for a supply of the beans from Japan, which he proposes to distribute extensively for trial. Much consideration has also been given to the utilisation of the various fibrous plants. In the Lloyd Botanic Garden, Darjeeling, much damage continued to be done by the cockchafer grubs until pretty nearly every plant in the garden was killed. "The whole of the grass in the garden and all herbaceous plants rapidly succumbed to its ravages, as did many of the flowering shrubs, only the deeper rooting shrubs and trees being spared. Even the plants in the conservatories did not altogether escape; eggs of the insect having got in considerable numbers into the soil of the pots." In response to vigorous efforts to exterminate this plague about six millions of the grubs were collected and destroyed by the garden labourers, so that at the time of writing the Report it was showing signs of disappearing. In Mr. Duthie's Report it is satisfactory to find that economic plants, as at Calcutta, are largely cared for, and that the cultivation of medicinal plants and the preparation of drugs from them is being proceeded with. Amongst these may be mentioned Alexandrian senna (*Cassia acutifolia*), henbane (*Hyoscyamus niger*), belladonna (*Atropa belladonna*), &c. Additions are also being constantly made to the museum.

PART VI. of the "Herefordshire Pomona" has been issued, and Part vii. and last will be published in the autumn of next year, after the Congress and Exhibition of the Pomological Society of France, to be held at Rouen in October.

IN the *Japan Mail* of August 23 and September 24, Mr. E. Knipping describes the course of two storms which occurred, one on August 17 to 20, and the other September 11 to 14. These descriptions show how very completely the Japan meteorological service is organised, and that good work is being done in the Far East in collecting data for scientific meteorology.

MESSRS. MACMILLAN AND CO. have published as one of their "NATURE Series" volumes, Drs. Gladstone and Tribe's "Chemistry of the Secondary Batteries of Planté and Faure." "About Photography and Photographers" is the title of an interesting gossipy little volume by Mr. H. Baden Pritchard, published by Messrs. Piper and Carter.

MISS J. M. HAYWARD wishes to state with reference to Mr. Denning's letter (p. 56) that she did give the hour (10.30) at which her letter was written, with the date, at the end. She adds that a clock struck ten shortly before she saw the meteor; but she thinks the clock was probably slow, as it generally is. She has no doubt it was the same meteor as that seen at Bath, Bristol, and Chelmsford about the same time.

THE additions to the Zoological Society's Gardens during the past week include two Bonnet Monkeys (*Macacus sinicus*) from India, presented respectively by Mr. H. G. Rose and Miss Morant; a Common Fox (*Canis vulpes*), British, presented by Mr. H. Vaughan; two Bullfinches (*Pyrrhula europæa*), European, presented by Mr. Archibald Aitchison; four Moorish Toads (*Bufo mauritanicus*) from Tunis, presented by Mr. Frederick Bridges; twelve Ruffe, or Pope (*Acerina cernua*) from British waters, presented by Mr. T. E. Gunn; two Michie's Tufted Deer (*Elaphodus michianus* ♂ ♀), a Chinese Water Deer (*Hydropotes inermis*), two Elliot's Pheasants (*Phasianus ellioti*) from China, deposited; six Coal Titmice (*Parus ater*), British, purchased; a Spotted Ichneumon (*Herpestes nepalensis*) from Nepal, five Blue-crowned Hanging Parrakeets (*Loriculus galgulus*) from Malacca, received in exchange.

OUR ASTRONOMICAL COLUMN

PONS' COMET.—Mr. S. C. Chandler has communicated to the *Astronomische Nachrichten* his own experiences at the Observatory of Harvard College with reference to the remarkable increase in the brightness of this comet on September 22, which has been already mentioned in NATURE (vol. xxviii. p. 624). He observed with an aperture of 6¼ inches. On September 21, between 8h. 55m. and 11h. M.T. he found the comet very faint and diffuse; the central condensation or nucleus about equal to a star of 11 m. On September 22, about 7h. M.T. he was astonished to find exactly in its place a bright, clearly-defined 8 or 8½ mag. star without sensible trace of nebulosity, except with a power of only 50, giving a field of 1¼ degrees, and even with that not noticeable except with attention. It was so distinctly stellar an object that an experienced observer might have failed to distinguish it from stars of similar brightness in the neighbourhood. On September 23, at 7h. 30m., he found the physical appearance again greatly changed. The nucleus seemed spread out into a confused bright disk about a half minute (arc) in diameter, outside of which was a nebulous envelope much brighter than on the preceding night, and about one minute and a half in diameter. The comet was judged to be a half magnitude brighter than on September 22. On September 25 it appeared spread out into a confused disk two minutes in diameter, a faint nucleus or concentration of light not brighter than 11 m. So rapid an increase and diminution of light is a very unusual phenomenon; Mr. Chandler thinks that phases of this kind may be characteristic of the comet's mode of light development, as the same variation was repeated on a smaller scale on October 15, when a nucleus of about 9·3 m. appeared, which gradually dissipated on the following evenings, through expansion into the general nebulosity. The comet's distance from the sun when Mr. Chandler remarked the great increase of brightness was 2·18, the earth's mean distance being taken as unity, not the least surprising condition in the case.

In the same number of the *Astronomische Nachrichten* Prof. Schiaparelli gives some account of his observations on the physical appearance of the comet at Milan, which are of much interest in connection with those of Mr. Chandler. On September 22 he found the comet about 3′ in diameter, faint and diffuse, the nucleus about 13m., but the sky was not perfectly clear; the observations for position were made at 8h. 30m. M.T. On September 23, about 8h. 13m., the comet had increased in brightness since the previous evening in an extraordinary manner; it now appeared as a star of 8 m., with a very faint surrounding nebulosity of from 1′ to 1½′ diameter. The central part was not exactly a luminous point, but had a sensible diameter and indistinct outline. On the 25th it was still bright, but the nucleus of the 23rd had spread out so as to form a circular nebulosity 3′ in diameter, without notable central condensation.

Comparing the Milan and Harvard observations, it would appear that the rapid increase in the light of the comet took place between September 22, at 7h. 45m. and 11h. 45m. Greenwich mean time; it remains to be seen how observations elsewhere will accord with this inference. Mr. Chandler suspected, from a comparison of his own notes with those made by the observers at Kiel and Vienna, that the increase would be found to have taken place between the European and American observations on September 22.

M. Bigourdan, of Paris, says on November 19, "The comet is a nebulosity of from sixth to seventh magnitude, with nucleus: the brightest part of the coma, that which borders on the nucleus, is not symmetrical about it; it is less extended in the angle 110°—140°, and is brightest in the angle 280°—290°." Taking the comet's theoretical intensity of light on November 19 as unity, the intensity on December 31 will be 9·5, and on January 14 (when it is at its maximum), 13·0. In the absence of moonlight the comet must be, for some time, a naked eye object.

THE GENERAL THEORY OF THERMODYNAMICS

THE first of the six lectures on "Heat in its Mechanical Applications" at the Institution of Civil Engineers was delivered on November 15 by Prof. Osborne Reynolds, M.A., F.R.S., the subject being as given in the title. The following is an abstract of the lecture:—

Thermodynamics, Prof. Reynolds said, was a very difficult subject. The reasoning involved was such as could only be expressed in mathematical language; but this alone would not prevent the leading facts and features of the subject being expressed in popular language. The physical theories of astronomy, light, and sound involved even more mathematical complexities than thermodynamics, but these subjects had been rendered popular, and this to the great improvement of the theories.

What rendered the subject of thermodynamics so obscure was that it dealt with a thing or entity (heat) which, although its effects could be recognised and measured, was yet of such a nature that its mode of operation could not be perceived by any of our senses. Had clocks been a work of nature, and had the mechanism been so small that it was absolutely imperceptible, Galileo, instead of having to invent a machine to perform a definite function, would have had, from the observed motion of the hands, to discover the mechanical principles and actions involved. Such an effort would have been strictly parallel to that required for the discovery of the mechanical principles of which the phenomena of heat were the result.

In the imagined case of the clock, the discovery might have been made in two ways. By the scientific method: from the observed motion of the hands the fact that the clock depended on a uniform intermittent motion would have led to the discovery of the principle of the uniformity of the period of vibrating bodies; and on this principle the whole theory of dynamics might have been founded. Such a theory of mechanics would have been as obscure but not more obscure than the theory of thermodynamics based on its two laws. But there was another method; and it was by this that the theory of dynamics was brought to light—to invent an artificial clock, the action of which could be seen. It was from the actual pendulum that the principles of the constancy of the periods of oscillating and revolving bodies were discovered, whence followed the dynamical theories of astronomy, of light, and of sound.

As regarded the action of heat, no visible mechanical contrivance was discovered which would afford an example of the mechanical principles and motions involved, so that the only apparent method was to discover by experiment the laws of the action of heat, and to accept these as axiomatic laws without forming any mental image of their dynamical origin. This was what the present theory of thermodynamics purported to be.

In this form the theory was purely mathematical and not fit for the subject of a lecture. But as no one who had studied the subject doubted for one moment the mechanical origin of these laws, Prof. Reynolds would be following the spirit if not the letter of his subject, if he introduced a conception of the mechanical actions from which these laws sprang. This he should do, although he doubted if he should have so ventured, had it not been that while considering this lecture he hit upon certain mechanical contrivances, which he would call kinetic engines, which afforded visible examples of the mechanical action of heat, in the same sense as the pendulum was a visible example of the same principles as those involved in the phenomena of light and sound. Such machines, thanks to the ready help of Mr. Foster his assistant in constructing the apparatus, he should show, and he could not but hope that these kinetic engines might remove the source of the obscurity of thermodynamics on which he had dwelt.

The general action of heat to cause matter to expand was sufficiently obvious and popularly known; also that the expanding matter could do work was sufficiently obvious. But the part which the heat played in doing this work was very obscure.

It was known that heat played two, or it might be said three, distinct mechanical parts in doing this work.

These parts were:—

1. To supply the energy necessary to the performance of work.
2. To give to the matter the elasticity which enabled it to expand—to convert the inert matter into an acting machine.
3. To convey itself, *i.e.* heat, in and out of the matter.

This third function was generally taken for granted in the theory of thermodynamics, although it had an important place in all applications of this theory.

The idea of making a kinetic engine which should be an example of action such as heat, had no sooner occurred to him than various very simple means presented themselves. Heat was transformed by the expansion of the matter caused by heat.

At first he tried to invent some mechanical arrangement which would expand when promiscuous agitation was imparted to its parts, but contraction seemed easier—this was as good. All that was wanted was a mechanism which would change its shape, doing work when its parts were thrown into a state of agitation.

In order to raise a bucket from a well either the rope was pulled or the windlass wound—such a machine did not act by promiscuous agitation; but if the rope was a heavy one (a chain was better) and it was made fast at the top of the well so that it just suspended the bucket, then if it was shaken from the top waves or wriggles would run down the rope until the whole chain had assumed a continually changing sinuous form. And since the rope could not stretch, it could not reach so far down the well with its sinuosities as when straight, so that the bucket would be somewhat raised and work done by promiscuous agitation. The chain would have changed its mechanical character, and from being a rigid tie in a vertical direction would possess kinetic elasticity, *i.e.* elasticity in virtue of the motion of its parts, causing it to contract its vertical length against the weight of the bucket. Now it was easy to see in this case that to perform this operation the work spent in shaking the rope performed the two parts of imparting energy of motion to the chain and raising the bucket. A certain amount of energy of agitation in the chain would be necessary to cause it to raise a bucket of a certain weight through a certain distance, and the relation which the energy of agitation bore to the work done in raising the bucket followed a law which if expressed would coincide exactly with the second law of thermodynamics. The energy of agitation imparted to the chain was virtually as much spent as the actual work in raising the bucket, that was to say, neither of these energies could be used over again. If it was wanted to do further work the raised bucket was taken off, and then to get the chain down again it must be allowed to cool, *i.e.* the agitation must be allowed to die out; then attaching another bucket, it would be necessary to supply the same energy over again.

He had other methods besides the simple chain which served better to illustrate the lecture, but the principle was the same.

In one there was a complete engine with a working pump. By mere agitation the bucket of the pump rose, lifting 5 lbs. of water one foot high; before it would make another stroke the agitated medium must be cooled, *i.e.* the energy which caused the elasticity must be taken out, then the bucket descended, and, being agitated again, made another stroke.

He felt that there was a childish simplicity about these kinetic engines, which might at first raise the feeling of "Abana and Pharpar" in the minds of some of his hearers. But this would be only till they realised that it was not now attempted to make the best machine to raise the bucket, but a machine that would raise the bucket by shaking. These kinetic engines were no mere illustrations or analogy of the action of heat, but were instances of the action of the same principles. The sensible energy in the shaking rope only differed in scale from the energy of heat in a metal bar. The temperature of the bar, ascertained from absolute zero, measured the mean square of the velocity of its parts multiplied by some constant depending on the mass of these parts. So the mean square of the velocity of the links of the chain multiplied by the weight per foot of the chain really represented the energy of visible agitation in the chain.

The waves of the sea constituted a source of energy in the form of sensible agitation; but this energy could not be used to work continuously one of these kinetic machines, for exactly the same reason as the heat in the bodies at the mean temperature of the earth's surface could not be used to work heat-engines.

A chain attached to a ship's mast in a rough sea would become elastic with agitation, but this elasticity could not be used to raise cargo out of the hold, because it would be a constant quantity as long as the roughness of the sea lasted.

Besides the waves of the sea there was no other source of sensible agitation, so there had been no demand for kinetic engines. Had it been otherwise, they would not have been left for him to discover—or, had they been, he might have been tempted to patent the inventions. But there had been a demand for what might be called sensible kinetic elasticity to perform for sensible motion the part which heat-elasticity performed in the thermometer.

And it had not been left for him to invent kinetic mechanism for this purpose, although it might be that its semblance to the thermometer had not been recognised. The principle was long ago applied by Watt. The common form of governors of a steam-engine acted by kinetic elasticity, which elasticity, depending on the speed at which the governors were driven, caused them to contract as the speed increased. The governor measured by contraction the velocity of the engine, while the thermometer measured by expansion the velocity in the particles of matter which surrounded it; so that it could now be seen that having to perform two operations, the one on a visible scale, the other on a molecular scale, the same class of mechanism had been unconsciously adopted in performing both operations.

The purpose for which these kinetic engines was put forward was not that they might be expected to simplify the theory of thermodynamics, but that they might show what was being done. The theory of thermodynamics could be deduced by the laws of motion from any one of these kinetic engines, just as Rankine deduced it from the hypotheses of molecular vortices.

Nothing had yet been said of the third part which heat played in performing work, namely, conveying heat in and out of matter. It was an innovation to introduce such considerations into the subject of thermodynamics, but it properly had a place in the theory of heat-engines. It was on this part that the speed at which an engine would perform work depended.

The kinetic machines showed this. If one end of a chain was shaken, the wriggle ran along with a definite speed, so that a definite interval must elapse before sufficient agitation was established to raise the bucket; further, an interval must elapse before the agitation could be withdrawn, so that the bucket might be lowered for another stroke. The kinetic machine, with the pump, could only work at a given rate. He could increase this rate by shaking harder, but then he expended more energy in proportion to the work done. This exactly corresponded with what went on in the steam-engine, only owing to the use of separate vessels, the boiler, cylinder, and condensers, the connection was much confused. But it was clear that for every h.p. (2,000,000 ft.-lbs. per hour) 15,000,000 ft. lbs. had to be passed from the furnace into the boiler, as out of the 15,000,000 no more than 2,000,000 could be used for work; the remaining 13,000,000 were available for forcing the heat into the boiler and out of the steam in the condenser, and they were usefully employed for this purpose.

The boilers were made as small as sufficed to produce steam, and this size was determined by the difference of the internal temperatures of the gases in the furnaces, and the water in the boiler; and whatever diminished this difference would necessarily increase the size of the heating surface required, *i.e.* the weight of the engine. The power which this difference of temperature represented could not be used in the steam-engine, so it was usefully employed in diminishing the size of the engine.

Most of this power, which in the steam-engine was at least eight times the power used, was spent in getting the heat from the gases into the metal plates, for gas acted the part of conveyance far less readily than boiling water or condensing steam. If air had to be heated inside the boiler and cooled in the condenser with the same difference of temperature, there would be required thirty or forty times the heating surface—a conclusion which sufficiently explained why attempts to substitute hot air for steam had failed. In one respect the hot-air engines had an advantage over the steam-engine. During the operation in the cylinder the heat was wanted to be kept in the acting substance; this was easy with air, for it was such a bad conductor of heat, that unless it was in a violent state of internal agitation it would lose heat but slowly, although at a temperature of 1000 degrees and the cylinder cold.

Steam, on the other hand, condensed so readily that the temperature of the cylinder must be kept above that of the steam. It was this fact which limited the temperature at which steam could be used. Thus, while hot air failed on account of time economy, the practical limit of the economy of steam was fixed by the temperature which a cylinder would bear. These facts were mentioned because at the present time there appeared to be the dawn of substituting combustion-engines in place of steam-engines.

Combustion-engines, in the shape of guns, were the oldest form of steam-engine. In these, the time required for heating the expansive agent was zero, while they had the advantage of incondensible gas in the cylinder, so that if the cylinder was kept cool it cooled the gas but slightly, although this was some 3000 degrees in temperature.

The disadvantage of these engines was that the hot gas was not sufficiently cooled by expansion, but a considerable amount of the heat carried away might be used again could it be extracted and put into the fresh charge; to do this, however, would introduce the difficulty of heating-surface in an aggravated form. However, supposing the cannon to have been tamed and coal and oxygen from the air to be used instead of gunpowder. Thermodynamics showed that such engines should still have a wide margin of economy over steam-engines, besides the advantage of working with a cold cylinder and at an unlimited speed. The present achievement of the gas-engine, stated to be some 2,000,000 ft.-lbs. per lb. of coke, looked very promising, and it was thus not unimportant to notice that whatever the art difficulties might be, thermodynamics showed no barrier to further economy in this direction, such as that which appeared not far ahead of what was already accomplished with steam-engines.

But however this might be, he protested against the view which seemed somewhat largely held that the steam-engine was only a semi-barbarous machine, which wasted ten times as much heat as is used—very well for those who knew no science, but only waiting until those better educated had time to turn their attention to practical matters, and then to give place to something better. Thermodynamics showed the perfections not the faults of the steam-engine, in which all the heat was used, and could only enhance the admiration in which the work of those must be held who gave, not only the steam-engine, but the embodiment of the science of heat.

PROFESSOR AUGUST WEISMANN ON THE SEXUAL CELLS OF THE HYDROMEDUSÆ[1]

PROF. WEISMANN of Freiburg is most highly skilled and most indefatigable in research, and all the memoirs which he publishes are of extreme scientific importance, and abound in original views and suggestions which render them of peculiar and widely spread interest. His "Studien zur Descendenz Théorie," his researches on the Daphnoids and on the fauna of Lake Constance, which are known to all naturalists, may be mentioned as examples of his work. Since the spring of 1878 till the present year he has been engaged in investigating the mode of origin of the gonad elements of the Hydromedusæ, and the results are embodied in the present splendid work, which consists of a volume of text of about 300 pages quarto and twenty-four most beautifully executed coloured plates, the whole representing a vast amount of laborious research. Some portions of the results have already appeared in short preliminary papers, but they form a very small instalment of what is here put forth. In the course of the investigation, which has extended to thirty-eight species of Hydromedusæ, important new observations on the habits and composition of Hydroid colonies generally and on their histology were made, and the results of these are fully described here, since most of them have a direct bearing on the elucidation of the main subject of the monograph. The work thus forms secondarily, as stated in the title-page, "a contribution to the knowledge of the structure and vital phenomena of the Hydromedusæ generally."

The principal value of the work, however, lies in the importance of the bearings of the results of the investigations detailed in it upon the general question of the origin of gonad cells. The Hydromedusæ were selected as the subject of research because they appeared to be of all groups of the animal kingdom best adapted for the purpose both because of the transparent nature of their tissues and because they present in closely allied forms so many remarkable differences in the development of the gonad elements.

The work commences with an historical introduction, which can be but briefly referred to here. The question of the origin of the sexual elements in the Hydroida has undergone several important transformations. Prof. Huxley, when he first defined the body of the Medusa as consisting of two layers of tissue—ectoderm and endoderm, raised the question in which of the two layers do the gonad elements originate, and at first concluded that they were formed between the two, and subsequently in 1859, from physiological considerations mainly, that they must originate in the ectoderm. As soon as the advance of histological method permitted accurate direct observation to be made on the matter, Keferstein and Ehlers showed that in the Siphonophora with well developed medusoid sexual individuals, the Calycophoridæ and male Physophoridæ, the germinal cells are developed in what is now recognised as the ectoderm of the manubrium;

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[1] "Die Entstehung der Sexualzellen bei den Hydromedusen." Zugleich ein Beitrag zur Kenntniss des Baues und der Lebenserscheinungen dieser Gruppe, von Dr. August Weismann, Professor in Freiburg-i-Br. (Jena: G. Fischer, 1883.)