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A PLEA FOR A BROADER BOTANY.

BY L. H. BAILEY.

THE science of botany, as ordinarily considered and taught, has not laid hold of the full amount of territory to which it is entitled, and it has not, therefore, reached its full measure of usefulness. Strictly speaking, botany is the science of plants, but by general consent it appears to have dwarfed itself into a science of wild plants; or if it deals with cultivated plants they are such as fall to the care of botanical gardens, or, in other words, those which are cultivated for the sole purpose of maintaining a collection. It is not strange that in the earlier days botanists should have eliminated from their domain the whole realm of cultivated plants, for cultivation then meant little else than the maintenance and improvement of plants for merely economic purposes, and there was little science of cultivation. But now that the teachings of evolution have thrown a new purpose into the study of all natural objects, cultivated plants have acquired a fascinating interest from the abundant light which they throw upon variation and descent. In fact, aside from paleontology, there is no direction in which such abundant material can be found for the study of evolution as in cultivated plants, for in nearly all of them the variation is fully as great as in domesticated animals, while the species are very many times more numerous; and, by the fostering aid rendered by man, the accumulative effects of modified environment and selection are much more quickly seen — and therefore more intelligible — than in wild plants. My nearest neighbor, who is a paleontologist, and myself, a horticulturist, compare our respective fields of study to the decay and burning of a log. In both decay and burning the same amount of work is finally accomplished and the same amount of heat is evolved, but one process requires years, perhaps a century, for its accomplishment, and the other requires but a few hours. Cultivated plants afford within definite periods of time as much variation and progression as their wild prototypes exhibit in ages. So the garden is one of the best places in which to study evolution. It is a common opinion, to be sure, that the variation of cultivated plants is anomalous and uninstructive because influenced by man, but this is wholly erroneous. I have yet to find a variation in cultivated plants which can not be explained by laws already announced and well known. It is strange that one can ever believe that any variation of natural objects is unnatural !

But wholly aside from the fascinations of pure science, cultivated plants and cultivation itself demand the attention of the botanists, for horticulture is nothing more than an application of the principles of botany. Just now, mycology is making important additions to horticultural practice, but there are greater fields for the applications of an exact science of plant physiology, whenever that science shall have reached a proportionate development. In short, the possibilities in horticulture, both in science and practice, are just as great as they are in the science of botany upon which it rests; and inasmuch as it is absolutely impossible to separate horticulture and botany by any definition or any practical test, the two should go together in an ideal presentation of the science of plants. Horticulture belongs to botany rather than to agriculture.

The ideal chair or department of botany, therefore, should comprise, in material equipment, laboratories, botanic garden, green-houses, orchards, vegetable and ornamental gardens, all of which should be maintained for purposes of active investigation rather than as mere collections; and I am sure that no department of botany can accomplish the results of which the science is capable until such breadth of equipment is secured. I am aware that there are difficulties in such a comprehensive field, but the only serious one is the lack of men. Botanists, as a rule, care little for gardens and cultivated plants, and horticulturists are too apt to undervalue the importance of scientific training and investigation; but the time cannot be far distant when men shall appear with sufficient scientific and practical training to appreciate the needs of the whole science and with enough executive ability to manage its many interests. Such men are no doubt teaching in some of our colleges to-day, were the opportunity open to them. One cannot be a specialist in all or even several of the many subjects comprised in this ideal, but he may possess the genius to encourage and direct the work of other specialists. The first need is the opportunity, for there is not yet, so far as I know, an ideal chair of botany in existence, where the science can be actively studied in its fullest possibilities and then be presented to the student and the world.

Cornell University.

THE LAWS AND NATURE OF COHESION.

BY REGINALD A. FESSENDEN.

DESIROUS of finding some relation between the conductivity of metals and their other physical properties, the writer, several years ago, began to tabulate all the data he could find. Realizing the uselessness of comparing the properties of substances whose natures are essentially different, as wood and iron, it was decided to confine the work to the elementary substances. It was found that the only elements whose properties were at all well known were those of the five chemical groups comprising the following metals: I., iron, nickel, cobalt, platinum, osmium, iridium; II., sodium, copper, silver, gold; III., magnesium, zinc, cadmium, mercury; IV., aluminium, thallium, indium, gallium; V., silicon, tin, lead.

The data collected were not very concordant, but when they had been compared and the most probable values taken, laying due stress on the purity of the substances examined and the standing of the observer, various regularities or laws were at once apparent, and it is for the purpose of pointing out one of these that the following paper has been written.

This piece of paper, taken as a whole, has certain properties, a certain size, a certain weight, a certain motion, and is the seat of a certain force which attracts other ponderable bodies to it. A single atom of matter has its weight, motion, size, and force. The weights of the atoms form the basis of electrometric chemistry, their motion that of the kinetic theory of heat. To their size less attention has been paid, we have only Mendelejeef's curve and certain experiments of Roberts-Austen, who has showed that the tensile strength of gold is weakened, not in proportion to the weight of the metal alloyed with it, but to the volume, in the same way as ten lumps of gravel weaken a casting more than ten grains of sand. Of the force — the force of cohesion — still less is known, in fact absolutely nothing, and the object of this note is to point out what the nature of this force is and what its laws are.

In its early youth science was riotously extravagant of ethers, and any puzzling phenomenon was considered warrant enough for the creation of a new one. As it has grown older it has grown also more economical, until at the present day the scientist who should ask for an appropriation of a new ether, to help him out of a difficulty, would be pounced upon. For this reason, if no other, we will confine ourselves to examining the various means by which our present ether has been supposed capable of producing the forces which cause cohesion.

1. Gravitation. There have not been wanting eminent scientists who have considered that gravitation could account for cohesion, and there have been many ingenious theories proposed, for instance that of Watts, who supposed that (since the effects of gravity on the moon's path may be supposed to consist of two parts, one independent of the shape of the earth and varying inversely as the square of the distance, the other dependent on the shape and varying inversely as the cube of the distance) if the atoms were of irregular shapes it might account for the effects. But no theory with gravitation as its basis will hold, first, because the effects are much too small; second, because, as we shall see, the cohesive force is totally independent of the weights of the atoms and depends on the size only.

2. Condensation and rarifaction of the ether caused by the motion of the atoms. If we hold a pith ball near a tuning fork the pith ball will be attracted up to a certain distance, and will then be repelled if brought closer. This theory has been a favorite with many, but, as such an attraction would vary with the motion of the atoms in a way that we know the force of cohesion does not, it also must be dismissed.

3. Electricity. That the force of cohesion was due to electricity has long been vaguely suspected. On the same principle apparently that electricity was considered to be the cause of life, *i.e.*, "Life is a wonderful thing and unexplainable, electricity is a wonderful thing and unexplainable; therefore electricity is life" — the argument being possibly aided by an instinctive recollection of the Athenasion creed, which states that "there is only one incomprehensible." The writer is not aware that any evidence in favor of this theory was ever offered, so it was probably merely a guess.

Having rejected theories 1 and 2, we may see how the facts agree with the theory that cohesion is an electrostatic effect.

If we electrolyse a solution of silver nitrate, we know from Faraday's work that every atom of silver deposited on the electrodes carries over a certain quantity of electricity. This quantity is always the same, no matter how or when or where we perform the electrolysis, and this quantity seems to be related to the atoms in the same way as a pint of water to a pint measure. We may calculate the quantity on each atom in the following way. One cubic centimeter of silver weighs about 10.5 grammes. One coulomb is carried over by every 1.12 milligrammes of silver deposited, therefore the charge on the atoms contained in one cubic centimeter of silver is $\frac{10500}{1.12} = 10^4$ coulombs.

As the sizes of the atoms vary from 10^{-7} to 10^{-8} centimeters in diameter, and silver is a small atom ($\frac{1}{4}$ the size of potassium), we may call its size 10^{-8} centimeters. In a cubic centimeter of silver then there would be 10^{24} atoms, which would give as the charge on each atom $10^4 \div 10^{24} = 10^{-20}$ coulomb. The capacity of an atom having a diameter of 10^{-8} centimeter is

$$\frac{10^{-8}}{18 \times 10^{11}} = 0.5 \times 10^{-20} \text{ farads.}$$

The potential on each silver atom will therefore be about one volt. We may look at the cubic centimeter of silver as being made up of planes, each plane consisting of one layer of atoms. The distance between the centres of any two layers would be 10^{-8} centimeters. The potential on the atoms being one volt, the attraction between any two layers would be

$$\frac{4.5 \times 10^{-11} \times 1^2}{10^{-16}} \text{ grammes per cm}^2 = 4500 \text{ kg. per cm}^2 = \text{calculated tensile strength of silver} = 45 \text{ kg. per sq. mm.}$$

From Wertheim's results we have observed tensile strength of silver 38 kg. per sq. mm. That the calculated and observed results should be so close is of course only a piece of good fortune. We had no right to expect it, as the data upon which the calculation is based are not known with sufficient accuracy. Still, the result is a remarkable one, and places beyond question the fact that the known electric charges on the atoms can produce effects of the same order as those observed.

Having shown this, we may follow up the theory by investigating in what way the cohesion of the metals would vary if this were the case. Evidently (since every atom, large or small, has the same quantity of electricity, and the larger the atoms of a metal the farther away the centres of the atoms would be) the cohesive force should be inversely proportional to some power of the size (or atomic volume, as it is called, and which is got by dividing the atomic weight by the density of the substance). The following table shows this to be the case. In the first column are the names of the metals, in the second their relative sizes, or atomic volumes, in the third their rigidity, as given by Mr. Sutherland in the *Philosophical Magazine* of August, 1891: —

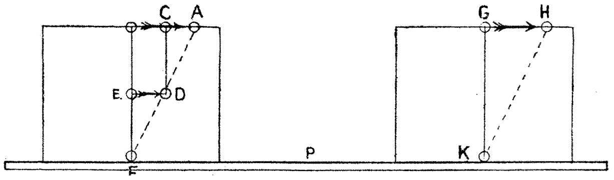


FIG. 1. FIG. 2.

I.	II.	III.	IV.	V.
Iron	7.1	750 × 10^9	483 × 10^9	550 × 10^9
Copper	7.1	430	483	550
Zinc	9.2	350	314	340
Silver	10 2	280	270	270
Gold	10.2	270	270	270
Aluminium	10.4	250	250	260
Magnesium	14.	150	154	143
Tin	16.	136	122	100
Lead	18.	84	100	83
Cadmium	13.			170

As will be seen, the agreement is perfect, with the exception of iron, and those who are familiar how greatly the properties of iron are changed by the least particle of impurity will possibly agree with me in thinking that absolutely pure iron would be less rigid; in fact, some recent experiments show that it is so, being nearer 600 than 750; but I have not inserted this value, because a comparison with a set of observations made by one observer at one time and by one method would have a greater value than comparison with a lot of picked results from different observers.

Assuming the electrostatic theory, we can easily calculate the exact function which rigidity should be of the atomic volume in the following way.

Suppose Figs. 1 and 2 to represent two cubic centimeters of different elements, of which the atoms of one are twice the diameter of the other, or, to put it more accurately, the distance between centres of atoms is twice as great in the one case as in the other. Let 1 contain the smaller atoms. Suppose one face made fast to the plank p, and both sheered slightly till they have the position shown by the dotted lines. It is evident that the ratio of work done in bringing the atom at G over to H to that done in bringing E to D, or C to A, will be the mean ratio of the force of attraction between K and G to that between E and F. This latter varies inversely as the square of the distance, according to the well-known electrical law, and, consequently, as the distance $G\,K$ is twice that of $E\,F$, the work done in moving E to D will be four times that done in moving G to H. Again, in Fig. 1 there will be 2^3 as many atoms to be displaced as in Fig. 2, so that, on the whole, there will be $2^2 + 2^3$ as much work done in displacing the cube in Fig. 1 as in Fig. 2. In other words, the rigidity will vary inversely as the fifth power of the distance between the centres of the atoms, or as (atomic volume) $^{\frac{5}{3}}$. Col. IV. gives the results calculated on this theory. As will be seen, they agree fairly well, as well as could be expected, considering the fact that we have left out one factor. This is the variation of rigidity with temperature, and as it would be obviously unfair to compare lead and silver at 600° C., it is obvious that our calculated results should only be applied when the metals are at some one point, say, at a temperature which is $\frac{1}{4}$ the temperature of their melting-point. As those metals having the greatest atomic volume, as a rule, melt at lowest temperature (though there are many exceptions to this) we may make a rough sort of formula, which shall give the rigidity at ordinary temperatures by multiplying again by the atomic radius, so we get (atomic volume) ^{2} as the rate at which rigidity varies with size of atoms. Col. V. is calculated in this way from the rough formula : —

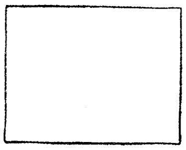


FIG. 3.

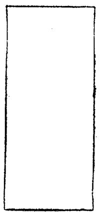


FIG. 4.

$$\text{Rigidity} = \frac{28 \times 10^{12}}{(\text{atomic volume})^2} \qquad \text{Equation I.}$$

The formula for Col. IV., and the more correct one, if we neglect variation of rigidity with temperature, is

$$\frac{12560 \times 10^9}{(\text{atomic volume})^{\frac{5}{3}}} \qquad \text{Equation II.}$$

The other moduli are related to that of rigidity. For if we represent Young's modulus by $\frac{1}{a}$, then the modulus of rigidity is represented by $\frac{1}{2\,(a+b)}$ and the bulk modulus by $\frac{1}{3\,(a-2b)}$, where b represents the lateral shortening accompanying the longitudinal lengthening a. So if b bears to a any constant ratio, then Young's modulus and the bulk modulus will each be some fraction of the modulus of rigidity. The continental writers, at least a good many of them, hold that $\frac{b}{a} = \frac{1}{4}$. Kelvin, Tait, and Stokes say there is no relation. On the one hand, it is certain that $\frac{b}{a}$ is not constantly equal to $\frac{1}{4}$. On the other hand, it does not follow that there is no relation between the two, and the evidence which has been brought to prove this has no value, for we have no right to argue from the facts that in india-rubber $\frac{b}{a} = \frac{1}{2}$, while in cork $\frac{b}{a} =$, say, $\frac{1}{100}$, that $\frac{b}{a}$ does not have any constant ratio in metals. The laws which govern the moduli of compounds and non-homogeneous substances like india-rubber and cork are not the same as those which govern homogeneous substances like gold and silver.

The following is a table of the metals and their Young's moduli. Col. I. contains the observed moduli taken from Sutherland's paper, and Col. II. contains the calculated values from the equation.

Equation III. Young's modulus $= \frac{78 \times 10^{12}}{(\text{atomic volume})^2}$ (corresponding to Equation I.).

Metals.	I.	II.
Iron	$2{,}000 \times 10^9$	$1{,}560 \times 10^9$
Copper	1,220	1,560
Zinc	930	920
Silver	740	750
Gold	760	750
Aluminium	680	690
Cadmium	480	465
Magnesium	390	395
Tin	420	295
Lead	190	235

There is only one metal which does not agree with theory, and that is tin (iron, of course, on account of its impurities does not, but we know that, as we obtain iron more pure, we find its rigidity less, so there is very little doubt but that if it were absolutely pure the agreement would be closer). But it is easy to show that the observed results of tin are wrong. For the rigidity is given as 136×10^9 and the Young's modulus as 420×10^9. Therefore, if we represent Young's modulus by $\frac{1}{a}$, then $\frac{1}{2\,(a+b)} = \frac{136}{420}$. Solving this we get $b = .55\,a$. Therefore the bulk modulus $\frac{1}{3\,(a-2\,b)}$ is negative, and the more tin is compressed the larger it swells, a result which is absurd. This will emphasize the fact that the agreement between theory and experiment is as close as that between the experiments themselves.

It will be noticed that the ratio-rigidity, Young's modulus, is about $\frac{28}{78}$. Therefore, as $\frac{1}{2\,(a+b)} = \frac{1}{2.7}$, Poisson's ratio for these metals is, on the average, 0.35. Therefore the bulk modulus = 1.1 times Young's modulus, which agrees with the only datum I find in Everett, i.e., Wertheims's figures for brass, which gives the ratio 9.48 : 10.2 = 1.08, very closely. All these moduli must contain the atomic volume to the same power, but this is not the case with the tensile strength; for, according to this electrostatic theory of cohesion, we may look at a wire as made up of thin discs, each disc consisting of a layer of atoms. The attractive force between any two such layers would vary inversely as the square of the distance between them and directly as the number of atoms in a layer. Combining these we find that it would vary as the fourth power of the atomic radius, or as (atomic volume)$^{\frac{4}{3}}$, making no allowance for the effect of temperature on the tensile strength. The following table gives in Col. I. the observed tensile strengths, taken from Wertheim for wires 1 millimeter in diameter; in Col. II. the atomic volumes of the elements, raised to the $\frac{4}{3}$-power; and in Col. III. the calculated tensile strengths, as found by the formula.

Equation IV. Tensile strength $= \frac{638}{(\text{atomic volume})^{\frac{4}{3}}}$ in kilograms for wires 1 millimeter in diameter.

Metal.	I.	II.	III.	IV.
Iron	65	13.7	48	2,000 (?)
Copper	41	13.7	48	1,327
Platinum	35	17.8	36	1,800 (?)
Zinc	15.77	19.3	33	690
Silver	29.6	22.2	29	1,223
Gold	28.46	22.2	29	1,313
Aluminium	18	23.2	27	898
Tin	3.40	41.	15	504
Lead	2.36	47.8	13	600

Col. IV. contains the melting-points in degrees Centigrade from absolute zero. Here we have to deal with a much more complicated phenomenon than that of rigidity. Rigidity is simply a function of the cohesive force. The tensile strength of a substance depends not only on the cohesive force of the metal, but also on its ability to resist flow. If a metal did not flow before being pulled apart, there is no doubt but that its tensile strength would be proportional to the $\frac{4}{3}$-power of the atomic volume. As, however, it does flow, and the amount of flow is not simply proportional to the diminishing of the cohesive force, we have to make a fresh allowance for it. In all the metals the melting-point is reached when the linear expansion has amounted to about 2 per cent. So when the cohesion has diminished about 4 per cent the atoms no longer hold the same relative positions, but one can slip in and take the place of another. So at equal distances from their melting-points only can the tensile strength be proportional to the $\frac{4}{3}$-power of the atomic volume. Consequently this ratio can only hold good with substances which have approximately the same melting-point. On examining the table, it will be seen that as copper, gold, and silver have approximately the same melting-point, the ratio does hold good with them. The same with tin and lead. Aluminium and zinc, which should be, the one slightly weaker, the other slightly stronger, than silver, have a melting-point about one-half that of gold and silver, and they have about half the strength at the temperature of comparison which they should have. The melting-point of iron and platinum is higher than that of gold or silver, and consequently their tensile strength is greater. The flow of a metal depends on two things, the cohesive force and the kinetic energy of the atoms. What function the flow is of the temperature, as reckoned in fractions of the temperature at which the substance melts, it is hardly worth while to go into now. If we suppose it directly proportional (though we may feel fairly certain it is not as simple a function) so that, at the same temperature, a metal melting at half the temperature that another does flows twice as easily, we get the following table, where Col. I. contains the observed tensile strengths, and Col. II. the calculated ones: —

Metal.	I.	II.
Iron	65	74
Copper	41	48
Platinum	35	48
Silver	29.6	29
Gold	28.5	29
Aluminium	18	18
Zinc	15.7	16
Tin	3.4	5
Lead	2.36	4

I have not been able to find any data on the tensile strength of magnesium. Theory gives about 9 kilograms for a wire 1 millimeter in diameter. It would be interesting to find if experiment confirms this.

If, when we have met with a new phenomenon in a substance, and are able to show that a certain property already known to exist in the substance is capable of producing effects of the magnitude observed, and that the phenomenon obeys the same laws as it would if it were caused by the already known physical property, we are to a certain extent justified in supposing that this property is really the cause of the phenomenon in question, and in applying our knowledge still further, we have seen that the charges which we know the atoms have on them are able to give effects of the same size as those observed in experiments on tensile strength, and that the various moduli follow the same laws as they would if cohesion were an electrostatic effect, and we may now apply our formula to other and less-known phenomena.

The velocity of sound in a wire is given by the formula: —

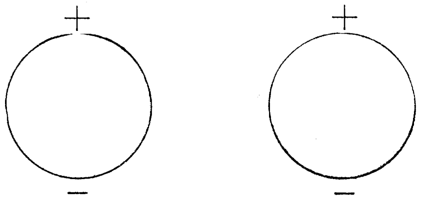
$$\text{Velocity} = \left(\frac{\text{Elasticity}}{\text{Density}}\right)^{\frac{1}{2}}.$$

Elasticity here means Young's modulus, the formula for which, as we have seen, was constant ÷ (atomic volume)^2, and atomic volume is atomic weight ÷ density, so we have velocity of sound in wire $= \left(\frac{\text{constant}}{\text{atomic weight} \times \text{atomic volume}}\right)^{\frac{1}{2}}$, the constant being 78×10^{12}. The following table gives in Col. I. the velocities of sound in wires of a number of metals which have been tested, and in Col. II. the calculated velocities for these and for other metals which have not yet been tested.

	I.	II.	III.
Silver	2.61×10^5	2.7×10^5	100
Copper	3.56	4.1	110
Gold	1.74	1.9	136
Alumin.		5.1	200
Magnes.		4.8	275
Zinc		3.6	374
Cadmium		2.3	450
Tin		2.0	878
Lead	1.23	1.4	1300

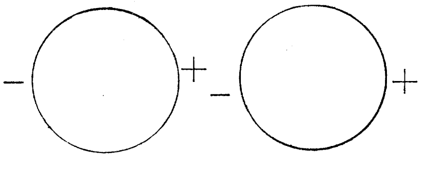
Col. III. gives the electrical resistance, silver being taken as 100, and it may be noticed that in any one group of metals the conductivity varies directly as the velocity of sound, and in passing from one group to another, by multiplying the conductivity by the valency we get proportionate values for all the metals. The same holds good for the heat conductivity. No close agreement can be expected here, for there are too many things to be taken into account. It is merely mentioned here because the fact of there being a relation between the velocity of sound and the conductivity for heat and electricity throws a light on the nature of these phenomena. This will form the subject of a separate paper. It may be asked *how* an electrostatic force can produce such effects. If the atoms are all similarly charged either + or — they would repel each other and not attract. The explanation is probably this: The atoms, if we may call them so, of electricity are not infinitely smaller than the atoms of matter. When an atom is neutral it does not mean that it has no charge but that it has equal quantities of both kinds of electricity. The resultant effect of these charges on a body at a distance is zero, it behaves as if it had no charge, as shown below, in *A*.

A

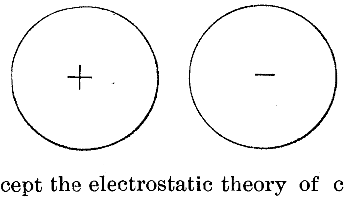


If the atoms be brought close together there is a state of unstable equilibrium, and the effect is that either the charges move on the surface of the atoms or the atoms themselves move so that the atoms attract each other, as in *B*. Consequently all atoms neutrally charged attract each other. If nothing further happens the attraction is simply cohesion. If, however, any third substance connects the two outside parts of the atoms and so enables these parts to neutralize each other we have chemical combination, and the two atoms when separated show opposite charges, as in *C*.

B



C



Whether we accept the electrostatic theory of cohesion or not, from the above tables of moduli, the following laws are evident.

I. In any two metals the force of cohesion varies inversely as the square of the distance between the centres of their atoms.

II. In any one metal the force of cohesion varies inversely as the square of the distance between the centres of its atoms.

We may expect these facts to be of great use in the study of the properties of matter. For, knowing the size and weight of the atoms and the velocity with which they move, all that was wanting to enable us to calculate the behavior of the atoms of matter, in the same way as we do the motions of the planets, was a knowledge of the laws of the force which holds them together; and, from the evidence given above, I have no doubt that you will agree with me in saying that we have at least made a beginning in that direction.

A few words might be said about Poisson's ratio. It is, as I said, not fair to argue from the behavior of cork or india rubber that there is no relation between longitudinal extension and lateral contraction or between *a* and *b*. When we compress a cork we are not compressing the substance which forms the cork any more than we are compressing a piece of paper when we crumple it up in our hand. A cork is like a dry sponge, and when we squeeze a sponge up in our hand we are simply doubling up the cell-walls, not compressing the substance of the sponge. The only way in which we can determine the compressibility of cork is to soak it in ether or some substance which fills all its pores and then subject it to hydrostatic pressure. In the same way when we stretch india rubber, or ivory or jelly, the longitudinal extension of the piece of rubber is not in the least a measure of the longitudinal extension of the substance of the rubber. All such substances are made up of two parts; rubber, for instance, of a hard elastic skeleton, insoluble in most solvents, and of a soft plastic substance, soluble in many solvents, by use of which the two parts may easily be separated, similarly ivory and jelly. Let us take a square cell as in Fig. 3, the walls of which are of elastic material and the contents an incompressible plastic substance. Suppose it to be extended till its length is 4 centimeters and its breadth and thickness each 2 centimeters, as in Fig. 4. The total area of cell-wall is 40 square centimeters, and the total volume of incompressible contents is 16 cubic centimeters. Imagine the cell to be released, it will regain its position as in Fig. 3, and form a cube of side 2.52 centimeters. In this case, the volume being the same, the cell area will be 38.1 square centimeters. So we find that by stretching the cell till its length was 60 per cent greater than before, we have only had to stretch the cell-walls 5 per cent. This gives us the explanation of the well-known fact that stretched rubber contracts when heated. For if we heat the cell shown in Fig. 4 the incompressible contents will expand and tend to make the cell-walls take that shape in which they can hold the most. This is obviously that of the original cube, therefore the result will be a contraction.

Of course the formulæ, derived from this theory of cohesion, give us the means of calculating the physical properties of metals which have never been examined, or even discovered. For example, it shows us that we have at our disposal a metal far superior to any metal yet known, one which is stronger than iron, lighter than aluminium, and a better electrical conductor than silver. Aluminium, in spite of its lightness, is too weak mechanically and too poor a conductor to be used in many cases. But this new metal is four times as strong as aluminium, and is twice as good a conductor of electricity. The metal referred to is glucinum or beryllium. All that is known about it is that it has an atomic weight of 9.1 and a density of 1.7 to 2, the exact figures not being known. But from these scanty data we can deduce the following figures:

Metal	Rigidity	Tensile st'gth	Conductivity	Sp. gr.
Alumin.	250×10^9	18 Kgms	50	2.75
Silver	280	27	100	10.5
Iron	750	42-65	14	8
Calculated for Glucinum	1300	65	105	2

We also see why diamond is so hard, and that there is only one other thing that might possibly scratch it, and that is a crystal of manganese. With the exception of glucinum, none of the other metals, either discovered or to be discovered, are likely to be any better than those we have now.

NOTES ON LOCAL HEMIPTERA-HETEROPTERA.

BY E. B. SOUTHWICK, PH.D.

IN the CORISIDÆ *Corisa Harrisii* Uhl. is very common in our park lakes, and the drag-net brings many of them to land at every haul. Another species as yet undetermined is about one-third the size of *Harrisii*, and equally abundant.

In NOTONECTIDÆ *Notonecta undulata* Say. is very common. This was at one time known as *variabilis* Fieb., a name quite appropriate, for they are variable to a marked degree, some of them being nearly white, while others are very dark. *Notonecta irrorata* Uhl. is also common, and is a very beautiful insect, and more uniform in coloration.

In NEPIDÆ *Ranatra fusca* Pal. Beauv. is our only representative, as far as my observation goes; this was at one time known as *R. nigra* H. Schf.

In BELOSTOMATIDÆ we have two species. *Benacus griseus* Say., that giant among Hemiptera. This much-named creature has been known as *B. haldemanus* Leidy, *B. harpax* Stal., *B. ruficeps var.* Duf., *B. distinctum* Duf., and *B. augustatum* Guer.; but at last has settled down to *B. griseus*, which name, I hope, gives credit where it belongs. *Zaitha fluminea* Say. is very common in our lakes, and the females are often taken with their backs completely covered with eggs, deposited in regular rows upon the elytra; at the same time the young of all sizes will be brought up with the drag-net.

In the family HYDRODROMICA and sub-family SALDIDÆ I have but one representative species, *Salda orbiculata* Uhl., and it is exceedingly rare.

In the sub-family HYDROBATIDÆ I have taken three species, viz., *Limnoporus rufoscutellus* Lat., *Limnotrechus marginatus* Say., and *Hygrotrechus remigis* Say; they are all about equally common on the waters of our lakes and in ditches and pools.

In the family REDUVIDÆ the sub-family PIRATINA is represented by *Melanolestes picipes* H. Schf., which is quite common under stones along with *Carabidæ*.

In the sub-family REDUVIINA we have three species. *Diplodus luridus* Stal. is very common with us, but in Professor Uhler's list it is only given as from Mexico. *Acholla multispinosa* is also common; this has been known as *A. sexspinosus* Wolff., and *A. subarmatus* H. Schf.

Sinea diadema Fabr. is not rare with us; this insect has had a number of names, and has been studied as *S. multispinosus* De G., *S. hispidus* Thunb., and *S. raptatorius* Say. I have a pair of insects from this State labelled *Harpactor cinctus* Fabr., which are probably what is now known as *Milyas cinctus* Fab. They are of a beautiful pinkish-white color, and have the limbs banded with black.

In the sub-family CORISINA three species of *Coriscus* are represented. *Coriscus subcoleoptratus* Kirby, a very common and curious insect, and formerly known as *C. canadensis* Prov., *C. annulatus* Reut, which is very rare, and *C. ferus* Linn, rather common.

In the family PHYMATIDÆ the sub-family PHYMATINA is represented by that very common and curious insect *Phymata Wolffii* Stal. *Phymata erosa*, which is quoted as common throughout the State of New Jersey, I have never found here.

In the family TINGITIDÆ and sub-family TINGITINA I have *Corythuca arquata* Say. as one of the most common. This species of Tingis is found on the butternut, and was at one time known as *Tingis juglandis* Fitch, and Dr. Riley found it on the white oak.