

THE FLYING DRAGON.

This beautiful little animal has, according to the measurements made by Cantor, a length of not more than eight inches, of which four and three-fourths inches belong to the long, slim tail. The nostrils are on the side and are directed upward, and the tympanum is not covered. The male animal has a neck comb, and both sexes have a small lump back of the eyes. Small scales of about equal size cover the body, and larger ones cover the sides. As in all dragons the color varies considerably, not only in different parts of the body, but also in one and the same scale. Their beauty is beyond all description. The head of the living animal is of a metallic brown or green color, and is ornamented with a black spot between the eyes. The back and the inner half of the wing consist of a mixture of metallic dark-brown and pink, in some cases in alternating stripes, with numerous black spots and curiously wound lines. The color of the outer half of the wing varies between orange yellow and pink red, and has numerous irregular black spots and a silver edge. The members and the tail are covered with alternating stripes of pink and brown, and the eyelids are covered with radiating black lines. The neck is very light yellow, and the breast is of the same color covered with black spots. The flying dragon is found on the Sunda Islands, in Penang, and Singapore. Like other dragons it lives in trees entirely, and probably never comes to the earth unless forced to do so. Lacépède says that it is able to climb, walk, fly, and swim, but no proof of this assertion has been given. They generally rest on the tops of the trees, watching for insects, and as soon as they spy one they will leap for it, descending to the bough below; for although they can fly through the air in descending, they are not able to rise by means of their wings.

The female lays three or four yellowish white eggs, of about three eighths of an inch in length, which it is said they deposit in the holes in the bark of the trees. No further details are known.

The Insect Enemies of Books.

Dr. H. A. Hagen, according to the *Science News*, has recently made the insect pests of libraries the subject of an interesting lecture. Dr. Hagen admits the important fact that the white ant is present in Cambridge, and "everywhere else in the United States," and furthermore, that there have been two instances in this country of this insect causing a great destruction of books. Fourteen years ago, at Springfield, Ill., the bound copies of State papers were put aside in a room of the State House, which was not opened for a considerable period. When it was examined every book was found to have been more or less mutilated by ants. A Boston lady, a teacher in one of the Freedmen's schools in South Carolina, had even a more striking evidence of the destructive power of the insect. During the lady's absence from the school, in a vacation of six weeks, the ants ate through an entire library. A few of the least damaged specimens were saved as curiosities of literature and sent to Dr. Hagen. The volumes devoured were chiefly Bibles and prayer books.

The white ant is an uncertain danger. It may suddenly spring into activity and destructiveness, as it did here in the instance mentioned; as it did in France, where it all at once became formidable; or as it always does in Mexico, where old books and manuscripts are consequently rare. On the other hand, it may reserve its power for use in our native forests indefinitely, until some more tempting fare is provided by books locked up and not in use. Such books, however, are frequently of great value, and their bindings may be costly.

The other insect pests most known are the beetles belonging to the family *Ptinidae*, and of these the larvæ of the genus *anobium* constitute the true "book worm." The ordinary methods used for destroying these may prove also injurious to the finer kinds of binding. Dr. Hagen suggests, as a beetle remedy, that the volumes be placed under the bell of an air pump and kept for a short time in the vacuum produced by the withdrawal of the air therefrom.

Dr. Hagen dismisses the cockroach (*Blatta orientalis*) with the remark that "libraries will not often be stored in cellars."

In regard to the more recently imported ally of this species, the "croton bug" (*Ectobia germanica*), the editor of the *Science News* remarks that it is capable of doing damage upstairs as well as down. He says: "We have before us a volume, originally possessed of a bright red binding, which now has a speckled cover of white and brown blotches. The croton bugs ate off the red color almost wholly, and in some places penetrated a darker color, which seems to have been under the red. Probably the glue or the oil in the pigment of the binding proved attractive. The book lay outside, on a desk in an editorial 'sanctum,' far removed from the cellar, and was in occasional use during the period of its disfigurement. This instance does not stand alone; we have seen books that had been similarly attacked on the back, while standing on the shelves of libraries."

Before leaving this subject we may state that an interest-

THE FLYING DRAGON.—(*Draco volans*.)

ing illustrated article, written for the *SCIENTIFIC AMERICAN*, on the subject of the various insects that are known to destroy books, may be found in our SUPPLEMENT, No. 138.

A Humming Bird's Nest.

Recently a humming bird's nest was found by some persons who had sufficient natural curiosity to overcome their compassion, and who captured the nest, two young hummers and the old one, took them home and had them stuffed. They are to be sent to a museum of natural curiosities in London. The nest is built on a little twig, and scarcely the size of half an English walnut. Both nest and twig are covered with little patches of lichen until it is almost impossible to tell one from the other, and the nest looks like a kind of natural excrescence on the twig. The nest is pliable, like a tiny cup of velvet, and the inside is lined with a white substance, as rich and soft as white silk. The little birds are about the size of bumble bees, very pretty, and they sit on a little perch just outside the nest, with open bills, while the old bird hovers over them to feed them.—*Elizabeth (N. J.) Journal*.

The Chemistry and Physiology of Aquaria.

An interesting and valuable paper has recently been written by Dr. W. Hinds on this subject; and, as the *Gardener's Chronicle* says, is deserving of wider acquaintance among physiologists than will probably be secured for it in the journal in which it appeared (*Birmingham Medical Review*). The author first alludes to the ideas prevalent as to the importance of purifying the water of aquaria; one being that a balance must be preserved between water plants and the animals, that the former may utilize the carbon dioxide expired by the latter. Another opinion considers that the chief means of aerating the water must be effected by agitation, which is only supplemented by the assimilating process of plants. Dr. Hinds proposes to examine into the questions: 1. The time required for water to redissolve or take up air after exhaustion; 2. The ultimate destruction of carbonic acid dissolved in water at ordinary pressure and temperature. 3. The relation of the law of atmospheric mutual diffusion of gases to the air taken up by water. By a series of interesting experiments he shows that carbon dioxide, instead of accumulating in the water, is continually being got rid of by its escaping from the water into the air. A jar holding about half a liter of tap water had six small fishes placed in it. They became exhausted in four hours, but the water then gave no trace of carbon dioxide. He found also that this same water regained its normal 2.5 per cent of air on exposure for four hours. A jar one foot deep and six inches in diameter, charged with carbonic dioxide, left in a close room, with gas burning, etc., so as to render it as unfavorable as possible, required seventy hours to liberate itself of the gas; while the same jar lost it in twenty minutes under the constant agitation of pouring it backward and forward from one vessel to another. The higher the temperature the more rapidly does the gas escape, nearly twice the length of time being required on a cold snowy day.

Dr. Hinds finally comes to the conclusion that the law of the mutual diffusion of gases hitherto applied to gases in air holds true as well for gases dissolved in water. The practical conclusion is, that no trouble need be taken about freeing an aquarium of carbon dioxide, but only as to resupplying it with air; and to do this he suggests jets of air (not water) in a minute state of division, combined with extensive and slow contact, as being more effective than the method now adopted in large public aquaria. Dr. Hinds' results seem parallel in a remarkable way to the conclusion of Schläsing as to the diffusion of ammonia. That physiologist regards the tropical seas as the great reservoir of ammonia, brought down from the continents by large rivers. The sea parts with its ammonia to the air at the high tropical temperature; but when it circulates and arrives at temperate regions, the air being cooled parts with it to the rain, which brings it to the earth. One still desires to know why oxygen should be absorbed at all, and why carbon dioxide is liberated by water; but the facts are obviously of vital

importance as far as the maintenance of aquatic animal life is concerned.

The Best Kind of Silkworm to Rear.

According to the *Zoologist*, Dr. Wallace (a well known authority on the silkworm) remarked at a recent meeting of the London Entomological Society that he had experimented with nearly every kind of silkworm which had been introduced into Europe, and that he had come to the conclusion that the only one which would pay to cultivate in England was the *Bombyx mori*. It was true that the ailantus moth and others would produce a silk; but inasmuch as manufacturers, brokers, and silk merchants had invested large sums in the produce of *B. mori* they were not disposed to look with an eye of favor upon any other produce, which certainly would require much alteration in machinery and in the arrangements for business now extant. Moreover, the product of *B. mori* was a very superior article to that produced by any other worm.

It was true that in India, China, and elsewhere native products were prepared from the cocoons of indigenous moths, as, for instance, the Tusser silks from *Antheraea paphia*;

Moonga silk from *A. assama*; Pongees, from China and Japan, from the cocoons of the ailantus moth and of *Bombyx pernyi*; likewise a very valuable silk from the Japanese oak feeding *B. yama-mai*; and he thought that the cocoons of species feeding on the gum trees near Adelaide, New South Wales, which were exhibited that evening to the society, might be utilized in a similar manner. But none of these silks were adapted to the machinery now in use in Europe, and therefore it would be better to allow native industry to collect the produce and fabricate the silks in the countries where produced.

MOLECULAR CHEMISTRY.—No. 5.

Besides the labors of Kopp and Schroeder, described in the last two articles, extensive researches have been made in molecular chemistry by numerous European investigators, notably by Loewig, Boullay, Filhol, and more recently Pettersen; but their work is not now of sufficient general importance to claim our attention.

In 1870 West read a curious memoir before the Société Chimique of Paris, in which he makes the old equivalents $O = 200$, $H = 12.5$, $C = 150$, etc., the basis of his investigations. To find the volumes of bodies, West compares them not at a common temperature, but at temperatures at which they expand equally when further heated. His standard of expansion is that of water at its maximum density, and to this standard the bodies to be compared are reduced to find the temperatures at which their densities give comparable volumes. Where the rate of expansion is not experimentally determined, West employs an assumed rate and looks to the concordance of his results for its confirmation. By this method he finds the molecular volumes of 29 of the elements to be multiples of 2.8125; each of them, moreover, has several volumes. Oxygen, for example, occurs with volumes equal to 12, 24, and 48 times 2.8125, to which he assigns the names of microtome, mesotome, and megatome respectively. Potassium, whose equivalent, according to this system, is 487.5, has three volumes, which are 72, 144, and 288 times 2.8125.

West enumerates 63 amorphous compounds of oxygen, hydrogen, and carbon, whose volumes are equal to the sum of the volumes of their constituents when calculated according to his method. He finds that when carbon is present as a megatome it is tetraatomic, *i. e.*, it will combine with four equivalents of another body; when it is present as a mesotome it combines with only two equivalents. Nearly 200 examples are given in illustration. Again, the volume of oxygen determines the chemical properties of a body; the microtome produces acidity, the mesotome neutrality, and the megatome a tendency to combine with more oxygen.

In this country the credit of paving the way for further discovery belongs to Prof. F. W. Clarke, of the University of Cincinnati, the author of a work entitled "Constants of Nature," and published by the Smithsonian Institution in 1873. This book, which has now become indispensable to the chemist, contains not only the densities, the boiling and melting points, and formulas of all substances that have been studied, but provides for the correction of unavoidable inaccuracies by its references to the original authorities.

In December, 1874, Clarke published an important memoir in the *American Journal of Science*, with the object of determining the nature of the difference between water of constitution and water of crystallization; that is, between water intimately combined with a substance and water that may be driven off by heat without destroying the compound. To discover, in the first place, whether water of crystallization had a constant volume or whether it differed for different compounds, he determined the volumes of 31 salts, both when hydrated and when deprived of their water, from a great number of density determinations, and then proceeded as follows: The molecular volume of hydrated chloride of calcium, $\text{CaCl}_2 + 6\text{H}_2\text{O}$, is 133.9; that of the anhydrous, CaCl_2 , is 49.6. Subtracting the latter from the former, $133.9 - 49.6 = 84.3$, the molecular volume of $6\text{H}_2\text{O}$; dividing by 6 we have 14.05, the volume of water of crystallization in this salt, provided that no change takes place in the volume of CaCl_2 in combining or parting with its water. The other 30 salts, which contained from 2 to 18 equivalents of water of crystallization, yielded volumes ranging between the narrow limits of 13 and 15, and averaging 13.76. From this it is evident not only that water of crystallization has a definite volume, but also that no change of volume takes place in the rest of the salt when it combines with such water.

On the other hand, when H_2O is present as water of constitution a great diversity of values is found for its volume in different salts. Thus, the volume of potassium hydrate, $\text{K}_2\text{O}, \text{H}_2\text{O}$, is 54.8; that of the anhydride, K_2O , is 35.4; subtracting we have for H_2O the volume 19.4. Again, in iron sesquioxide we have for the hydrate, $\text{Fe}_2\text{O}_3, \text{H}_2\text{O}$, and the anhydride, Fe_2O_3 , a difference of volume equal to 9.0. Hence we may reasonably conclude that when water combines in this intimate manner with a salt both undergo a change of volume.

In the *American Journal of Sciences* for April, 1877, Clarke published a list of the fluorides, chlorides, bromides, and iodides of lithium, sodium, potassium, and rubidium, 16 compounds in all, whose volumes proved to be almost exact multiples of 5.5. It was from this list that Schroeder derived some of the data for the support of his steric law.

It was reserved for the genius of Dr. Henry Wurtz, of Hoboken, to evolve entirely new and fertile ideas from the enormous mass of material which had accumulated for the study of molecular volumes. Availing himself of the den-

sity determinations collected by Clarke, and verifying them by reference to the original authorities, Wurtz subjected the views of Kopp, Schroeder, and others to the test of accurate computation. A vast number of bodies, simple and compound, organic and inorganic, were examined in this way, and the results showed discrepancies that could not be reconciled with each other or with the chemical relations of the bodies in question. While engaged in this work it struck Wurtz that, as all the molecules of a homogeneous body must occupy equal spaces or volumes, there should exist not simple multiple but *cubic relations* between the molecules of different bodies, especially when they are compared at some uniform temperature. This novel idea he afterward established, to his own satisfaction, by a long chain of evidence.

Before giving his proofs it will be well to state his method of interpreting the very considerable discrepancies that are often found in the densities of the same body by the most accurate experimenters, and that have proved a snare to many investigators of molecular volumes, who did not resist a very natural partiality for such numbers as would agree with their preconceived views. Wurtz believes that we are not warranted in rejecting any density determinations by reputable experimenters on the ground of personal errors or of impurities present in their specimens. In the case of common salt, NaCl , for example, we have the following densities: By Playfair and Joule, 2.011; Unger, 2.03; Sterry Hunt, 2.135; Stolba, 2.163; Hassenfratz, 2.2; Filhol, 2.24; Mohs, 2.26. He considers such variations of density as due to real differences of molecular volume produced by divers causes, such as the temperature at which the body was formed, the condition of the liquid from which it crystallized, etc. That he does not stand alone in this opinion is shown by the remark of Favre and Valson in the *Comptes Rendus* of the French Academy of Sciences for 1873, who were led to believe by their researches in crystalline dissociation "that the density of a salt is not an absolutely fixed element, but that it may vary slightly with the circumstances of its formation, *e. g.*, according as it has crystallized slowly or has been precipitated more or less rapidly from the mother liquor." As regards the figures just given for common salt, Wurtz believes that we have here a number of modifications or allotropes of the same substance, and also that the tendency to vary in density and consequently in volume is almost universal throughout the whole range of chemistry.

Another noteworthy feature in the mode of operation of this investigator is an attempt at obtaining greater accuracy in the comparison of the various density figures of two different compounds for the purpose of arriving at the value of some constituent common to both. Instead of simply averaging each series, each individual number of one is compared with all the numbers of the other. Thus, if there are four densities given of one body and six of another, twenty-four values are obtained, which are then averaged.

The starting point for the new system was found in the density of peroxide of hydrogen, $\text{H}_2\text{O}_2 = 1.452$ by Thénard. This specimen contained 2.6325 per cent of water. On making allowance for this impurity the density becomes 1.4642, and this divided into the equivalent of $\text{H}_2\text{O}_2 = 34$ gives us 23.220 for the volume. Now we have only to subtract the volume of water, $\text{H}_2\text{O} = 18.000$, to obtain the volume of the extra equivalent of O contained in the peroxide: $\text{H}_2\text{O}_2 - \text{H}_2\text{O} = \text{O} = 23.220 - 18.000 = 5.220$. Again, on the supposition that the two volumes of oxygen in H_2O_2 are equal, we have only to subtract their value from the volume of H_2O_2 to obtain, $23.220 - 2 \times 5.220 = 12.780$, the value of H_2 , and this divided by 2 gives us for the hydrogen volume 6.390. Subsequent research proved these values to be slightly inaccurate, and 5.184 was definitively settled upon for the oxygen and 6.1408 for the hydrogen volume. It will suffice to select one among the many means of verifying these figures. The volume of liquid N_2O is 47.913, that of liquid N_2O_4 is 63.4625; difference, $\text{O}_2 = 15.5495$, and $\text{O} = 5.1832$.

When the new oxygen volume was substituted in a number of carbonates, the volume of carbon was found in nearly all cases to come out almost exactly 8. The approximations in these and other computations were the closer the nearer to 0°C . the densities had been determined. Now, 8 is the cube of 2.

Perhaps the reason that no one had before observed the close approximation of some volumic values to even cubes lies in the fact that they all contain a decimal point. The density of the diamond, for example, is 3.55. Dividing this into the equivalent 12, we find that carbon in this form has a volume of 3.380. Now, we have only to omit the decimal point to see that we have here as close an approximation to the cube of 15 = 3375 as we have any right to expect from the unavoidable imperfection of our experimental processes. If we make the equivalent of hydrogen 1,000 instead of 1, and thus multiply all the equivalent numbers by 1,000, all our volumes will come out as whole numbers, and cubic relations will at once become apparent.

Bunsen found the density of iceto be 0.91674. Its molecular volume is, therefore, the equivalent 18.000 divided by 0.91674 or 19,635. The cube of 27 is 19,683.

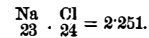
When Kopp found the volume of $\text{CH}_4 = 22 = 21.8$ at zero, if he had multiplied by 1,000 he would have obtained 21,800, which is not very far from $28^3 = 21,952$.

Clarke's volume for water of crystallization = 13.76, treated in the same way, becomes 13,760, and suggests the cube of 24 = 13,824.

The carbon volume 8, alluded to above, when multiplied by 1,000 is exactly the cube of 20.

As solids are to each other as the cubes of their diameters,

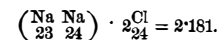
the numbers obtained by extracting the cube roots of volumes may be regarded as molecular diameters. Thus, 20 represents the diameter of the carbon molecule in carbonates, 15 that of the diamond molecule, 27 that of the ice molecule, etc. This conception gives rise to a new system of notation, in which the numbers expressing diameters are placed directly under the symbols of the substances designated. To represent the common salt of Filhol and Mohs, Wurtz writes:



This means that the volume of Na is $23^3 = 12,167$, and that of Cl is $24^3 = 13,824$. Their sum, 25,991, divided into 58,500, the molecular weight of NaCl , gives us the density 2.251. (The density of a substance is its weight divided by its volume.)

We cannot do more here than indicate the vast amount of labor performed in these researches by simply stating that every important class of chemical compounds has been studied, tabulated, and shown to conform to the laws presently to be explained. For detailed information we refer to a memoir entitled "Geometrical Chemistry," in the *American Chemist* for March, 1876, and to later and more accurate publications in the last edition of "Johnson's Cyclopaedia," chiefly under the head of "Volumes, Molecular." Since then Wurtz has continued his investigations with unremitting zeal, not satisfied with his generalizations until he had convinced himself of their universal application.

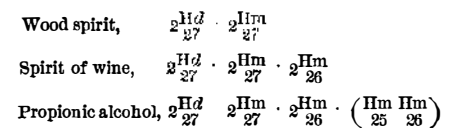
He found, in the first place, that the diameters of elementary molecules had a limited range of variation throughout the compounds into which they enter, and that their tendency to vary is directly as their basicity or electro-positive attitude toward the elements with which they are associated. In the different varieties of common salt, for instance, the sodium diameter will vary, while that of the chlorine remains constant. Stolba's variety is represented by



Hydrogen, the most electro-positive element, has a range of 16 to 28, while oxygen, the most electro-negative of all, never varies, but always has the fixed volume 5,184, which is not an even cube, but curiously enough 3×12^3 .

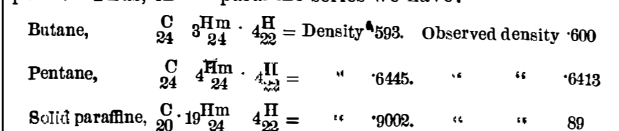
The diameters of some of the other common substances are: Chlorine in chlorates 20, in chlorides 24 or 28; sulphur in most metallic sulphides 20 in sulphates 24; carbon in hydrocarbons and carbonates 20; nitrogen 20, in cyanogen 24; silicon 20.

In the case of allotropes like the two varieties of common salt whose formulas have been given, and of organic homologues—that is, of series whose members differ in composition by the successive addition of the same elements—the tendency of the added molecule is to assume a diameter already present, or a diameter next above or below one already present. To understand this more fully compare the following volumic formulas for some members of the alcohol series:



In these formulas Hd stands for H_2O with the ice diameter, and Hm for H_2C . In the former Wurtz gives the name of hydor and to the latter that of homolgen. Observe that the diameter of each additional molecule shows the tendency just mentioned. It was at first supposed that this tendency, to which the name of engymmetry was given, applied also to other classes of compounds; but it afterward turned out that they exhibited a remarkable regularity of a different kind. Before taking up this subject it will be expedient to learn Wurtz's views with regard to the nature of the components designated by him as Hd and Hm. In constructing his volumic formulas he found very numerous instances in which the calculated densities could not be made to agree with those obtained experimentally, except on the theory that in these bodies certain ones of the elements were more intimately combined with each other than with the other constituents, and that they formed groups expanding and contracting as a whole. Of such groups, or radicals as he calls them, he at first found only four, *viz.*, cyanogen, ammonium, Hm and Hd; but he now holds that others may be formed from the last two by substitution. Such a view, of course, sweeps away a great army of hypothetical radicals in organic chemistry—a proceeding which chemists will be very loth to permit.

When the formulas of organic bodies are examined according to the method just indicated, and the volumes of Hm and Hd have been subtracted, there will be found remaining a carbon nucleus consisting of C in alcohols, ethers, and fatty acids, of 3C in aldehydes, of 4C in benzoles and olefines, of 4C in sugars and starches, etc. The variations in diameter of these carbon molecules appear to be connected with the liquidity and solidity of a body, and also with its boiling point. Thus, in the paraffine series we have:



The first two are liquids and have $C = 24$; in the third, which is solid, $C = 20$. Between them there are 14 members of the series which furnish concordant formulas.

The 16 specimens of butyric alcohol, $\text{C}_4\text{H}_9\text{O}_2$, whose densities have been determined by different chemists, may be