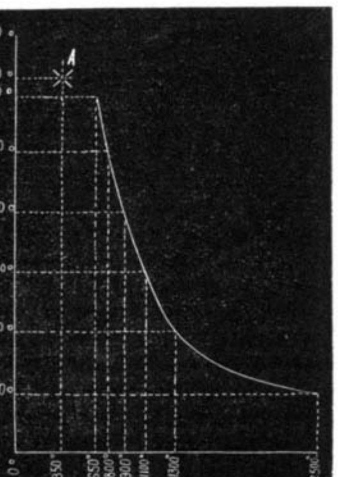
dence that they are justified in imposing very severe restrictions upon the use of steam pipes.

Mr. Robert Harper, some time ago, contributed, to the collection of the Engineering Department of the Stevens Institute of Technology, a piece of wood, which, as he states, "stood during sixteen years and one month on top of and in contact with a one inch steam pipe, containing steam at fifty pounds in cold weather, used for warming the First United Presbyterian Church of Hoboken, N. J." The wood seems to be spruce. It is well seasoned, but no sign of injury or of charring is perceptible, and there is nothing to indicate that it might not have remained on the steam pipe an indefinite length of time without injury.

The accompanying diagram is interesting, and gives valu-



able evidence in this connection. We gave, at the time when this subject first came up, a table showing the temperatures of preparation and the corresponding temperatures of ignition of charcoal for a wide range on the scale.

Mr. Stahl, a student of the graduating class of the Stevens Institute of Technology, has prepared for us, at the request of Professor Thurston, this diagram, in which the vertical scale is one of temperatures of preparation and the horizontal scale is one of temperatures of ignition, and the curve shown contains the points of correspondence as given in our table.

It will be seen that the curve is apparently nearly hyperbolic. The lowest temperature of preparation was 500° Fah., but it is seen at a glance, even that at 350°, the temperature of steam under a pressure of over 125 lbs. per square inch, the temperature of preparation and of ignition cannot coincide unless some marked change of law should occur at so low a temperature, carrying the curve, which here represents that law, abruptly inward to reach the point A. We need hardly state that such a phenomenon would be quite improbable, and is probably impossible. Our readers will find this little diagram very interesting and instructive.

SCIENTIFIC FACTS AND SPECULATIONS.

Addressing a Glasgow society the other day—his subject being the relations of Science to religion—the Earl of Shaftesbury was pleased to be very patronizing to Science. No possible harm could come to his hearers' faith, he assured them, through the advancement of true Science. The speculations of scientific men might be misleading and mischievous, but facts never; and the function of true Science was simply the observation and registering of facts. Therefore, if he had the wealth of Glasgow, he would send fifty thousand pounds to Max Müller to help on his explorations at the fountain head of Aryan civilization. The learned professor's opinions on many things were far from sound; nevertheless, he was doing good work and ought to be encouraged. For like reasons, this champion of English orthodoxy would send another quarter of a million dollars to Professor Tyndall, and say to him: "Accumulate your facts; I don't care about your theories, but turn your powerful intellect to the pursuit of facts."

The evil that men do lives after them; and probably the worst legacy left by Francis Bacon—that pretender in Science, time-serving politician, insidious lawyer, corrupt judge, treacherous friend, and bad man, as Dr. Draper justly styles him—is this very theory of Science which Earl Shaftesbury echoes. According to this school of superficial thinking, the man who turns his powerful intellect to the recording of the temperature of the air, the direction of the wind, and the state of the sky three times a day is a meteorologist worthy of the name; but the man who leaves the recording of facts to other men, or to automatic machinery, and busies himself with suggesting and testing hypothetical interpretations of the recorded facts is a mere theorist, not to be acknowledged by "true Science." Similarly, the greatest astronomer is he who makes the greatest number of observations and discovers the most asteroids or comets; the greatest geologist, he who finds the most fossils. To seek the law within the law, by investigation guided by hypothesis, is to destroy one's right to the title of a true son of Science!

It is the fallacy of the French Academy, which rejected Darwin as an unscientific theorist because he turned from the blind accumulation of facts to the development of an hypothesis whereby to account for the facts. The very important truth that Darwin's hypothesis had given life to millions of otherwise fruitless facts, and still more had given purpose and direction to the observations of hundreds of naturalists, thus accomplishing more for the substantial enrichment of natural history than all their Academy had ever done, was ntirely overlooked.

We are far from deprecating the accumulation of facts. No great truth was ever discovered without them, and the masters of Science have ever been zealous in their pursuit. But their service to Science did not end in barren observations, nor were they made at haphazard. In every case where great discoveries were the result, point and purpose were given to their investigations by hypothesis. Indeed, there can be no true inductive investigation without a marriage of hypothesis and experiment; and it is by such investigations only that Science has come to be what it is. The secret of the successful career of Faraday lies not less in his fertility in inventing hypotheses than in his patient observation and conscientious determination to prove all things. Without his genius for guessing, he would never have been able to add so much to our knowledge of electricity and magnetism. The first observer of the transit of Venus tells how he tried theory after theory, in order to discover one in accordance with the motions of Mars. So, too, Kepler submitted guess after guess, hypothesis after hypothesis, to computations of infinite labor, in determining the laws of planetary distance and motion. The writings of every great man in Science afford confirmation of the necessity of hypothesis in the pursuit of facts, as well as in the pursuit of scientific truths. But probably there cannot be found in the whole history of Science a more striking example of the worth of investigation guided by hypothesis, and the worthlessness of investigation without such guidance, than is afforded by the labors of Sir Isaac Newton. In his case we may see a great man studying chemistry, unaided by any theory: studying the phenomena of light under the influence of an utterly erroneous hypothesis: and again, incited by a bare suspicion that the attraction of the earth might extend as far as the moon, spending his ripest years mathematically testing hypotheses of the most stupendous reach, having for their object nothing less than the laws of the physical government of the solar system, if not of the Universe.

It is easy to imagine how a patronizing Earl of Shaftesbury, a brother alchemist, a Baconian philosopher, might have reproached him for wasting his precious time in theoretical investigations, advising him to stick to his laboratory and bend his powerful intellect to the accumulation of facts. But what says history of the days and nights which he spent in his laborious chemical experiments?

"While his hypothetical and deductive investigations have given us the true system of Nature, and opened the way in almost every one of the great branches of natural philosophy, the whole results of his tentative experiments are comprehended in a few happy guesses given in his celebrated 'Queries.'"

Aided by the insight into the principles of Nature which chemical theory affords, the student of to-day is able to discover more useful facts in a year than Newton could in a lifetime. So it is in every department of Science; and though weak men are apt to mistake hypothesis for final truth, resting on it instead of using it as a means of further progress, the hypotheses formed by powerful intellects are the stepping stones of true Science, without which there could be no advancement. If it were possible and necessary to confine our great men to one department of their work, we should therefore say, not "accumulate facts," but "give us theories. There are men enough, of smaller caliber, to observe and register: men enough to test your hypotheses and to follow their lead; do you give us theories. The guesses of genius are more valuable than the demonstrations of mediocrity."

Fortunately, however, there is no great need of such division of labor. Genius for sound hypothesis is very apt to be seconded by superior skill in devising means for subjecting hypotheses to the test of experiment.

SEEING THROUGH COLORED GLASSES.

A child, or an adult not accustomed to critical observation, looks through a bit of colored glass, and straightway declares that it makes everything green, or blue, or red, as the color of the glass may be. The first impression is that the glass somehow throws a flood of colored light upon the scene; and such, for many ages, was the universal belief.

The ancients explained the phenomena of sight by supposing that the eyes shot forth rays which passed through space to the objects seen: that they saw by means of these rays, much as one might explore by touch the bed of a pond by using material rods. From this standpoint there could be no apter explanation of the action of colored media than to say that they changed the character of the rays proceeding from the eye, and so changed the aspect of the objects looked upon through such media. Nearly eight hundred years ago this view was shown to be erroneous by the Mohammedan philosopher Alhazen, who taught the true theory, since adopted by the christian world, namely, that the light proceeds from the object to the eye. The old theory is practically forgotten; yet its influence is still seen in common speech. To most people a colored glass colors a landscape by adding color to it, though it is well enough known that it really takes more or less away from the color of the several objects, or at least the most of them. Even educated people will say that a green glass, for example, gives its color to objects seen through it. More than that, they will say, as Professor Clifford does in his able essay on the Philosophy of the Pure Sciences, printed in a late number of the *Contemporary Review*, that a colored medium will give its color to *everything*. Thus: "If a man had on green spectacles, he would see everything green. And if he found out the property of his spectacles, he might say with absolute certainty that everything he saw, without exception, would be green."

Surely Professor Clifford can never have looked through a pair of green spectacles! It is equally sure that he could have given no thought to the actual phenomena of color in writing the illustration we have quoted, else he would have stayed his hand. Even if it were possible to make a glass which would be transparent to all green rays and opaque to all others, the asserted result would not happen. All things would not look green through it, but only those which emitted or reflected green light. All objects colored red, orange, yellow, blue, violet, or showing any combination of these hues, would furnish no rays capable of passing through the supposed glass, and would consequently look black, not green.

But the transparency of colored glasses is marked by no such exact chromatic limits, so that the effect of them is still less likely to be as Professor Clifford assumes, as any one may readily see by looking through a pair of green spectacles. If the observer has paid but little attention to the matter before, he will be surprised to see how slightly the natural aspect of things is affected by the glasses. Still more will he be surprised to see how many objects show neither their natural tint nor the tint of the glasses, but a color bearing no apparent relation to either. We happen to have on our table samples of red, green, and blue glass. Probably the colors are as perfect as glass can be made to receive, yet neither specimen shows a pure color. For instance, all allow a little yellow light to pass through them; the green transmits blue rays quite freely, and the blue glass fails to arrest some of the red rays. Seen through the red and green together, the golden clouds above the setting sun show a pale canary-yellow tint, and so does a bright white cloud in another part of the sky. Through the blue glass, the golden clouds have a fainter hue, approaching orange, yet are distinctly visible. The clouds change to orange, then to red. No change can be observed through the green glass, save a gradual fading, the clouds becoming invisible when they have attained their brightest tint of red, the green glass being opaque to all rays below the yellow. Through the blue glass, however, the reddening sky grows purple, the final hue being exceedingly rich and beautiful. Through the red glass, the sky appears lurid, like the reflection of a great fire. The blue glass seems perfectly opaque only to green and yellow; the green is opaque to red rays alone, the red glass to green only.

These observations give a clue to the changing hues of colored objects when looked at through the several glasses in bright daylight, a few instances of which may be cited to show how widely Professor Clifford's assertion varies from fact. The salmon-colored cover of the *Contemporary* looks yellowish brown through green glass, and a dead brown through blue. Through the red it shows the palest possible orange tint. A yellow envelope shows a brighter yellow through the green glass, bright orange through red glass, and salmon color through blue. Some cherry colored silk appears a lustrous brown through green glass, pale pink through red, and an almost invisible purple through the blue. A piece of light blue silk appears a light drab through green glass, a pale brown through red, and bluish gray through the blue glass. A red spot in the carpet seems brown through green, pale red through red glass, and wine color through blue. A deep green band on a water pitcher shows lead color through the green, slate color through red, and brown through blue. Curiously, any color in the glass, instead of enhancing, as one would naturally suppose, the corresponding color in objects, invariably makes it less bright and clear. It is only as objects emit or reflect white light that their color approaches that of the medium through which they are seen.

Single Rail Steam Towage on the Belgian Canals.

We learn from the *Moniteur Industriel Belge* that a system of steam towage is about to be established on the Bourgogne canal, over a distance of about 150 miles. The tow path will be laid with a single rail weighing some 16 pounds to the yard, and fixed on traverses placed 3·2 feet apart. The locomotive has four wheels, two of which are placed directly along the axis of the vehicle, one in advance of the other, and two, one at either side. The former pair are directing, the latter driving wheels. The directing wheels are grooved, and fit the rail: the others have rubber ties which give purchase on the macadamized road, and which press thereon only to the extent of 0·07 pounds per square inch. By means of simple mechanism, the weight of the machine may be thrown either upon the driving or directing wheels at will. In the first case the maximum and in the last the minimum of adherence is obtained, to suit the conditions of a loaded or an empty boat. A single road is to be used, with relay engines provided at suitable distances. Each locomotive tows one boat; and when a meeting takes place of two traveling in opposite directions, the engines change boats and retrace their paths.

This single rail system has already been satisfactorily tested for short distances on the Belgian Canals, and the projector, M. Larmangat, has obtained a government concession for its extended construction for forty years. The locomotives are to weigh 4 tuns each, and will travel at the rate of 3·1 miles per hour, with full boats carrying, a cargo of 150 tuns each.

Proposed Utilization of the Hudson River Sources.

The Legislature of New York, last year, ordered a survey in order to determine whether the immense accumulation of water on the great Adirondack plateau could be held in reserve and drawn upon as needed for State purposes. A report on the subject has recently appeared, from which we learn that this storage can be safely and economically effected. At the present time this water runs to waste, and is productive of much damage during the spring freshets. If confined, it could be obtained in sufficient quantities, when needed, to supply deficiencies in the river during the dry summer season for at least one hundred days.