In No. 1 the general anatomico-physiological relations of the order are for the first time established with scientific precision, and a series of species are described accordingly. In No. 2 a very remarkable deviation of the genus *Dinophilus* is described. No. 3 contains the description of seventeen Rhabdoceles, which are all new with the exception of *Convoluta paradoxa*. In No. 4 are described nine species of Rhabdoceles from the Mediterranean, mostly from the Bay of Naples, together with some other worms. No. 5 contains the list and special description of twenty species, of which ten are new, observed in the neighbourhood of Cracow. The anatomical descriptions embrace almost all the principal genera: *Vortex, Derostomum, Mesostomum, Prostomum*. Nos. 6, 7, 8 contain researches respecting Turbellaria dendrocoela. The author has described most of the freshwater species existing in Germany, and some from Corfu.

Professor Schmidt's investigations extend to eighty species of the Turbellaria rhabdocoela, and dendrocoela, sixty-two of which were discovered by himself.

Since Quatrefages published his 'Mémoire sur les Planaries,' 1847, and Dalyell published his observations on various orders of Turbellariæ ('The Powers of the Creator,' 1851, 1853), nothing has been done either in France or England to improve the anatomical knowledge of this very attractive group. Professor Schmidt declares that he will consider it a reward for his own labours if English zoologists can be induced by means of this notice to turn their attention to the Fauna to which it refers.

The following notice of his researches has been furnished to the Foreign Secretary by M. Schrauf.

## Determination of the Optical Constants of Crystallized Substances. (First and Second Series.) By ALBERT SCHRAUF (Vienna).

In the two hitherto published series of these investigations, the data concerning the refractive and dispersive powers of twenty crystallized substances are communicated.

Being persuaded that crystallo-physics, more than any other branch of physical science, is founded on quantitative calculation of absolute exactitude, I contrived to obtain first incontestable facts

connected with the hitherto somewhat neglected phenomena of dispersion and refraction. Nearly 1000 substances have been crystallographically investigated, and about 200 have been made the object of optical researches; many of them, however, have remained unknown as to their dispersive and reflective powers, which, representing the quantitative and qualitative action of any substance on the propagation of light, are of absolute necessity for the construction of any sound theory.

It becomes every day a greater necessity to obtain, within these extensive dominions of human knowledge, a certain number of general views, subservient to the explanation and systematic arrangement of a great number of isolated facts, as only a small portion of the present investigation has led to the establishment of general laws. The great problem of crystallo-physics proposed for solution may be expressed by the question, *What is the causal connexion between chemical constitution and morphological and optical properties?* The phenomena of isomorphism, discovered by Prof. Mitscherlich, have indeed thrown considerable light on the mutual relation of chemical constitution and morphological properties; yet little, if anything, has been done to arrive at the solution of the problem in its general form.

As latterly several doubts have been expressed as to the possible existence of such a connexion, the purpose of my investigations shall be not only (as expressed in their title) to fill up deficiencies in the knowledge of facts, but also to propose several explanations indicating the real existence of such a connexion, and the necessity of making it an object of earnest research.

In the following paragraphs I intend only to mention some theorems whose solution is already achieved. Another series of my investigations, to be published subsequently, is to afford general demonstrations and applications of consequences in strict connexion with duly stated facts.

The most important of the theorems, as far as they may be simply enunciated, are—

§ 1. The calculation, graphic representation, and derivation of all the crystallographical and physical properties of the *rhombohedral system* are possible if three rectangular axes are assumed; the axis $c$ coinciding with the principal rhombohedral axis, and the axes $a$ and $b$ with the diagonals of the prism of 60°.

§ 2. The following indices represent consequently the characteristic equations for the *symmetrical* crystallographic systems:—

*Rectangular Axes.*

| | | |
|---|---|---|
| Tesseral | $a:b:c=$ | $1:1:1$ |
| Pyramidal | $=$ | $1:1:l$ |
| Rhombohedral | $=$ | $\sqrt{3}:1:l$ |
| Prismatic | $=$ | $h:1:l.$ |

§ 3. The optical axes of elasticity, coinciding with the diagonal of the prism of 60°, are nearly equal to each other, and ($\alpha$ and $\beta$ being axes of elasticity and $a$ and $b$ crystallographical axes) if limit $\frac{a}{b}$ is supposed to be $=\sqrt{3}$, then $\alpha=\beta$.

§ 4. Whenever a prism of 60° is extant in the *prismatic* system, the first median line ("bissectrice de l'angle aigu") is perpendicular to its diagonal*.

§ 5. Whenever a number of prisms of 60° are extant (110, 011, 101), the first median line stands perpendicular to the diagonals of one of these prisms, and simultaneously to the plane of cleavage.

§ 6. The first median line is generally perpendicular to the diagonal of prisms, whose limit may be expressed by simpler proportions, as $1:\sqrt{2}:\sqrt{3}:\sqrt{5}:\sqrt{7}$.

§ 7. The *dispersion* of the optical axes in the prismatic system is dependent on the magnitude of the crystallographical axis, with which the *middle axis of elasticity* is coincident.

(A) If the crystallographical axes ($d_{2m}$ being a crystallographical axis, with which coincides the *second median line* $d_\beta$, with this the *medial axis* of elasticity being coincident) are to each other as limit of the square roots of *odd* numbers, then for

$$d_\beta > d_{2m} \text{ is } \rho > v,$$
$$d_\beta < d_{2m} \text{ is } \rho < v.$$

(B) If the same axes are to each other as the square roots of *even* numbers to the *odd*, then the law of dispersion becomes the *reverse* of what it was under the first supposition (A).

* The totality of the substances belonging to the prismatic system, as far as they have been hitherto objects of optical investigation, may stand in proof and as exemplifications of the propositions enounced here.

§ 8. *Hemimorphous* substances are dependent on the *opposite* law as to the dispersion of their optic axes.

§ 9. Whenever, according to Cauchy, the index of refraction $\mu = A + \frac{B}{\lambda^2}$ (A being the coefficient of refraction and B the coefficient of dispersion), the relation between density D of the substances and the coefficients A and B is expressed by the following formulæ:

$$\int_{\lim D=0}^{D=x} 2A\,dA = \int_{\lim D=0}^{D=x} M\,dD,$$

$$\int_{\lim D=0}^{D=x} dB = \int_{\lim D=0}^{D=x} 2ND\,dD,$$

M and N remaining invariable quantities for every elementary substance. If M is made to signify *specific power of refraction*, and N *specific power of dispersion*, their values may be found out by means of the following equations:—

$$\frac{A^2-1}{D} = M, \quad \frac{B}{D^2} = N.$$

§ 10. The consequence from § 9 is, that the density of the *ether* may be set in proportion to the density of the *substances**.

§ 11. Not the *elasticity*, but rather the *density* is subject to variation (Fresnel's theory).

§ 12. The consequence of § 9 is, that the *propagation* of *light* may be equally conceived as being independent of the *luminous ether*, and only in dependence on the *substantial molecules*.

§ 13. If Fresnel's formula is derived from the principle of conservation of *vis viva*, and $\frac{A^2-1}{D}$ is substituted, a formula similar to Cauchy's in structure is thus obtained.

§ 14. In consequence of § 9, it appears possible to calculate the *density* in the three dimensions of any crystal, and to bring this new moment in connexion with the rest of the physical properties.

§ 15. The *densities* being proportional to the *masses*, and these to the *distance* $r$ of the *molecules*, the coefficient of *dispersion* must be subject to the general law of *gravitation*, and it would be admissible

* Calcareous spar, Arragonite; diamond, graphite, coal; water, ice; different varieties of topaz, beryl, apatite, &c.; and all the substances examined by Dale and Gladstone may serve as evidences and exemplifications of the above propositions.

to write
$$\frac{B}{r^2}=N.$$

It must be remarked that, in consequence of the more or less relative mobility of the molecules, N must have a different value for different substances.

§ 16. The elementary substances, according to Boedecker's theory, not entering into mutual combination with the same density and correlation of atoms as they possess in the state of liberty, it may be admitted that they are probably compelled to form *double molecules*, or *semi-molecules*. In the second case of combination the *specific power* of *refraction* would be the *double*, in the *first* only the *half* of what it was in the elementary substance, when still chemically free.

§ 17. The indices of *refraction* of *chemical* combinations and mixtures may be calculated on the supposition enounced in § 16. Absolute exactitude may be obtained for any extensive groups, of which some members, and consequently the law of their chemical combination, are known*.

The general law here is—Substances with nearly equal *powers* of *refraction* may combine without alteration in them. If these powers are very different, and far distant from each other, they tend to become homogeneous, so that the greater power of refraction is *halved*, and the lesser is *doubled* (see § 16).

§ 18. The coefficient of *dispersion* of combined substances† seems also to be derivable from the principles stated in §§ 9 and 16; as B being dependent on $d^2$, must change proportionally to the square of molecular condensation (see § 16).

§ 19. In consequence of § 9, the *lines* of Fraunhofer (although the constancy of the lengths of undulation, to which they answer, remains unaltered), when refracting substances are condensed, must advance their *centre* toward the *violet* end, in analogy to the phenomena of *absorption*, observed by Weiss (Poggendorff's 'Annalen,' 1861). For this reason *absorption* must depend on the length of the undulation.

* Evidence is afforded by Dulong's, Dale's, and Gladstone's determinations, also by *all* other, especially organic, combinations, on account of the simplicity of their formulæ; also by Deville's, Grailich's, Handl's, and Weiss's determinations concerning mixed substances.

† Our knowledge of the coefficients of dispersion proper to chemical elements being still very defective, it is impossible to bring this proposition to full evidence. Sulphuret of carbon may serve for demonstration, and similar inferences may be deduced from investigations concerning mixtures.

These propositions, and some others of similar nature which I succeeded in deriving, incomplete as they still may be in many respects, prove at all events that, even in this department of human knowledge, theoretical points of departure exist from which, by progressive investigation, the real connexion of facts may possibly be traced. My next purpose is to coordinate as much as possible whatever is at present known of facts, bringing them under general points of view as materials for a future scientific theory. I intend to publish by and by these investigations as completely as possible, in constant connexion with the phenomena which they are suited to explain, never leaving the secure foundation of experimental research.

Here I intend only to offer a brief abstract of the facts obtained through the first two series of investigations, published in the 'Proceedings' of the Vienna Imperial Academy (vols. xli. and xlii.).

These investigations took place in the Imperial Physical Institute of Vienna, and could only be effectually accomplished through the liberal and kind assistance I received from the Director of the Institute, from the Director of the Imperial Museum of Mineralogy, and from the Superintendent of the Chemical Laboratory of the Imperial Geological Institute

In these results are comprised—the exponent of refraction, the calculated axial angle, the aperture of the cone of internal conical refraction, the measure of the apparent axial angle, and crystallographical investigations.

For brevity's sake I will only communicate the exponent of refraction for Fraunhofer's lines B and H, and the most important among the crystallographical determinations.

1. Diamond. C.

$\mu_B = 2{\cdot}46062 \qquad \mu_H = 2{\cdot}51425$

2. Mellite. $Al_2O_3, 3C_4O_3 + 18HO$.

$\omega_B = 1{\cdot}53450 \qquad \epsilon_B = 1{\cdot}50785$

$\omega_H = 1{\cdot}56113 \qquad \epsilon_H = 1{\cdot}52769$

3. Acetate of Ammonia and Oxide of Uranium.

$[AmO, \overline{A} + 2(Ur_2O_3, \overline{A}) + 6HO.]$ Pyramidal.

$\omega_B = 1{\cdot}47538 \qquad \epsilon_B = 1{\cdot}48770$

$\omega_H = 1{\cdot}50687 \qquad \epsilon_H = 1{\cdot}51974$

4. Chloruret of Potassium and Cadmium. [$2KCl+CdCl$.]

Rhombohedral. $a:c=1:1\cdot6483$.

$\omega_B=1\cdot58409$ $\epsilon_B=1\cdot58420$

$\omega_H=1\cdot62083$ $\epsilon_H=1\cdot62100$

5. Chloruret of Ammonium and Cadmium. [$2NH_4Cl+CdCl$.]

Rhombohedral. $a:c=1:1\cdot5704$.

$\omega_B=1\cdot59581$ $\epsilon_B=1\cdot59610$

$\omega_H=1\cdot64142$ $\epsilon_H=1\cdot64180$

6. Nitrate of Soda. $NaO, NO_5$.

Rhombohedral. $a:c=1:1\cdot1903$.

$\omega_B=1\cdot57933$ $\epsilon_B=1\cdot33456$

$\omega_H=1\cdot62598$ $\epsilon_H=1\cdot34395$

7. Nitrate of Potash. $KO, NO_5$.

$\alpha_B=1\cdot49939$ $\beta_B=1\cdot49881$ $\gamma_B=1\cdot33277$

$\alpha_H=1\cdot54045$ $\beta_H=1\cdot53848$ $\gamma_H=1\cdot34359$

8. Citric Acid. $3(C_4H_2O_4, HO)+HO$.

$\alpha_B=1\cdot50542$ $\beta_B=1\cdot49432$ $\gamma_B=1\cdot48964$

$\alpha_H=1\cdot52541$ $\beta_H=1\cdot51398$ $\gamma_H=1\cdot50978$

9. Sulphur. S. Prismatic. $a:b:c=1:0\cdot5264:0\cdot4279$.

$\alpha_B=2\cdot22145$ $\beta_B=2\cdot02098$ $\gamma_B=1\cdot93651$

$\alpha_H=2\cdot32967$ $\beta_H=2\cdot11721$ $\gamma_H=2\cdot01704$

10. Quartz. $SiO_2$ [for control].

$\omega_B=1\cdot54106$ $\epsilon_B=1\cdot55012$

$\omega_H=1\cdot55806$ $\epsilon_H=1\cdot56758$

11. Anatase. $TiO_2$.

$\omega_B=2\cdot51118$ $\epsilon_B=2\cdot47596$

$\omega_H=2\cdot64967$ $\epsilon_H=2\cdot58062$

12. Apatite. From Tumilla.

$\omega_B=1\cdot63463$ $\epsilon_B=1\cdot63053$

$\omega_H=1\cdot65934$ $\epsilon_H=1\cdot65260$

13. Beryl. From Elba.

$\omega_B=1\cdot57028$ $\epsilon_B=1\cdot56540$

$\omega_H=1\cdot58884$ $\epsilon_H=1\cdot58261$

From Graõ Mogor, Brazil.

| | |
|---|---|
| $\omega_B = 1{\cdot}57762$ | $\epsilon_B = 1{\cdot}57148$ |
| $\omega_H = 1{\cdot}60321$ | $\epsilon_H = 1{\cdot}59542$ |

From Nertschinsk.

| | |
|---|---|
| $\omega_B = 1{\cdot}56630$ | $\epsilon_B = 1{\cdot}56105$ |
| $\omega_H = 1{\cdot}58818$ | $\epsilon_H = 1{\cdot}58393$ |

14. Carbonate of Lead. Cerussite. $PbO, CO_2$.

| | | |
|---|---|---|
| $\alpha_B = 2{\cdot}06131$ | $\beta_B = 2{\cdot}05954$ | $\gamma_B = 1{\cdot}79148$ |
| $\alpha_H = 2{\cdot}15614$ | $\beta_H = 2{\cdot}15487$ | $\gamma_H = 1{\cdot}86329$ |

15. Formiate of Baryta. $BaO\ Fo\ O_3$.

Prismatic. $a : b : c = 1 : 0{\cdot}8638 : 0{\cdot}7650$.

| | | |
|---|---|---|
| $\alpha_B = 1{\cdot}63098$ | $\beta_B = 1{\cdot}59181$ | $\gamma_B = 1{\cdot}56788$ |
| $\alpha_H = 1{\cdot}66047$ | $\beta_H = 1{\cdot}62176$ | $\gamma_H = 1{\cdot}59643$ |

16. Formiate of Lime. $CaO\ Fo\ O_3$.

Prismatic. $a : b : c = 1 : 0{\cdot}7599 : 0{\cdot}4671$.

| | | |
|---|---|---|
| $\alpha_B = 1{\cdot}57314$ | $\beta_B = 1{\cdot}50997$ | $\gamma_B = 1{\cdot}50669$ |
| $\alpha_H = 1{\cdot}59851$ | $\beta_H = 1{\cdot}52971$ | $\gamma_H = 1{\cdot}52577$ |

17. Formiate of Strontia. $SrO, Fo\ O_3 + 2HO$.

Prismatic. $a : b : c = 1 : 0{\cdot}9477 : 0{\cdot}8922$.

| | | |
|---|---|---|
| $\alpha_B = 1{\cdot}53421$ | $\beta_B = 1{\cdot}51743$ | $\gamma_B = 1{\cdot}48057$ |
| $\alpha_H = 1{\cdot}55624$ | $\beta_H = 1{\cdot}53769$ | $\gamma_H = 1{\cdot}49899$ |

18. Bimalate of Lime. $CaO, 2\overline{M} + 9HO$.

Prismatic. $a : b : c = 1 : 0{\cdot}9477 : 0{\cdot}8922$.

| | | |
|---|---|---|
| $\alpha_B = 1{\cdot}54037$ | $\beta_B = 1{\cdot}50293$ | $\gamma_B = 1{\cdot}48873$ |
| $\alpha_H = 1{\cdot}56500$ | $\beta_H = 1{\cdot}52564$ | $\gamma_H = 1{\cdot}51192$ |

19. Ferrocyanuret of Potassium. $3KCy + Fe_2\,Cy_3$.

Prismatic. $a : b : c = 1 : 0{\cdot}7725 : 0{\cdot}6220$.

| | | | |
|---|---|---|---|
| | $\alpha_B = 1{\cdot}57586$ | $\beta_B = 1{\cdot}56151$ | $\gamma_B = 1{\cdot}55913$ |
| [for D] | $\alpha_D = 1{\cdot}58306$ | $\beta_D = 1{\cdot}56888$ | $\gamma_D = 1{\cdot}56596$ |

20. Asparagine. $HO, C_8\,H_7\,N_2\,O_5 + 2HO$.

Prismatic. $a : b : c = 1 : 0{\cdot}8327 : 0{\cdot}4737$.

| | | |
|---|---|---|
| $\alpha_B = 1{\cdot}61392$ | $\beta_B = 1{\cdot}57517$ | $\gamma_B = 1{\cdot}54380$ |
| $\alpha_H = 1{\cdot}64221$ | $\beta_H = 1{\cdot}60194$ | $\gamma_H = 1{\cdot}56538$ |