about the same course as that for pure water, except that the maximum of density was reached, not at 4°, as in the case of pure water, but under 3°, as is the case with salt substances.

RECENT observations by M. Ebermayer demonstrate (1) that the air in a large forest is in summer nearly twice as rich in carbonic acid as free open air ; (2) that forest ground in summer contains much less CO_2 than unwooded ground (the CO_2 formed by slow decomposition of humus in the close forest seems mostly to pass into the air, and is probably utilised by the leaves for assimilation) ; (3) that, with rise of temperature, the increase of CO_2 in arable ground is very much greater than in forest ground ; and (4) that the spread and motion CO_2 in the ground seems to take place very slowly, for in two places quite near together the amount of CO_2 may be very different. Among other bearings of these facts, the ground covering of a forest can have no important influence on the amount of CO_2 and lime in spring water, and unwooded ground may have a greater action in this respect. Again, animals living underground, *e.g.* foxes, naturally prefer the ground air of the forest, with its little CO_2, to to the ground air of the open field, which has much more.

THE influence of concentration of liquids on their electromotive force has lately been investigated by M. Moser (*Monatsb. der Berliner Acad. der Wiss.*) who connected two glasses of differently concentrated solutions of the same salt by a siphon, and completed the circuit by wires with electrodes, which were always of the same metal. In all such cases a current arises, passing in the liquid from the dilute to the more concentrated solution. M. Moser used zinc sulphate, nitrate, chloride, and acetate, copper sulphate and nitrate, iron chloride, silver acetate and nitrate, and other salts. The highest electromotive force was $\frac{1}{5}$ Daniell, and was got with very dilute and concentrated zinc chloride solution. The various effects are arranged in tension-series. By the currents referred to, metal is dissolved in the dilute solution, separated out in the concentrated one. The equivalent of the work done by the current, M. Moser considers, is the work of attraction force between the salt and the water. The current is to be regarded as a reaction current against passage of the ions, as the polarisation current is the reaction current against the decomposition current.

THE subject of acoustic repulsion continues to be studied by M. Dvorak (*Wied. Ann.*, No. 3). Among other things he constructs an acoustic reaction wheel and an acoustic torsion balance. The former consists of four light paper or glass resonators placed tangentially at the four ends of two thin cross-bars of wood, pivoted at their intersecting point by means of a glass cap. The mouths of the resonators are all in the same relative position. The wheel is placed before the open end of a tuning-fork resonator, and enters into rotation when the fork is sounded. In another case the sound from the large resonator is transmitted through a conical tube beyond whose thin end is a wheel with square pieces at the end of the cross-arms. In the acoustic torsion balance a wooden bar furnished with a resonator is hung by a wire (as in Coulomb's balance) within a case, which has on the resonator side an opening for admission of sound. By repulsion of the resonator the strength of tones of the same number of vibrations may be compared.

LECTURING at the Sorbonne lately on atmospheric electricity, M. Mascart sought to reproduce the phenomena of thunderstorms. The dull explosions of thunder and the fulgurations in the heart of clouds preceding fulminant discharges, as also the latter, were imitated by means of a powerful Holtz machine, charging batteries, and condensers suitably arranged. The singular movements of thunder-clouds, which, obeying electric attractions and repulsions, are often observed to move in the atmospheric ocean in counter-currents, were illustrated with the aid of a balloon of hydrogen gas, to which was suspended a piece of metallic wire. The weight of the wire was such that the small aerostat, rendered slightly heavier than the displaced air, would descend ; but when it was electrified, it rose again, as if freed from its burden. M. Mascart did not attempt an explanation of this curious phenomenon, which has not been repeated since the time of van Marum.

IN a recently-published report by M. Kellner to the Naturforscher Versammlung at Munich, he describes experiments made along with some others on an eleven-year old Wallachian horse of 434 kilo. weight, with regard to the relation of work done and decomposition of albumen. In five successive periods of thirteen to fourteen days the animal was fed with 5 k. meadow-hay, 5 k. oats, and 1·5 k. chopped wheat straw, and did work to the extent of 500,000, 1,000,000, 1,500,000, 1,000,000, and 500,000 kilogrammetres in the five periods respectively. In periods I. and V. the work done was the same, in II. and IV. doubled, and in III. tripled ; in II. and III. the course was doubled and tripled, and in IV. the weight doubled. Of the dry substance of the fodder were digested in period I. 56·53 per cent., II. 56·45 per cent., III. 56·49 per cent., IV. 54·01 per cent., V. 53·07 per cent. The horse's weight varied as follows :—I. 534·1, II. 529·1, III. 522·3, IV. 508·8, V. 518 kilo. The excretion of nitrogen was on an average of the last six to nine days of each experimental series, I. 98·81 k., II. 109·16, III. 119·82, IV. 107·53, V. 101·88. These numbers show strikingly, in opposition to Voit's and Pettenkofer's results, that with increase of work done, is associated a not inconsiderable increase of decomposition of albumen.

THE additions to the Zoological Society's Gardens during the past week include an Indian Leopard (*Felis pardus*) from India, presented by Major Tubbs ; a Red Deer (*Cervus elaphus*), a Common Fox (*Canis vulpes*), European, presented by Mr. Carroll W. Ansdell ; two Spotted Ichneumons (*Herpestes auropunctatus*) from Nepal, presented by Mr. J. McIntosh ; a Suricate (*Suricata zenik*) from South Africa, presented by Mr. Percy Howard ; an Azara's Fox (*Canis azarae*) from Brazil, presented by Dr. A. Stradling ; a Stanley Crane (*Tetrapteryx paradisea*) from South Africa, presented by Capt. A. F. Lendy ; a Lead-beater's Cockatoo (*Cacatua leadbeateri*) from Australia, presented by Mr. W. Ruston ; a Collared Fruit Bat (*Cynonycteris collaris*), four Common Foxes (*Canis vulpes*), born in the Gardens.

THE DETERIORATION OF OIL PAINTINGS[1]

II.

IF we compare the pictures of the Italian and Dutch schools of the fifteenth, sixteenth, and seventeenth centuries, with those of the French and English schools of the last hundred years, we are struck by the great difference in the nature of their diseases. We may divide those diseases into *constitutional* ones—that is to say, such as are based on the method and the material used for painting, and into those produced by external influences.

The Dutch pictures of the fifteenth, sixteenth, and seventeenth centuries, and the Italian pictures of the fifteenth and sixteenth centuries, seem to me perfectly free from constitutional diseases. It is only in the seventeenth century that the Italian pictures show a special constitutional alteration, caused by the practice of the Bologna school.

The pictures of the last hundred years of the French school, of a part of the English school, and some painters of other schools, have been attacked by a constitutional disease perfectly defined and characteristic of this period.

Among external influences injurious to oil painting, we have to consider dampness, heat, bad air, dust, smoke, mechanical injuries, and last, not least, the destructive or "altering" hand of the picture-restorer.

Pettenkofer's scientific researches first clearly defined the influence of humidity on oil paintings, showing that it produced a discontinuity of the molecules of the vehicle and the resinous substances. As glass, when pulverised and thereby mixed with air, loses its transparency, and water, when mixed with oil,

[1] Paper read at the Royal Institution, Friday, March 1, by R. Liebreich, M.D., M.R.C.S., M.R.I. Continued from p. 495.

becomes of a milky aspect, so the oily and resinous substances contained in paintings will become dim as soon as air penetrates between their particles. The picture thus assumes a greyish, dim appearance, and the pigments seem to have been fading. That this is not really the case has been proved by the influence of a process invented by Pettenkofer, which he calls regeneration. In a flat box the picture is exposed to air impregnated with alcohol. Of this latter the resinous elements of the picture absorb a certain quantity, swell and fill up the interstices between the separated particles so as to reunite them into an optically homogeneous transparent substance.

The alcohol does not affect in the same way the hardened oil. If the interstices between its particles are not filled up by the swelling resin, it becomes necessary to introduce a new substance into the picture, and this is called nourishing a picture.

Pettenkofer has the great merit of having clearly proved that the nourishing of a picture with oils, as the custom was formerly, and still is to some degree, is a very objectionable proceeding, as it has the effect of darkening the colours for ever. He recommends, instead of oil, balsam of copaiva, which has become since an invaluable means for preserving and restoring oil paintings, and will be more and more extensively used.

I have frequently applied Pettenkofer's method, and with very beneficial effect; but whenever I mentioned it to professional picture-restorers, here as well as on the Continent, I always found them to reject it, either *à priori*, or after experiments incorrectly made.

In Munich, it seems, the pictures of all periods and of all schools have had to suffer under local influences and through the changes in the humidity of the air. This accounts for Pettenkofer having principally described this, so to say, endemical disease. In other galleries this affection does not appear so frequently, and Pettenkofer's method, therefore, will not find everywhere the same extensive application as at Munich. I think, however, that with some modifications it may be employed against some other alterations. I have, for instance, found it efficacious with paintings which had been injured by exposure to great heat. I shall show you a small picture which had been hanging for a long time so near a gas flame that it was almost completely scaling off, and so entirely faded that it scarcely looked like an oil painting at all. In that state it was exposed to alcoholised air, then nourished with balsam, and its back slightly varnished; and the scales starting from the canvas were refixed by pressure. And now it appears fresh in colour, firm in substance, and perfectly smooth on its surface. The old, cracked varnish, melted together by the alcohol, looks as if fresh laid on.

Humidity sometimes favours the development of fungus. The round, black, small spots which pass through the canvas and the painting of these two pictures are produced by the same little plant which Prof. Tyndall showed you when he spoke on the highly interesting subject of spontaneous generation.

Oil and water, so injurious to oil paintings, enter both into the material used for lining. Anxious to exclude these sources of danger, and to simplify the whole process, I have endeavoured to replace it by a new method which I shall submit to you this evening.

How paintings may be disfigured by restorers you see in this picture, which was renovated with oil colours according to the practice only abandoned about thirty years ago, when it was advantageously replaced by the use of varnish colours.

The amount of external injury oil paintings sometimes endure and stand is perfectly amazing. Pictures in the course of centuries, during the destructive fury of wars and revolutions, may have been torn out of their frames, rescued from below the ruins of burned monasteries, may subsequently have passed from one *bric-à-brac* shop to another, where they have been piled up, to be pulled about at each new inspection, and literally trodden under foot, whereby they have finally been reduced to a state of colourless, greyish, or black rags. Still such pictures may not unfrequently be awakened, as it were, to new life, to their original brilliancy of colour, if, with all necessary care, their injured limbs are put together again, their wounds are healed, and fresh nourishment, air, and thorough cleansing, are administered to their lacerated bodies.

A sound constitution is, of course, a necessary condition for obtaining any such result, without it we can only obtain a partial cure. We see this with reference to the Bolognal school of the seventeenth century. The pictures which you see here are instances of this. From the state of rags to which they were reduced they have passed, by appropriate treatment, into the state of firm, even, well-conditioned, and clean pictures. The constitutional alteration characteristic of their time and school, however, could not be cured. You will, therefore, perceive that the contrast is too great between light and shade, that the half tones are too weak and that the glazings spread on dark ground, which certainly existed formerly, have been destroyed by the growing of bolus and umber of the priming. That this is not the fault of the method of restoration is clearly proved by the state in which you will find all the pictures of this school, even those best preserved in the best galleries of all countries.

The constitutional diseases of pictures belonging to the French and to the English school of the last hundred years are of still more serious nature, and much more difficult to cure. Many of them, though they were never exposed to any injury whatever, nor are likely ever to be so in our present state of civilisation, cannot be guarded from premature decay in spite of all possible care with which they are kept.

The principal symptoms of their bad constitution are :—

1. Darkening of the opaque bright colours.
2. Fading of the transparent brilliant colours.
3. Darkening, and above all, cracking of the transparent dark colours.

The best opportunity to study these several appearances is given us in the Museum of the Louvre, which contains a great number of such pictures in the section occupied by the French school. I have paid particular attention to the cracks in these pictures, as I find that in shape, in size, in position, as well as in relation to the various colours, they differ distinctly from the cracks in older pictures and in those of other schools. This, of course, is of importance, not only for the explanation of the reasons which produced them, but as a symptom which, in a given case, might determine the diagnosis, whether a picture be an original or only a copy. The special characteristics of these cracks are the following :—

They are all but exclusively found in the thickly laid on transparent dark colours, and they are the deeper and the more gaping in proportion to the thickness of the layer of the colour and the extent of the dark surface. The chief cracks run parallel to the outlines of surfaces painted with bright opaque colours, such, for instance, as are used for the flesh tints, and which are more or less thickly laid on. But there is generally a slight distance between the bright colours and the cracks.

Lateral branches of these cracks pass into the white, but they do not gape, provided the white colours had been laid on directly upon the priming, and not upon a layer of dark transparent and not sufficiently dried colour.

This examination of the cracks of pictures has sometimes afforded me a peculiar insight into the practice used for the picture. In the well-known picture, for instance, by Guèricault, of "The Wreck of the *Medusa*," in the Gallery of the Louvre, the cracks follow exactly the outlines of the bright flesh-tints. The arm of one of the dead bodies hanging in the water is so covered by planks and water that nothing of the forearm is to be seen. It is, however, very easy to prove that originally that arm was painted in all its length, for the cracks do not only follow the outline of the visible upper arm, but also the no longer visible forearm, and all the five fingers. This proves that the fore part of the arm and the hand were originally painted in flesh-tints before they were covered over by the planks, and the water painted afterwards. In Ingres' portrait of Cherubini, the face of the latter is beautifully preserved, while that of the Muse, as well as her drapery, is covered with cracks. In the depth of the cracks of the white drapery an intense blue tint is to be seen. Mr. Henry Lehmann, of Paris, the favourite pupil of Ingres, who knows the history of this picture as an eye-witness, and whom I consulted about this very striking appearance, gave me the following information :—Ingres painted the head of Cherubini in Paris, and then took it with him to Rome. There it was pieced into a new canvas and lined. Then the Muse was painted, and before the colours were perfectly dry, another model was chosen, and a new Muse painted over the old one. The colour of the drapery was likewise altered, and this explains the cracks in the white colour, and explains also why the blue appears in the depth of the cracks of the drapery.

Among the English artists of the last hundred years, some have painted with the same material and by the same process as their French contemporaries, and consequently with the same unfortunate results. Others avoided these by using the same

material with more precautions. Others, again, and among them Sir Joshua Reynolds, have in their different works followed various practices, and consequently had varied results. Thus, some of Sir Joshua's pictures have kept perfectly sound. Others are cracked in the characteristic way just mentioned. Others, again, are cracked in an absolutely irregular way. We can easily form an idea of it if we read in his "Diary Notes," for instance, the way in which he painted the portrait of Miss Kirkman, which he began with whiting and gum tragacanth, then covered it successively with wax, then white of eggs, and then varnished it.

The study of the alterations already fully developed in pictures painted within the last hundred years only, and their comparison with the works of the old masters, would suggest the following rules for the process of painting :—

1. The oil should in all colours be reduced to a minimum, and under no form should more of it than absolutely necessary be introduced into a picture.

2. All transparent colours which dry very slowly should be ground, not with oil at all, but with a resinous vehicle.

3. No colour should be put on any part of a picture which is not yet perfectly dry; and, above all, never a quick-drying colour upon a slow-drying one, which is not yet perfectly dry.

4. White and other quick-drying opaque colours may be put on thickly. On the contrary, transparent and slow-drying colours should always be put on in thin layers.

If the effect of a thick layer of these latter is required, it must be produced by laying one thin layer over another, taking care to have one completely dry before the next is laid on. If transparent colours are mixed with sufficient quantity of white-lead, they may be treated like opaque ones.

We come now to the last layer of the picture, to that one which is spread over its surface in order to equalise optical irregularities, and to protect it at the same time from the air. I mean the varnish.

The varnish may crack or get dim; then it should be treated with Pettenkofer's method; but it may become dark yellow, brown and dirty, and so hide the picture that it becomes necessary to take it off and to replace it by a thin layer of new varnish. It is here that picture-restorers, or we may say picture-cleaners, display their beneficial skill, and also their very destructive activity.

If a picture is throughout painted in oil, if its substance has remained sound and even, and varnished with an easily soluble mastich or dammar varnish, then there will be neither difficulty nor danger in removing the varnish. This can, in such a case, be done either by a dry process, that is, by rubbing the surface with the tips of the fingers, and thus reducing the varnish by degrees to a fine dust, or by dissolving the varnish by application of liquids, which, when brought only for a short time into contact with the oil painting, will not endanger it. We have, however, seen that the works of the old masters are not painted with oil colours like those used by modern painters, but, on the contrary, that certain pigments, and especially the transparent colours used for glazing, were ground only with resinous substances. These latter have, in the course of time, been so thoroughly united with the layer of varnish spread over the surface of the picture, that there no longer exists any decided limit between the picture and the varnish. It is in such pictures that a great amount of experience, and knowledge of the process used for the picture, as well as precaution, are required in order to take away from the varnish as much only as is indispensable, and without interfering with the picture itself. Numberless works of art have been irreparably injured by restorers, who, in their eagerness to remove dirt and varnish, attacked the painting itself. They then destroyed just that last finishing touch of the painting, without which it is no longer a masterpiece.

The difficulty and danger are much greater in cleaning those pictures which have not been varnished with the ordinary easily-dissolved mastich or dammar varnish, but have been painted over with oil, oil-varnish, or oleo-resinous varnish. It seems incredible that these substances should ever be used for such purposes; it is, however, a fact that there are still people who fancy that it will contribute to the good preservation of their pictures to brush from time to time a little of those liquids over their surface. They recognise too late that the varnish becomes more and more dark, of a brownish colour, and opaque. If such varnish has afterwards to be removed, then we meet with the great difficulty, that this can be done only with substances which would just as easily dissolve the whole picture as the hardened layers spread over it.

This shows what can be the value of those universal remedies which from time to time appear, and are praised for the innocuous way in which pictures by their means may be cleaned.

There is at this moment a great discussion going on in Italy about Luporini's method. Luporini is a painter and picture-restorer in Pisa, who believes himself to have invented a new means of cleaning pictures without any danger. Some months ago, in Florence, I examined a large number of pictures cleaned by him. Those of the Gallery of St. Donato, belonging to Prince Demidoff, mostly Flemish and Dutch landscapes, are cleaned very well and without any injury to the painting. On the contrary, the St. John, by Andrea del Sarto, one of the finest pictures of the Palazzo Pitti, I found very much altered by the restoration of Luporini. I had studied that picture very closely the year before, and should now sooner believe it to be a modern copy than the cleaned original. It has lost all softness of outline and the characteristic expression of the face. The change in the flesh tints can scarcely be explained otherwise but by an entire removal of the glazing.

I think it is taking a heavy responsibility to allow a new experiment to be tried upon such an invaluable work of art. Even private persons, who are fortunate enough to be in possession of such treasures, ought to feel responsible for the good preservation of masterpieces, which are, it is true, their material property, but which intellectually belong to the whole civilised world of the present and of the future.

UNIVERSITY AND EDUCATIONAL INTELLIGENCE

CAMBRIDGE.—Messrs. Mackren, Robbs, and Hichens, have been appointed to Scholarships in Natural Science at Gonville and Caius College.

EDINBURGH.—At the Graduation Ceremonial on Tuesday the degree of Doctor of Science in the Department of Mental Science, was conferred on Jacob Gould Schurman, B.A.; in the Department of Mathematics on Alexander Macfarlane, M.A., B.Sc.; in the Department of Chemistry on William Inglis Clark, B.Sc. The degree of Bachelor of Science was conferred on William Thomson in the Department of the Mathematical Sciences; on John Adrian Blaikie and James Johnstone Dobbie in the Department of the Physical Experimental Sciences; on William A. Haswell in the Department of the Natural Sciences; on James Alfred Ewing and John Gray in the Department of Engineering; and on John Brown, M.D., John Berry Haycraft, M.B., C.M., and John Trehame, M.B., C.M., in the Department of Public Health. The Hope Prize Scholarship in Chemistry was awarded to Mr. Lewis Johnstone, and the Falconer Memorial Fellowship for the encouragement of the study of Palæontology and Geology, of the annual value of 100*l.*, tenable for two years, and conditionally for four years, was awarded to R. A. Lundie, M.A., B.Sc.

BALTIMORE.—We recently referred to the system of fellowships at the Johns Hopkins University, Baltimore. From a statement on the subject which has come to hand, we learn that twenty fellowships, each yielding 500 dols. a year, are annually open in the University. They are awarded by the trustees on the nomination of the Faculty, as nearly on the first of June as may be found practicable. Candidates are invited from any part of the country. The object of this foundation is to give to a few scholars of promise the opportunity to prosecute further studies, under favourable circumstances, and likewise to open a career for those who propose to follow scientific and literary callings. The University expects to be benefited by the presence and influence of the Fellows, and by their occasional services; from among the number it hopes to secure from time to time some of its teachers. Three of the twenty fellowships are allotted this year to each of the five departments, Greek, mathematics, chemistry, physics, and biology; and the remaining five will be allotted either in these departments or in others, at the discretion of the Faculty. Appointments are made by a careful consideration of all the evidence submitted to the Faculty. Every candidate in presenting his name is expected to address a letter to the president indicating the course of his previous reading and study, and his general purposes with reference to future work. It is desirable for him to present in printing or manuscript an essay or thesis which may have been written either