

these animals are rather dainty in regard to their food, we resolved to try its action on a pig, which, as every one knows, will swallow almost anything placed before it. As our time was somewhat limited, we gave sixty grains of the sulphate of copper in milk and meal to a young pig weighing nine pounds; but, contrary to our expectations, the animal refused this food for twenty-four hours. Therefore, on Dec. 12 we made a weaker solution (ten grains to the ounce of water), and when this quantity was added to the milk and meal it was taken easily. The same quantity, ten grains, was taken for four days, and then the animal was killed. The liver and kidneys were boiled with water and strong sulphuric acid, and a knife was placed in the filtrate. At the end of eighteen hours the knife showed, to the extent of its immersion, two inches, a complete covering of copper on both sides. The evidence of experiments 1, 2, and 3 was shown in court and their significance explained to Sheriff Birnie, who tried the case at the instance of the sanitary authority of Glasgow. The evidence for the prosecution and the defense is fully and correctly given in the *Chemist and Druggist*, in its issues of Jan. 1 and Jan. 15. A careful reading of each shows that the evidence for the defense in no way traversed what we had done, and which was supplemented by such well known chemists as Messrs. Tatlock and Clarke. Yet, in deciding for the defense, the sheriff stated that "no new evidence had been brought forward." By his decision he sanctioned the use of a strong irritant metallic poison in food intended for consumption by human beings, the amount of which is not fixed, but is left to the discretion of foreign manufacturers over whom the authorities of our country have no control.—*The Lancet*.

CARPET BEATING.

THE destruction of morbid germs in order to prevent the propagation of epidemics has been practiced from remote antiquity. The means employed for this purpose consisted for the most part in burning the linen and effects that belonged to the deceased, and sometimes even the house that he lived in or all the houses in which the scourge had made its appearance. Such a process, by far too radical, and, we may say, far too barbarous, did not, however, always yield the results that were expected, because it could scarcely be applied except when the epidemic had assumed a general character that robbed this method of all its efficacy. The progress that has since been made in our knowledge of these diseases and of the way in which they are propagated has permitted of establishing preventive measures which, although they do not always prevent an epidemic from breaking out at such or such a point, yet sometimes permit of confining it to such places and of creating almost insurmountable barriers to it. Besides, as we could not think seriously of setting the four corners of a city on fire in order to destroy the miasms due to an epidemic disease, an earnest effort has been made to find a means of annihilating the action of such miasms without having recourse to the violent process of destruction. Among such means, those most used are washing with antiseptic liquids for dwellings and treatment by disinfecting stoves for garments and personal effects. But, aside from the diseases called epidemic, science has made known others whose propagation is likewise effected by way of contagion, without, however, the action of the germ being sufficiently rapid, in most cases, to conceal its origin. Among such diseases, that which has attracted most attention in recent times is undoubtedly tuberculosis. The numerous scientists who have studied this terrible scourge are unanimous in regarding it as of a contagious nature. Nothing is commoner than to see one or more persons living in a room in which a consumptive has died, and in which minute precautions have not been taken to destroy the morbid germs, attacked by the disease, and that, too, a long time after the decease of the first subject.

Farther, the labors of Messrs. Cornet and Pransnitz have established the fact that it does not require a lengthy cohabitation with a tuberculous subject, nor a prolonged stay in a room where the latter has been attended, for a person to be attacked by the disease.

In fact, Mr. Pransnitz has shown that a trip in the compartment of a railway car in which a consumptive has ridden suffices to communicate the germ of the disease to the traveler. This he discovered by collecting the dust contained in the coaches running from Berlin to Meran, a station frequented by a large number of consumptives, and inoculated guinea pigs with it after Cornet's method, by peritoneal way. Out of five coaches submitted to experiment, two were found to contain the bacillus of tuberculosis. The dust of one communicated the tuberculosis to three out of the four guinea pigs inoculated, and that of the other two out of four. On another hand, Mr. Cornet has cited a case of tuberculous infection in a person that had lived in a hotel room in which a consumptive had died.

But how is the transmissibility of the bacillus produced? Here we are less positive, at least experimentally, but it appears very natural to suppose that the infection is due to the spitting of the invalids upon the carpets either of the railway coaches or living rooms. It is therefore this part of the furnishing of rooms that should particularly attract attention. It is this too that is most difficult to clean, and this explains the fact that people are very often content, after a death has taken place, to simply sweep or imperfectly beat the carpet.

The processes employed up to the present for the beating of carpets are based upon the use of rods or leather thongs manipulated by hand or actuated mechanically. The violent and repeated blows that the carpets receive in this way soon tear the seams and injure the fabric, and, despite everything, are inadequate to completely expel the dust.

It is in order to remedy all such inconveniences that has been devised the system represented in our engravings, and the operation and advantages of which we are going to point out to our readers. Fig. 2 shows the arrangement of the works in which the beating is done. The carpets are unrolled and spread out on the floor, whence two men take them and fix them to a drum formed of a series of horizontal iron rods placed quite close to each other and fixed upon the circumference of two pulleys mounted upon a shaft actuated by gearings. This drum is almost completely surrounded by

a wooden cage of prismatic form, which leaves but a narrow passage on each side for the introduction and exit of the carpet. Over the drum, which is represented on a larger scale in Fig. 1, runs a pipe, A, provided beneath with a series of nipples, C, which nearly reach the carpet, D. The conduit, A, contains air compressed to a pressure varying from 5 to 10 atmospheres. This air, escaping through the nipples, strikes the carpet with great force during its passage over the drum, and passes through it and carries along all the particles of dust that are contained in the fabric. The compressed air comes from a reservoir, A (Fig. 2), through a system of pipes, B, which cause it to traverse an iron vessel, C, where it becomes charged with antiseptic substances. From thence it flows into the conduit, B, from which start the branches that distribute it throughout the entire length of the pipe located in the cage of the drum.

After the carpet has entirely passed through the apparatus, the drum's motion is reversed and two workmen standing on each side fix it anew to the drum, and so on, until the dust has been completely expelled. The air thus charged with dust and miasms is sucked

Even when the genuine Thomas slag is obtained it is divided into two classes, one containing excess of lime and the other not.

The former of the two, namely, that having excess of lime, only contains about 12% of phosphoric acid, but it disintegrates readily under the influence of moisture, on account of the excess lime which it contains becoming hydrated, swelling through its combination with the water, so that it completely assumes a finely divided state. Thus, there being no need to grind these slags, they are sold at a low price, and afford a cheap source of phosphoric acid. At the same time, since they are poor, they are not suitable for transport to a distance, but most advantageously employed in the neighborhoods surrounding the works where they are produced. The slags which do not contain an excess of lime are much richer, and are found to contain from 14% to 20% of phosphoric acid; but they do not disintegrate of their own accord, but have to be finely ground, thus increasing their price.

Both classes of slags contain phosphate of lime in combination with silicate of lime, etc. Reduced to a powder, either by natural or mechanical means, they

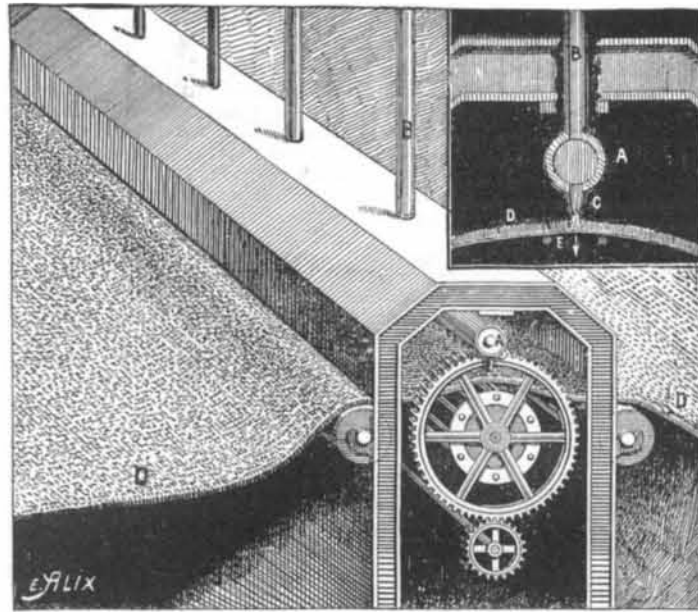


FIG. 1.

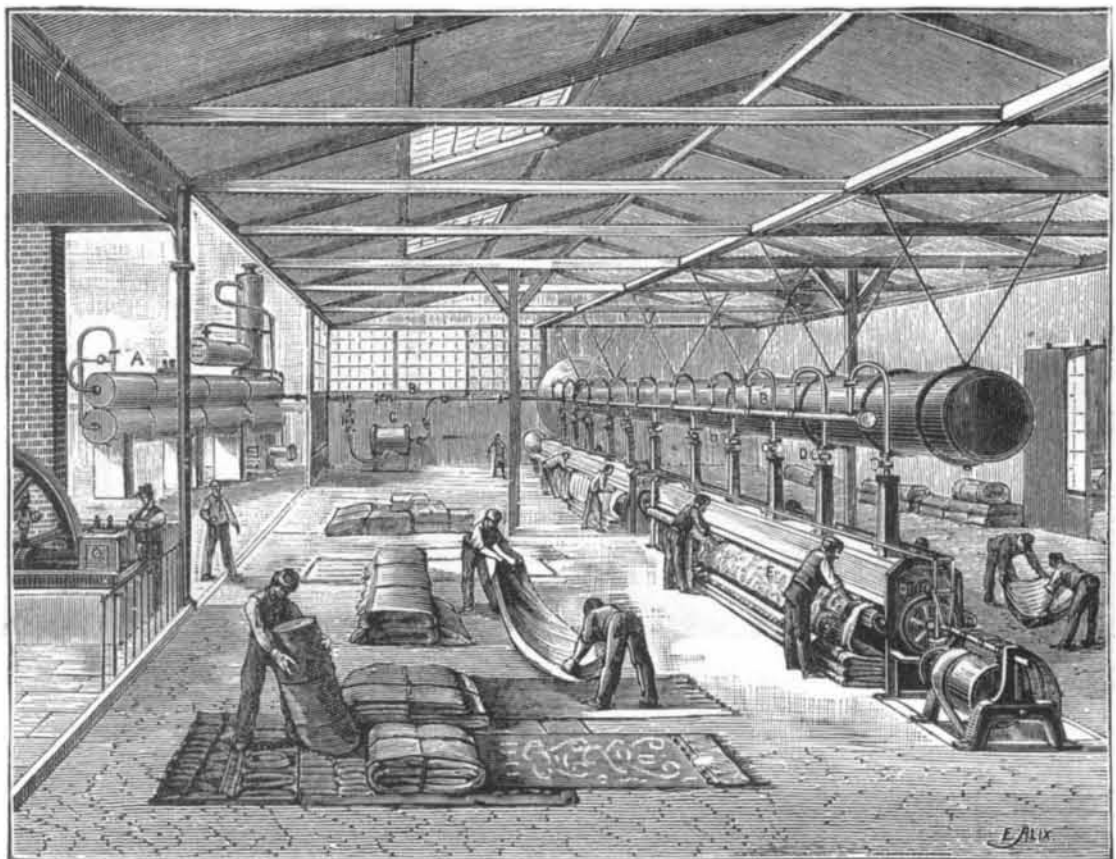


FIG. 2.

A CARPET BEATING ESTABLISHMENT.

out beneath the carpet by an exhaustor, which sends it into a series of depositing chambers containing vertical partitions, where it is gradually cleansed, the dust falling upon the floor, and the air finally escaping through a chimney situated at the extremity of the last chamber.

It will be seen that, through this arrangement, the beating, while being undoubtedly more complete than in the older systems, can do no injury to the fabric, and that it destroys for the most part the morbid germs spoken of above.—*Les Inventions Nouvelles*.

AGRICULTURAL USE OF THOMAS SLAG.

By M. JOULIE.

THE following remarks upon the use of Thomas slag were made by M. Joulie at the Agricultural Congress at Versailles.

The slags produced at works which do not work the acid Bessemer plant according to the process of Messrs. Thomas and Gilchrist contain little, if any, phosphoric acid, and ought, in consequence, to be rejected for manurial purposes.

are readily attacked in the soil by carbonic acid, which dissolves the phosphate of lime, thus assisting a state of molecular division, so that they are very easily assimilated.

On this account they can be used in the place of superphosphates. This, however, is only true for soil rich in organic matter, such as recently cleared forest land and garden soils, etc., because soils of this nature contain large quantities of carbonic acid, and, moreover, humic acid in abundance.

But in ordinary plowed land their action is generally much slower than superphosphates, while, in calcareous earths, their action is even wholly inappreciable. These slags are, therefore, specially suited for non-calcareous and highly organic soils, where they act rapidly, both their phosphoric acid and lime being utilized at once.

In soils which contain little organic matter, so long as they are not calcareous, they may be employed, though they are inferior to superphosphates. It is thus apparent that, for soils rich in lime, superphosphates are the only phosphatic manure that can be used with advantage.

In any case, these slags ought to be plowed in or

spread in the autumn, upon land which is lying fallow. They ought never to be mixed with superphosphates, which they deteriorate, neither with ammonium sulphate, from which they liberate nitrogen as ammonia, nor should they be allowed to sweat, for the same reason.—*Chem. Tr. Jour.*

ON THE RELATION OF NATURAL SCIENCE TO ART.*

By Dr. E. DU BOIS-REYMOND.

I.

WE are assembled to-day in annual commemoration of a man whose marvelous breadth of view and extraordinary variety of interests are each time a fresh surprise to us. It seems incredible that the same hand could have penned the "Protogea" and the state paper adjudging the principality of Neuchâtel to the King of Prussia, or that the same mind could have conceived the infinitesimal calculus and the true measure of forces, as well as the pre-established harmony and the "Theodicea." A closer examination, however, reveals a blank in the universality of his genius. We seek in vain for any connection with art, if we except the Latin poem composed by Leibnitz in praise of Brand's discovery of phosphorus. We need hardly mention that his "Ars Combinatoria" has nothing to do with the fine arts. In his letters and works, observations on the beautiful are few and far between; once he discusses more at length the pleasure excited by music, the cause of which he attributes to an equable, though invisible, order in the chordal vibrations, which "raiseth a sympathetic echo in our minds." However, the world of the senses had little reality for Leibnitz. With his bodily eye he saw the Alps and the treasures of Italian art, but they conveyed nothing to his soul. He was indifferent to beauty; in short, we never surprise this Hercules at Omphale's distaff.

The same neglect, at least of sculpture and painting, strikes us in Voltaire, who as polyhistorian can in some measure compare with Leibnitz. We are obliged to descend as far as the third generation—that is, to Diderot in France, to Winckelmann and Lessing in Germany—before we meet with a decided interest in the fine arts, and an appreciation of the part they play in the progress of civilization.

The period thus defined, though it excels in science, shows with few exceptions a falling off in the fine arts. On considering the historical development of these two branches of human productiveness, we find no correspondence whatever between their individual progress. When Greek sculpture was in its prime, science scarcely existed. True, Leonardo's gigantic personality, which combines the immortal artist with the physicist of high rank, towers at the beginning of the epoch generally known in the history of art as the Cinquecento. Still, he was too far in advance of his age in the latter capacity to be cited as an example of simultaneous development in art and science; so little that Galilei was born the day of Michael Angelo's death. The mutual development of art and science at the commencement of our century is, I believe, merely a casual coincidence; moreover, the fine arts have since been at the best stationary, whereas science strides on victoriously toward a boundless future.

In fact, both branches differ too widely for the services rendered to science by art, and *vice versa*, to be other than external. "Nature," Goethe very truly observed to Eckermann, little thinking how harshly this remark reflects on part of his own scientific work, "Nature allows no trifling; she is always sincere, always serious, always stern; she is always in the right, and the errors and mistakes are invariably ours." Fully to appreciate the truth of this, one must be in the habit of trying one's own hand at experiments and observations, while gazing in Nature's relentless countenance, and of bearing, as it were, the tremendous responsibility incurred by the statement of the seemingly most insignificant fact. For every correctly interpreted experiment means no less than this: whatever occurs under the present circumstances, would have occurred under the same conditions before an infinite negative period of time, and would still occur after an infinite positive period.

Only the mathematician, whose method of research has more in common with that of the experimenter than is generally supposed, experiences the same feeling of responsibility in presence of nature's eternally inviolable laws. Both are sworn witnesses before the tribunal of reality, striving for knowledge of the universe as it actually is, within those limits to which we are confined by the nature of our intellect.

However, there is a compensation for the philosopher, laboring under this anxious pressure, in the consciousness that the slightest of his achievements will carry him one step beyond the highest reached by his greatest predecessor; that possibly it may contain the germ of vastly important theoretical revelations and practical results, as Wollaston's lines contained the germ of spectral analysis; that, at any rate, such a reward is not only in the reach of a born genius, but of any conscientious worker; and, finally, that science, by subduing nature to the rule of the human intellect, is the chief instrument of civilization. No real civilization would exist without it, and in its absence nothing could prevent our civilization, including art and its master works, from crumbling away again hopelessly, as at the decline of the ancient world.

This consciousness will also make up to the philosopher for the thoughtlessness of the multitude, who, while enjoying the benefits thus lavished upon them, hardly know to whom they owe them. The country rings with the name of every fashionable musical virtuoso, and encyclopedias insure its immortality. But who repeats the name of him who achieved that supreme triumph of the inventive intellect—to convey through a copper wire across far-stretching countries and over hill and dale the sound of the human voice as though it spoke in our ear?

"Life is earnest, art is gay," this saying of Schiller's remains as true if we substitute science for life. Art is

the realm of the beautiful; its productions fill us with an enjoyment, half sensuous, half intellectual; it is, therefore, a realm of liberty in the widest sense. No rigid laws are enforced in it, no stern logic binds the events of the present to those of the past and future, no certain signs indicate success, blame and praise are distributed by the varying taste of ages, nations, and individuals, so that the glorious Gothic church architecture came to be derided by the eighteenth century. In art, the definition of genius as a talent for patience does not hold good. Its creations, once brought forth in a happy hour of revelation, stir our souls with elementary force, and scorn all abstruse explanations, subsequently forced upon them by art criticism. Whoever accomplishes such a feat also ministers in a sense to the cares and troubles of humanity. Unfortunately the nature of things does not allow such fruit to ripen at all seasons. At one time, in one direction, the culminating point will be reached, and then age after age will strive in vain to emulate the past. The finest æsthetic theories can neither carry the individual beyond the limits of its own natural powers nor retrieve the fortunes of a declining period. Of what use has been the recent strife in the artistic world between naturalists and idealists? Has it protected us from the frequently almost intolerable extravagances of the latter? There is an attraction in every boldly advanced novelty which the common herd is unable to resist, and which will invariably triumph till antiquated ideas are somehow supplanted by fresh ones, or by the lofty rule of some irresistibly superior personality. Nor can science in the stricter sense come to the aid of art, and thus, strangers at heart, without materially influencing each other, each seeks its own way: the former advancing steadily, though irregularly; the latter slowly fluctuating like a majestic tide. Those unfamiliar with science are apt to recognize the supreme development of our mental faculties in art alone. Doubtless this is a mistake, yet human intellect shines brightest where glory in art is coupled with glory in science.

We may notice something here which is similar to what occurs in practical ethics. The more corrupt the morals of an age or nation, the more we find virtue a favorite topic. The flood of æsthetic theories rises highest when original creative power is at its lowest ebb. Lotze, in his "History of Æsthetics in Germany,"* gives a wearying and discouraging account of such fruitless efforts. Philosophers of all schools have raved in abstract definitions of the essence of beauty. They call it unity in multiplicity, or fitness without a purpose, or unconscious rationality, or the transcendent realized, or the enjoyment of the harmony of the absolute, and so forth. But all these properties, which are supposed to constitute the beautiful, have no more to do with our actual sensation of it than the vibrations of light and sound with the qualities they bring to our perception. Indeed, it would be vain to attempt to find one term equally fitted to describe all the varieties of the beautiful—the beauty of cosmos as contrasted with chaos, of a mountain prospect, a symphony, or a poem, of Rostri in Medea, or a rose; or even, taking the fine arts alone, the beauty of the Cologne Cathedral, the "Hermes" of Praxiteles, the Madonna Sistina, a picture of still life, a landscape, a genre piece, or a Japanese flower design, not to mention the questionable custom which permits us in German to speak of a beautiful taste or a beautiful smell. Let us rather admit that here, as so often, we meet with something inexplicable in our organization; something inexpressible, though not the less distinctly felt, without which life would offer a dull and cheerless aspect.

In an essay of Schiller's there is a disquisition on physical beauty.† He distinguishes between an architectural beauty and a beauty which emanates from grace. I attacked this æsthetic rationalism, to which the last century was strongly addicted, twenty years ago, on a similar occasion in a lecture on Leibnitz's ideas in modern science. I ventured to assert that "the attraction which physical beauty exerts on the opposite sexes can as little be explained as the effects of a melody."‡ On reflection, it seems, indeed, incomprehensible why one distinct shape, which, according to Fechner, might be represented by a plain algebraic equation between three variables, should please us beyond a thousand other possibilities. The reason can be traced from no abstract principle, no rules of architecture, not even from Hogarth's line of beauty. A year after this remark was made, Charles Darwin published his "Descent of Man," in which the principle of sexual selection, only cursorily treated in the "Origin of Species," is fully expounded, and pursued in all its bearings. I remember vividly how, in a discussion with Dove as to the necessity of admitting a vital force, he embarrassed me by the objection that in the organic world luxury occurs, for example, in the plumage of a peacock or a bird of Paradise, while in inorganic nature Maupertuis' law of the minimum of action precludes such prodigality. Here was a solution to the problem, allowing that one might attribute to animals a certain sense of beauty. The gorgeous nuptial plumage displayed by male birds may have been acquired through the preference of the female for more highly ornamented suitors, a progeny of constantly increasing brilliancy of coloring being thus obtained. Male birds of Paradise have been observed to vie in showing off their beauty before the females in courtship. The power of song in nightingales might be attributed to the same cause, the female in this case being more susceptible to the charms of melody than to those of brilliant coloring. Darwin goes on to observe that, in the human race likewise, certain sexual characteristics, such as the imposing beard in man and the lovely tresses in woman, might have been acquired through sexual selection.§ It is a well known fact that, by the repeated introduction of handsome Circassian slaves into aristocratic Turkish harems, the original Mongol type in many cases has been remarkably ennobled. And carrying the same principle

further, we may find therein an explanation for the fascination which female beauty has for man. According to our present views, the first woman was not made of a rib taken out of the first man—a process fraught with morphological difficulties. It was man himself who, in countless generations, through natural selection, fashioned woman to his own liking, and was so fashioned by her. This type we call beautiful, but we need only to cast a glance at a Venus by Titian, or one by Rubens—let alone the different human races—to recognize how little absolute this beauty is.

If one kind of beauty could be said to bear analyzing better than another, it is what might be termed mechanical beauty. It is noticed least, because it escapes all but the practiced eye. This kind of beauty may belong to machines or physical apparatus, each part of which is exactly fitted to its purpose in size, shape and position. It answers more or less to the definition of "unconscious rationality," our satisfaction evidently proceeding from an unconscious perception of the right means having been employed to combine solidity, lightness, and, if necessary, mobility, with the greatest possible profit in the transmission of force, and the smallest waste of material. A driving belt is certainly neither attractive nor unattractive; but it pleases the "*visus eruditus*" to see a connecting rod thickened from the ends toward the middle, where it has to bear the greatest strain. Of course this kind of beauty is of recent origin. I remember Halske telling me that, as regards the construction of physical and astronomical instruments, it was, to his knowledge, first understood and established as a principle in Germany by Georg von Reichenbach in Munich. Berlin and Munich workshops produced instruments of perfect mechanical beauty at a time when those supplied by France and England were still often disfigured by aimlessly ornamented columns and cornices, unpleasantly recalling the impure features of Rococo furniture and architecture.

I forget which French mathematician of the last century, in sight of the cupola of St. Peter's at Rome, tried to account for the sense of perfect satisfaction it gives to the eye. He measured out the curves of the cupola, and found that, according to the rules of higher statics, its shape supplies the exact maximum of stability under the given circumstances. Thus Michael Angelo, guided by an unerring instinct in the construction of his model (the cupola was not erected till after his death), unconsciously solved a problem the true nature of which he could hardly have understood, and which was even beyond the reach of the mathematical knowledge of his age. Apparently, however, there are several roots to this equation of beauty; at least there is one other type, for which I quote the cupola of Val de Grace, in Paris, which, if not as imposing, is quite as gratifying to the eye, as Michael Angelo's.

It will be observed that in this case mechanical beauty becomes part of the art of architecture; and instances of this kind are daily growing more frequent, our modern iron structures being more favorable to its display than stone buildings. In the Eiffel Tower we see mechanical beauty struggling with the absence of plastic beauty. On this occasion it was probably revealed for the first time to many who hitherto had no opportunity of experiencing its effect. It is certainly not wanting in the new Forth Bridge. There is no doubt, however, that in stone structures, too, together with much that pleases from habit or tradition, there are certain features which evidently attract through mechanical beauty—such as the outline of the architectural members of a building, or the gentle swelling and tapering of the Doric column toward the top, and its expansion in the echinus and abacus; and there are others which offend a refined taste through the absence of this beneficial element, such as the meaningless ornamentations of the Rococo style.

Even in organic nature mechanical beauty prevails to such an extent that it transforms many objects into a source of delight and admiration to the initiated, which are naturally repulsive to the untrained eye. Anatomists recognize it with pleasure in the structure of the bones, especially of the joints. In their opinion the "Dance of Death" outrages good taste from more reasons than because it differs from the classical conception of death. Mechanical beauty was already perceived by Benvenuto Cellini in the skeleton, much to his credit; and but for our imperfect knowledge, it would invest with its glory every organic form, down to the inhabitants of the aquarium, even under the very microscope. According to Prof. Schwendener, even plants are constructed on the same principle of fitness combined with thrift; and something of this we feel at sight of a spreading oak tree proudly distending its vigorous branches toward air and sunlight.

Again, our appreciation of the forms of animals, especially of noble breeds, is greatly influenced by mechanical beauty. The greyhound and the bulldog, the full-blooded race horse and the brewer's dray horse, the Southdown and the merino sheep, the Alpine cattle and the Dutch milch cow, all are beautiful in their kind; even though a bulldog or a Percheron may appear ugly to the uninitiated, because in each the type of the species has been modified to the utmost degree of fitness.

Though science is unable, as we have seen, to check the occasional decline of art and inspire it with fresh vigor, yet it renders invaluable services of a different kind to artists, by increasing their insight, improving their technical means, teaching them useful rules, and preserving them from mistakes. I do not allude to anything so primitive as the manufacture of colors or the technique of casting in bronze; the less so, as, curiously enough, our modern colors are less durable than those of entirely unscientific ages, and the unsurpassed thinness of the casting of Greek bronzes is regarded as a proof of their authenticity. Nor does it seem necessary to recall the notorious advantages of this kind for which art is indebted to science. Linear perspective was invented by Leonardo and Dürer—artists themselves. It was followed by the laws of reflection—unknown to ancient painters, as would appear from the Pompeian frescoes of Narcissus—and by the geometrical construction of shadows. The rainbow, which had better not be attempted at all, has been sinned against cruelly and persistently by artists, in spite of optics. Statics furnished the rules of equilibrium, so essential to sculptors. Aerial perspective, again, owes its development to painters chiefly of northern climates.

But to this fundamental stock of knowledge the pro-

* Munich, 1868.

† "Ueber Anmuth und Würde."

‡ The author's "Collected Addresses," etc., vol. I., pp. 49, 50, Leipzig, 1886.

§ The author is not unaware of Mr. Wallace's attack on Darwin's explanation of the brilliant plumage of male birds by the female's preference and of the discussion arisen between him and Messrs. Poulton, Pocock and Peckham. This was not the proper place to enter into it, the less so as, whatever may be its outcome, the author's conclusion from the theory of sexual selection would remain unaltered.

* An address delivered by E. du Bois-Reymond, M.D., F.R.S., at the annual meeting of the Royal Academy of Sciences, of Berlin, in commemoration of Leibnitz, on July 3, 1890. Translated by his daughter. This address was first printed in the weekly reports (*Sitzungsberichte*) of the Berlin Academy, then in Dr. Rodenberg's *Deutsche Rundschau*, and lastly it was published as a separate pamphlet by Veit & Co., at Leipzig, 1891.—*Nature*.