this is a subject which needs a chapter to itself, I may pass on to more general remarks on what we have learnt so far.

It will be noticed that, whereas such fungi as *Trametes radiciperda* and *Agaricus melleus* are true parasites which can attack the living roots of trees, the other fungi referred to can only reach the interior of the timber from the exposed surfaces of wounds. It has been pointed out along what lines the special treatment of the former diseases must be followed, and it only remains to say of the latter: take care of the cortex and cambium of the tree, and the timber will take care of itself. It is unquestionably true that the diseases due to wound-parasites can be avoided if no open wounds are allowed to exist. Many a fine oak and beech perishes before its time, or its timber becomes diseased and a high wind blows the tree down, because the spores of one of these fungi alight on the cut or torn surface of a pruned or broken branch. Of course it is not always possible to carry out the surgical operations, so to speak, which are necessary to protect a tree which has lost a limb, and in other cases no doubt those responsible have to discuss whether it costs more to perform the operations on a large scale than to risk the timber. With these matters I have nothing to do here, but the fact remains that by properly closing over open wounds, and allowing the surrounding cambium to cover them up, as it will naturally do, the term of life of many a valuable tree can be prolonged, and its timber not only prevented from becoming diseased and deteriorating, but actually increased in value.

There is no need probably for me to repeat that, although the present essay deals with certain diseases of timber due to fungi, there are other diseases brought about entirely by inorganic agencies. Some of these were touched upon in the last article, and I have already put before the readers of NATURE some remarks as to how trees and their timber may suffer from the roots being in an unsuitable medium.

In the next paper it is proposed to deal with the so-called "dry-rot" in timber which has been felled and cut up—a disease which has produced much distress at various times and in various countries.

H. MARSHALL WARD.

(*To be continued.*)

PERPETUAL MOTION.[1]

IF we study the past in order to trace the development of machines, we cannot help being astonished at the long centuries during which man was content to employ only his own muscular effort and that of animals, instead of utilizing the other forces of Nature to do his work; for it is a striking fact that it is during little more than the last quarter of a century that the power of the steam-engine has in the aggregate become twice as great as that of the whole working population of the world.

Although the early history of the subject is shrouded in obscurity, there is little doubt that the power of water was the first to be employed. We can easily imagine that, in those early days when the laws of Nature were so little understood, the idea would arise that, if some machine could be contrived which would not get tired like man or animal, as machines appeared to do when left to themselves, and, moreover, one which did not depend upon a capricious and variable supply of water, such a machine would go on for ever—in short, would have perpetual motion. As a matter of fact, Geiger, the German philologist, has adduced strong grounds for believing the Buddhist praying-wheels—on which the prayers of the worshippers were fastened, and which were turned by water power—to be probably the first kind of water motor; and at the same time the first record of a proposal for a perpetual motion machine appears to be in the "Siddhânta Ciromani," a Sanskrit text-book on astronomy, in which a wheel for this purpose is suggested, having a number of closed equidistant holes half filled with mercury upon a zigzag line round its rim. No doubt other suggestions of this kind were made from time to time, but writers and literary men did not condescend to notice them, or even the progress of the really practical and useful machines. We are thus brought from that distant date down to the thirteenth century, when we find in the sketch-book of an architect, Wilars de Honecort (the original being now in the École des Chartres, at Paris), a drawing of a proposed perpetual motion machine, with the statement which, translated, runs:—"Many a time have skilful workmen tried to contrive a wheel that shall turn of itself: here is a way to make such by means of an uneven number of mallets or by quicksilver." The engraving shows four mallets upon what is evidently meant to be the descending side of the wheel, and three upon the ascending side, the former therefore overbalancing the latter. To get the mallets into this desirable position the top one on the descending side has evidently been made to fall over before its time; but independently of this there is to the ordinary mind a strong suggestion of speedy dissolution in any structure a greater number of whose parts are going in one direction than in the other, but this little difficulty M. de Honecort does not allude to or discuss. The unevenly weighted wheel in which the action of gravity is to be cheated in some way or the other has appeared in a great variety of forms since, and, from the words "many a time," probably before, and is by far the most important type of proposed contrivance for perpetual motion.

About two centuries after De Honecort, the famous Leonardi da Vinci gives sketches of six designs, either due to his own fertile brain or taken from other sources, and since then there has been an incessant flow of proposals of this type of machine, a large number of which are given in the work of Dr. Henry Dirks, "Perpetuum Mobile," and several in vol. xii. of the *Mechanical World*.

The next class of proposed machines we may consider are those in which gravity was to be made use of in one direction and evaded in the opposite, by the agency of falling water, amongst these being the devices of Schott, Scheiner, Böckler, and others. The idea in all these was that a quantity of water might be kept circulating between two tanks, one above, and one below; being raised to the upper one by means of pumps driven by a water-wheel which derived its motion from the selfsame water in falling the same distance, there being a balance to the good in the form of extra work to be done by the wheel.

A third class of proposals suggests the application of capillary action to raise the water instead of employing pumps, one of the earliest being that of a Professor of of Philosophy in Glasgow about 200 years ago. In this case and others the drawings show (in anticipation) the water thus raised flowing out at the top in a good substantial stream, as, for instance, in the scheme of Branca about the date of the Professor's production.

The fourth and last class, which partook more of a philosophic nature, proposed to employ magnets, the attraction of which is to be effective in one position, and masked in another. There are many proposed ways of effecting this, all equally futile, although one contrived by a shoemaker of Linlithgow actually deceived for a time Sir David Brewster, who communicated an account of it to the *Annales de Chimie*. In the simplest a ball is to fall through a certain distance, so as to come into a position where it can be raised up an inclined plane by magnetic attraction. The first part is carried out in strict

[1] Abstract of a Lecture delivered by Prof. Hele Shaw, University College, on December 21, 1887, in St. George's Hall, Liverpool.

accordance with the programme, but the ball refuses to go through the second part without coercion.

Now most of these schemes had a very definite object in view, which was to obtain motive power, and not at all the innocent philosophic notion of delighting future ages by the sight of a machine which, like the sacred flame Mark Twain tells of, had been going for so many centuries; in short, it was not to benefit posterity but themselves that perpetual motion seekers worked and patented their inventions; and thus the question naturally arises, Did any of their inventions appear to work? Well, they did; and here we may divide these machines into two classes, those which did not succeed, and those which did. The former are in a strong majority, but the latter are important; and I will briefly give an account of one case, perhaps the most celebrated, of the latter. About the year 1712 a great stir was made on the Continent by the appearance of a wonderful machine contrived by a German Pole, by name Jean Ernst Elie-Bessler, who apparently (not perhaps having enough names) had assumed the additional surname Orffyreus. This Orffyreus had, it was said, contrived upwards of 300 perpetual motion machines, and at last had got one that worked. Kings, princes, landgraves, not to say professors and learned men, were all convinced of the absolute certainty of the action of the machine, and Baron Fischer writes to the celebrated Dr. Desaguliers as seriously as Prof. s'Gravesande did to Sir Isaac Newton about it as follows, concerning a visit paid to this machine in the castle of Wissenstein, in Cassel:—"The wheel turns with astonishing rapidity. Having tied a cord to the axle, to turn an Archimedian screw to raise water, the wheel then made twenty turns a minute. This I noted several times by my watch, and I always found the same regularity. An attempt to stop it suddenly would raise a man from the ground. Having stopped it in this manner it remained stationary (and here is the greatest proof of a perpetual motion). I commenced the movements very gently to see if it would of itself regain its former rapidity, which I doubted; but to my great astonishment I observed that the rapidity of the wheel augmented little by little until it made two turns, and then it regained its former speed. This experiment, showing the rapidity of the wheel augmented from the very slow movement that I gave it to an extraordinary rapid one, convinces me more than if I had only seen the wheel moving a whole year, which would not have persuaded me that it was perpetual motion, because it might have diminished little by little until it ceased altogether; but to gain speed instead of losing it, and to increase that speed to a certain degree in spite of the resistance of the air and the friction of the axles, I do not see how any one can doubt the truth of this action." The inventor himself wrote various pamphlets—with dedications 60 pages in length in German—entitled, "Das Triumphirende Perpetuum Mobile Orffyreanum," and in Latin, "Triumphans Perpetuum Mobile Orffyreanum." This machine worked hard, raising and lowering stones or water as required, being locked in a room; the people outside could see the work done by means of a rope which passed through an opening in the wall, and this ought to have satisfied them. Still, there were disbelievers, and amongst others we find a M. Crousaz writing as follows:—"First, Orffyreus is a fool; second, it is impossible that a fool can have discovered what such a number of clever people have searched for without success; third, I do not believe in impossibilities; . . . fifth, the servant who ran away from his house for fear of being strangled, has in her possession, in writing, the terrible oath that Orffyreus made her swear; sixth, he only had to have asked in order to have had this girl imprisoned, until he had time to finish this machine; . . . eighth, it is true that there is a machine at his house, to which they give the name of perpetual motion, but that is a small one and cannot be removed." These are serious charges even if not in logical sequence, and before we conclude the history of this invention we will examine a machine which has been made at University College, which has certainly surprising properties, although very simple. It is now locked, for we may say of it what was said of a machine about twenty years ago by the *Boston Journal*:—"It will not, nay cannot, stop without a brake, as it is so fixed by means of balls and arms that the descending side of the wheel is perpetually farther from the centre of motion than the opposition ascending." That is just our machine, which, started, behaves exactly as Baron Fischer describes, and raises a weight or does other work. This machine is so constructed as to enable complete examination to be made, and all possibility of unfair play apparently detected, and yet it is a fraud,[1] as was that of Mr. Orffyreus, which was afterwards exposed.

The conclusion we arrive at is, that it would have been well for a great number of folks if the saying due to Lucretius nearly 2000 years ago, "Ex nihilo nihil fit,"[2] had been appreciated and believed in by them. Thus the waste of many lives of fruitless work might have been avoided not only in the past but even in the present day, for it is an astonishing fact that during the last twenty years more than 100 English and French patents for perpetual motion machines have been obtained; in one case a gentleman not very far from Liverpool having spent a very large sum on this profitable subject. The lecturer stated that the other day he had a visit *in propria persona* from an inventor of, and of course believer in, such a machine, and after having for an hour and a half discussed the question with this gentleman as calmly as was possible under the circumstances, he had grounds for feeling that his lecture would be utterly incomplete if he left the subject content with raising a laugh at the whole matter: not so very long ago it was easy enough to do this at the expense of railways and ocean steamers. He would therefore briefly and simply, but he hoped conclusively, state the general nature of the problem of perpetual motion. Firstly, all machines such as we have seen projected for creating power are as impossible as the idea of creating matter. Secondly, many machines have been projected for using sources of energy, such as heat, as proposed by Desaguliers, and many others since, in which known sources of power were to be rendered available. Such machines continue to work only while the supply of energy lasts, therefore have not perpetual motion. Thirdly, since, just as energy cannot be created, so it cannot be destroyed, but can only take another form, the question arises, Cannot the causes retarding a body's motion be removed and the body go on moving for ever? In order to answer this reasonable question, he proposed for a few moments to search for perpetual motion. He then proceeded to illustrate, by means of a variety of machines, what efforts had been made to reduce frictional resistance. In one case, an inventor working on the principle that in a wheel of half the size the friction was reduced in the same proportion proposed to employ two in this ratio; no doubt with the same idea as the man who, seeing a stove advertised to save half the usual quantity of coal, bought two with the idea of saving it all. Many people thought that, theoretically, friction was entirely removed by means of rolling contact—illustrated by roller and ball-bearings—but it was only because the theory was imperfect, and the true nature of rolling not understood; and, by means of lantern illustrations, the action of rolling surfaces was experimentally examined. The irresistible conclusion must be arrived at that friction is as universal in its action

[1] Being driven by concealed cords passing down the hollow legs and actuated by a youth beneath the platform.

[2] Propounded, indeed, in a different form by Democritus 400 years before that.

as gravitation, and to avoid it on the earth is impossible; and with this conclusion vanishes all hope of a perpetual motion machine. If we are inclined to regret this fact, a little reflection on what would occur if friction ceased to act may not be uninstructive, for the whole face of Nature would be at once changed, and much of the dry land, and, even more rapidly, most of our buildings, would disappear beneath the sea. Such inhabitants as remained for a short time alive would not only be unable to provide themselves with fire or warmth, but would find their very clothes falling back to the original fibre from which they were made; and if not destroyed in one of the many possible ways—such as by falling meteors, no longer dissipated by friction through the air, or by falling masses of water, no longer retarded by the atmosphere and descending as rain—would be unable to obtain food, from inability to move themselves by any ordinary method of locomotion, or, what would be equally serious, having once started into motion, from being unable to stop except when they came into collision with other unhappy beings or moving bodies. Before long they, with all heavier substances, would disappear for ever beneath the waters which would now cover the face of a lifeless world.

We turn to the motion of planetary bodies—is that perpetual? At first, everything seems to show that it is. The earth with its mass of 3000 trillion tons turns with a speed which enables a student to go bare-headed a good many miles without catching cold in the act of saluting a Professor, for a long time defied all attempts to detect in it loss of speed; but with the friction of the tides continually at work such loss must take place, and now it is pretty certain from the calculations of Adams, the astronomer, that the earth loses about an hour in 16,000 years, and is coming to rest, though it must be admitted rather leisurely. So, also, the hurrying up of the comets as they go round the sun is possibly accounted for by a retarding action in space which makes it necessary for them to try and make up, as it were, for lost time; and in fact the general arguments in the present day are in favour of what Sir Isaac Newton believed—that the motions of all bodies in space are suffering retardation, and that their velocity is becoming less and will ultimately cease.

Perpetual motion, then, is impossible. By no means. We have duly considered motion of matter in its visible and mechanical form, and if the foregoing remarks are true, then in this form assuredly it is; but there is, as we have seen, the great fact of indestructibility of energy, and the greatest generalization of the present century is that which accounts for the disappearance of energy in the form of mechanical and visible motion by showing that an exactly equal amount appears in the form of molecular and invisible motion. To this all outward motion tends, and friction is the agency by which the change is effected. Down to a certain point the change can be effected in either direction, and the heat-engine converts molecular motion into mechanical, again to be reconverted into molecular motion in all its working parts, as well as in connection with the useful work it does. This stage reached, there is no process known to us by which the cycle can be continued, and the term "degradation," in the sense of having gone down a step, but nevertheless a step which can never be reclaimed, is applied to the tendency of energy to assume molecular form by dissipation over a larger mass of matter, so that its effect is less intense, though equal numerically in amount. To this all Nature tends, and beyond this point we cannot go. Here, at any rate, the motion is perpetual, but it is motion that tends to approach a state unsatisfactory to the instinct of the human mind. Great intellects, such as Rankine and Siemens, have striven to conjecture ways at present unknown to us by which the energy now spreading itself over the vast expanse of space may be gathered again and regenerated, so that we may look forward not to the lowest but to the highest form of motion as that which, passing through all its cycles, shall last for ever.

THE CHAIR OF DARWINISM IN PARIS.

ONE of the most interesting evidences of the differing results of municipal organization in foreign countries, as compared with those resulting from such organization in our own, is the news that the Municipal Council of Paris intends to found (in connection with the Sorbonne, or the Jardin des Plantes, or the Collège de France, we do not know which) a Chair of Philosophical Zoology, with a special view to the propagation of the doctrine of evolution as elaborated by Darwin. It appears that the official naturalists in France—those holding the leading professorships and museum appointments—have not hitherto been very friendly to Darwinian doctrine. The Municipal Council of Paris has recognized the fact that there is an undesirable hostility to Darwin's views amongst the official group, and actually proposes to remedy the evil results of this hostility by establishing a new Chair, destined to give fair play and a full hearing to the new philosophy. It is as though the Corporation of London should propose to build and endow a laboratory of physiological experiment or of bacteriology. The imagination recoils before the task of picturing Mr. Alderman Greenfat expounding to his colleagues the importance to the community of scientific research, and carrying with him a large majority in favour of a scientific enterprise hitherto neglected and even penalized by middle-class authority.

There is very little doubt as to who is the fittest man in France at this moment to hold such a Chair as that which is now to be created. M. Giard, for many years Professor of Zoology at Lille, and only this year called to a similar Chair in Paris, has not only been the first in France to teach from an official position the doctrine of evolution in zoology, but has made many most valuable researches himself, and has created a school amongst whom are the ablest of the younger French zoologists. Every embryologist knows the works not only of Alfred Giard, but those of his pupils Barrois, Halley, Monnet, and others. Alfred Giard had to submit to some painful remonstrances, and to imperil his official career as a Professor of Zoology in France, when he determined to break with the traditions of his eminent master, Henri de Lacaze Duthiers, and to boldly accept Darwinism and the methods of the modern English and German school. It is therefore only right that his name should be the first to be considered in relation to the new Chair in Paris, and we have no hesitation in saying that, should he be appointed, a man will have been secured as the first occupant of a difficult position whose qualifications render it certain that he will not only do credit to himself, but will justify, by his successful teaching, the enlightened, patriotic, and high-minded initiative of the Municipality of Paris.

E. R. L.

NOTES.

ON the 3rd of this month there passed away a Scottish parish minister, who though not himself a scientific man has come in contact with three successive generations of men of science whom the love of travel or of geology has led to the picturesque island of Skye. The Rev. Dr. Donald Mackinnon was the third of his family who have been ministers of the parish of Strath. His grandfather was appointed to the incumbency in 1777, and held it for forty-nine years. His father took the office in 1826, and held it for thirty years, until he himself succeeded to it in 1856. The parish has thus been presided over by the same family for the long period of 110 years. Unfortunately none of