through? 28. What bodies are called *dense?* What bodies are called *rare?* 29. What is Compressibility? What is Expansibility? Show how these properties