This would require only to suppose the form of the force changed, in quantity proportionate to the quantity of matter, by passing through it, so as to act against particles in proportion to size, and to some other features, of which velocity and kind are elements, instead of in proportion to weight only, as before.

We cannot blame Lesage for overlooking the inconsistency of the utter disappearance of so much dynamic energy as his theory requires, because in his day the idea of the conservation of energy had not grown up; and it was a great, a sublime, grasp of thought, to conceive of a relation of mechanical action which was parallel in its nature to that utter, that bewildering, mystery of gravitation, which seemed as if it could only be due to the fiat or action of Creative Energy itself, acting forever and everywhere *de novo;* yet, at the same time, always with an absolutely steady and measured force and relation to quantity of matter, to distance in space, and to length of time, which indicated kinship in character to the other proximate and not ultimate forces of nature.*

But we cannot so easily overlook the failure of those who have later considered this theory to notice this great dynamic hiatus, and to follow it up to some conclusion.

These facts, stated, of the comets, of the planets, and of meteorites, indicate very clearly that there is a peculiar propulsive force acting outward from the sun.

And this force is of the general nature required to fill this hiatus.

Can we further determine anything of its nature?

We have already seen that it seems to act upon some kinds of matter in preference to other kinds; and that there seems to be different varieties of this selective difference caused by and in some proportion to velocity.

This last is a curious feature. How can velocity act to increase the action of a force on one kind of matter more than on another? Can any of the facts of ordinary knowledge give us any indications?

If we subject different substances to dry friction, electro-static disturbance is produced; the different kinds of substance will be acted upon differently, and perhaps the difference may be increased by the increase of the friction.

Now the condition shown in the comet is very much like that of an electrified body. But we must not jump to conclusions without examining the attendant conditions which would govern the facts.

We can suppose that the velocity of a body or assemblage of bodies through the ether, required to transmit light, or through a space containing other stray particles of matter, might produce a friction that would set up in it an electrified state; and which would be increased by increase of the velocity.

We can suppose that the light and electrical bodies, and the heavy metals would be electrified to different degrees; or at least that there would be different electric states produced,

And we can suppose that THE FORCES ACTING OUTWARD FROM THE SUN ACT ON PARTICLES IN SOME PROPORTION TO THEIR ELECTRIFIED STATES; and that on striking an assembly of particles it is reflected from their members, something like light is, in a great number of directions, which tends to drive them outward, and, in a less degree, to disperse them apart, as shown by the tail of the comet.

These suppositions show that the requirements which observation seems to call for have parallellisms within our knowledge, and indicate the course of new enquiries.

As a result of these and other considerations we may be led to infer that the growth of the solar system has been affected by such causes. That the heavy metals have, in coming into it, taken positions at last, very much dependant upon their weight and kind, in which respect the Earth, Venus and Mars, in their great interior masses, may represent the region of iron, while Mercury may represent the region of still heavier metals, and the outer planets the great mass of lighter substances; the average or mean distance of a body from the sun being governed inversely as the square of its mean velocity.

Thus a comet and its tail may become the missing link in astronomy and in science.

* We may believe that under the whole face and system of Nature there is an ultimate creative force which acts immediately each instant, to keep alive, to measure, and to guide, all of the actions and reactions taking place; but that is a conclusion and not a "knowledge." If it is true, yet it chances that the character of the action is such that we recognize all actions and reactions as taking place in chains having equality of links and certain peculiarities we call laws; which constitute proximate causes.

CORRESPONDENCE.

[*The Editor does not hold himself responsible for opinions expressed by his correspondents. No notice is taken of anonymous communications.*]

To the Editor of "SCIENCE":—

I have been interested in reading Mr. Rock's account of his observation of the great Comet on the 6th of July. On that evening the comet was hidden at this Observatory by clouds until about ten o'clock, local time, when Mr. Wilson went into the dome to observe its position with the eleven-inch refractor. He soon returned, however, and called my attention to the remarkable appearance of the nucleus. I went to the dome and from that time until three o'clock we alternately examined the Comet, making sketches and measures. The fan had its usual appearance, but when first observed a bright red jet projected from the nucleus into the dark region on the side of the nucleus opposite the fan. This jet was totally different in appearance from those usually seen. It was at first straight and in brightness rivalled the nucleus itself; in fact at the first glance it seemed to form one with the nucleus. On a closer inspection, however, I saw that it had a transparent appearance but still intensely bright and red. The next glance showed that there was a dark line separating it from the nucleus. Mr. Wilson had already called my attention to this dark line before I went to the dome. During the first few minutes a decided change took place. The jet seemed to separate and form a nucleus of its own, so that for a time the comet appeared double; gradually, however, the detached portion grew fainter, until when last seen, at about three in the morning, although plainly visible, it was no brighter than the fan-shaped appendage on the opposite side of the nucleus. I noticed the band of light which Mr. Rock speaks of as connecting the "node" with the nucleus, and mentioned it to Mr. Wilson at the time, but this afterwards disappeared, leaving a separate mass floating like a cloud in the dark region opposite the fan.

There can be no question that a great outburst took place in the comet on that evening, nor that a portion of the nucleus became detached. The phenomenon was watched very carefully for five hours and I think I could hardly be mistaken in what I saw. ORMOND STONE.

CINCINNATI OBSERVATORY, *July* 19, 1881.

To the Editor of "SCIENCE."

In Mr. Rachel's reply, in No. 52, to my letter in No. 47 of "SCIENCE," he appears to entertain a different conception of the law of gravitation from that which I supposed to be usually entertained by astronomers. As there may be many others who share his view, it seems advisable to give a more detailed exposition of what I think was Sir Isaac Newton's own conception, and is that of many more recent astronomers.

Newton's law of gravitation is that "every particle of matter in the universe attracts every other particle with

a force that is directly proportioned to the mass of the attracting particle and inversely to the square of the distance between them." The first question arising is, what are we to understand by "particle" in this theory? Certainly not a mass of utterly indefinite size. Undoubtedly Sir Isaac meant a mass of unit size, since the very terms of the proposition require this. For if every particle attracts every other particle with a certain vigor, then it must necessarily attract two particles with twice the vigor with which it attracts one. Or if a particle of unit mass attracts another with unit vigor, then it must attract two others, or one other whose mass is double the unit vigor. And as each of these two others attracts it with the unit vigor, then their sum, or their double mass, must attract it with double the unit vigor. It is simply the principle, still older than Newton in its expression, that "action and reaction are always equal and opposite."

But if it be granted that such will be the reaction between a unit and a double unit mass, the whole question is settled. For if the second mass may be doubled it may be quadrupled, or may be increased a million fold, without any difference in the principle. And likewise the first mass may be increased without affecting the principle. A mass of one unit attracts a mass of ten units with an energy equal to ten units, since it attracts each of the ten with unit energy. And each unit of the ten reacts on the one with unit energy, so that their combined attraction equals ten units. Again, if the first mass contain two units, each of these separately acts upon each of the ten with unit energy. Thus as each unit of the two exerts ten units of energy, the two together exert twenty units. In other words, the energy which the first mass exerts upon the second is proportioned to the product of the number of mass units in the first into the number of mass units in the second; and the action of the second upon the first also is in proportion to the product of their units.

This is the true principle of the attraction of gravitation. We may take the unit mass of any size we wish. In the action between the earth and the moon, for instance, we may take the mass of the moon as the unit, that of the earth being about 75 units. The moon will attract each unit of the earth with unit energy, and the whole earth with an energy of 75 force units. But each unit of the earth will react upon the moon with unit energy, and the whole earth will exert on the moon an energy of 75 force units. Thus the moon attracts the earth with precisely the same vigor as the earth attracts the moon. Of course the resulting motions are not the same, but the resulting momentums are precisely equal. As the earth is 75 times the weight of the moon a motion of one foot per second in the earth would give it a momentum equal to that given the moon by a motion of 75 feet per second. It is well known that the moon does not revolve around the centre of gravity of the earth, but that these two bodies revolve around their common centre of gravity. But this common centre is within the mass of the earth, and may be found by dividing the distance between the centres of the earth and moon by the ratio of their weights. If we take this distance as 240,000 miles, and divide by 75—the weight of the earth as compared with the moon—the common centre of gravity will appear to be 3200 miles from the earth's centre.

Or we might consider this case from the principle of inertia. The earth having 75 times the mass of the moon has 75 times the inertia, or resistance to exterior forces. Thus its movement in response to lunar attraction is only 1-75th that of the moon in response to terrestrial attraction. But its weight being 75 times greater, its momentum in response to lunar attraction must be precisely equal to the moon's momentum in response to the earth's attraction; or, in other words, their vigor of action upon each other must be precisely equal. This movement of the earth under the action of the moon does not affect the line of its orbital movement, since it is less than the length of the earth's radius. Its movement is like that of a bead with a large aperture, which advances along a string moving from side to side, but not leaving the string. But as the earth moves about 46 millions of miles in its orbit while completing one of these gyrations, the effect is excessively minute. That of the moon, in fact, which swings 240,000 miles to each side of the orbit each fortnight, is very slight when compared with the length of the orbit.

But if, the earth being 75 times the mass of the moon, it also attracted the moon 75 times more vigorously than the moon attracts the earth, this common centre of gravity would be found by dividing 240,000 by 75^2 and would be but 36 miles from the earth's centre. As to which of these results is the more correct the books will show.

I am, therefore, obliged to repeat the idea advanced in my former article. An atom falling towards the earth attracts it with as much energy as the earth attracts the atom, and they move toward each other with equal momentums. But the great weight of the earth reduces its rate of motion towards the atom to a speed inconceivably small, while the small weight of the atom gives it an excessively rapid speed towards the earth. It would be strange if, at this late date in the history of the theory of gravitation, I had been the first to advance this idea as Mr. Rachel seems to suppose. Perhaps my mode of presenting it may be original, but I can readily quote other expressions of the same idea. Thus Dr. Ball, Royal Astronomer of Ireland, speaks as follows, in his article on Gravitation in the new edition of the Encyclopedia Britannica: "It has been found that the intensity of the attraction of gravitation between two masses is directly proportional to the product of those masses." This is precisely the result I have reached in the above argument. Again he says: "Let m, and m' be the masses of two bodies, and let r be their distance. The force with which m attracts m' is equal in magnitude though opposite in direction to the force with which m' attracts m. The reader may perhaps feel some difficulty at first in admitting the truth of this statement. We speak so often of the effects which the attraction of the sun produces on the planets that it may seem strange to hear that each planet reacts upon the sun with a force precisely equal and opposite to the force with which the sun acts upon the planets." He illustrates as follows: "Suppose the earth and the sun to be at rest in space, and prevented from approaching each other under the influence of gravity by a rigid rod extending from one to the other. If now the sun pressed toward the earth more vigorously than the earth toward the sun the greater pressure of the sun must overcome the lesser pressure of the earth, and the whole arrangement would be driven through space in the direction in which the rod points outward from the sun. For there would be a motion producing vigor in the sun unopposed by a sufficient resistance in the earth. And yet, in the event of such a movement, we would have the kinetic energy of their motion created out of nothing, which is now well known to be impossible." Such is Dr. Ball's argument briefly stated. It leads to the same result as mine, and I therefore claim to be in full accord with the Newtonian law of gravitation.

In regard to the other points of Mr. Rachel's letter there is nothing on which I desire to dwell. As to the use of the phrase "Latent Heat," the scientific world will be very ready to give it up if a term can be suggested more significant of the character of the energy indicated. But there would be nothing gained by simply substituting one unmeaning name for another. Mr. Rachel himself uses the phrase "Radiant Heat," yet he must be aware that the mode of motion so called is very different from ordinary Heat Motion. Radiant Heat is readily convertible into Static Heat; but so is

Electricity; and we have the same warrant to consider Electricity as some modification of Heat. In fact the term "Radiance" would be a more distinctive appellation than "Radiant Heat."

As to trust in authorities, of course we must trust in them as long as their explanations seem most in accordance with facts, but no longer. Well-established facts are the only trustworthy data of Science. No theory can be sustained against the pressure of unconformable facts. In short, every theory is in danger while a single fact remains unexplained. For the facts of nature are so closely linked that each in some way bears upon all, and all upon each. And yet it is by no means advisable to stop theorizing, for correct theories are themselves facts of science—facts concerning forces and relations as deduced from facts concerning things. And every partially correct theory is a footstool through which higher levels of conception may be reached; while every theory proved incorrect is a warning board, advising all future scientists not to waste time in following a path that leads nowhere.

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BOOKS RECEIVED.

TEXT-BOOK OF EXPERIMENTAL ORGANIC CHEMISTRY for Students, by H. CHAPMAN JONES. D. Van Nostrand. New York, 1881.

Although termed a text-book, the author admits that this little volume will be found of greater use as a companion for the student in the laboratory, who wishes to study organic chemistry both practically and theoretically.

We recommend this volume to those who have a limited time at their command for study, and are not overburdened with cash, the author having wisely restricted the number of experiments, and suggested only such as are available in a laboratory of the humblest pretensions, and the use of expensive chemicals is altogether avoided. The author has shown considerable judgment in arranging this work, the plan of which is excellent, because while the subject has been reduced to its simplest form, the instructor will find all that is necessary for teaching the elementary stages of practical organic chemistry, and it will serve as a reliable guide to the average student who relies on his own resources for instruction.

CONTRIBUTIONS TO METEOROLOGY: being results derived from an Examination of the Observations of the United States Signal Service, and from other sources. By ELIAS LOOMIS, Professor of Natural Philosophy in Yale College.

A pamphlet reprinted from the *American Journal of Science*, being the subject matter of a paper read before the National Academy of Sciences. Washington, April 19, 1881.

ON THE GROUP "*b*" ON THE SOLAR SPECTRUM. By WILLIAM C. WINLOCK. From the proceedings of the American Academy of Arts and Sciences. Presented by Professor Wolcott Gibbs. June 9, 1880.

The most complete charts of the solar spectrum now available are Kirchhoff's, which were published in 1861, and Angström's, published in 1869. Kirchhoff employed a battery of four flint-glass prisms, with a collimator and observing telescope each of about 4 centim. aperture and 49. centim focal length; while Angström used telescopes of about 4.6 centim. aperture, and 36.3 centim. focal length, and a diffraction grating made by Nobert, containing about 133 lines to the millimetre.

Such great advances have been made very recently in the construction of optical instruments, and more especially in the ruling of diffraction gratings, that it would now be possible to enlarge Angström's great chart almost as much as he improved upon Fraunhofer's first maps. But it would be an almost endless undertaking for a single observer to attempt a map of the whole spectrum, from the ultra-violet to the invisible red, brought to light by our most powerful instruments, and accordingly most physicists who have paid especial attention to solar spectroscopy have devoted themselves to a careful study of detached portions which appear of unusual interest. As a contribution to this work, the following observations upon the group of dark lines "*b*," of the solar spectrum, were undertaken by Mr. Winlock, at the suggestion of Dr. Gibbs, and carried on under his immediate supervision.

A PRACTICAL TREATISE ON THE MANUFACTURE OF STARCH, STARCH-SUGAR AND DEXTRINE, based on the German of Ladislaus Von Wagner and other authorities, by JULIUS FRANKEL. Edited by Robert Hutter. Illustrated by 58 engravings, covering every branch of the subject. Henry Carey Baird & Co., 810 Walnut street, Philadelphia, 1881. Price, $3.50.

The increased manufacture of Glucose and the prospect of this substance becoming a staple article of produce in the United States, makes this volume a welcome addition to the excellent series of technical works published by this house.

Those about to engage in the manufacture of Glucose will find this treatise an indispensable guide, and, as we understand, it is the only work in the English language describing in detail the processes and machinery made use of in this important class of industry.

It is stated in the preface that this subject has been heretofore surrounded by more or less mystery than any other manufacture of recent years, and that access to factories has been barred to all but workmen, and that inventors and manufacturers of the necessary machinery have refused to furnish drawings of the machines. It is therefore evident that the present work, which has been prepared with care, intelligence and zeal by one who is a master of the subject, must be a valuable acquisition to those interested in this industry.

Mr. Frankel introduces the subject by describing the Chemistry of Starch, its technology and methods of manufacture. The Chemistry of Starch-sugar is then taken up and its manufacture in all its branches explained in detail. The author concludes with an exhaustive description of Dextrine and its manufacture.

It was Professor Kirchhoff, of St. Petersburg, Russia, who made the important discovery in 1811, that starch boiled in diluted sulphuric acid is transformed into sugar, but the origin of glucose manufacture dates from the time of Napoleon I., when the English were blockading the Continent. At the time it caused a great and general sensation, as it was then thought that grape sugar was identical with cane sugar, and hence could in every respect be substituted for that product. This new branch of industry was, therefore, pursued with energy, and immense quantities of starch-sugar were manufactured, but subsequently, when it was proved that this material was by no means identical with cane sugar, being less soluble, of less sweetness, and not at all suitable to serve as a substitute for the former, then for a number of years the demand ceased. Of late years a revival has taken place in this industry, and in 1876 Germany alone produced in her 47 glucose, starch-sugar and syrup factories 100 million pounds, and as we stated in a recent article 500 tons a day of glucose are now produced in the United States.

It is singular to observe that such substances as Starch, Grape-sugar and Cane-sugar, which have such opposite properties in some respects, are almost chemically alike. If starch absorbs two molecules of water, it becomes transformed into glucose (grape or starch sugar), while cane sugar contains one molecule more than starch and one molecule less than the starch sugar. The chemical