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Royal Microscopical Society

CONTAINING ITS TRANSACTIONS AND PROCEEDINGS

AND

A SUMMARY OF CURRENT RESEARCHES RELATING TO

ZOOLOGY AND BOTANY
(principally Invertebrata and Cryptogamia)

MICROSCOPY, &c.

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Minimis partibus, per totum Naturæ campum, certitudo omnis innititur
quas qui fugit pariter Naturam fugit.—*Linnæus.*

FOR THE YEAR
1917

TO BE OBTAINED AT THE SOCIETY'S ROOMS
20 HANOVER SQUARE, LONDON, W.

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earlier authors. Besides the files of the species of the "Tableau Méthodique" there are files in the cases for some of his later genera, e.g. Asterigina, Candeina, Dactylopora, Gaudryina, Lituola, Ovulites, Verneuilina. These have only figures cut from publications (vi) in them.

It will be remembered that de Férussac announced to the Académie that d'Orbigny had finished "nearly half of the plates for his great work,"[1] and that Latreille announced that seventy-three plates were laid before that body. These numbers agree roughly with the above enumeration.

D'Orbigny devoted his skill as a draughtsman to every branch of science that he took up. Gaudry tells us that he made drawings with the most minute detail of nearly 900 species of Bryozoa;[2] and there are a number of cases in Professor Marcellin Boule's study, each as large as those containing the Foraminifera, filled with equally exquisite drawings of fossil Invertebrata.

VI.—The Revelations of Félix Dujardin.

Concerned as we are with the earliest records of the modern era of the study of the Foraminifera, we cannot proceed further without pausing to consider what may really be called the *discovery* of the Foraminifera in 1835 by Félix Dujardin. During the nine years which had elapsed since the publication of the "Tableau Méthodique" no general work had appeared dealing with the group — excepting, of course, the corrections and addenda of de Férussac.[3] D'Orbigny had been in South America, and had landed in France on his return on February 2, 1834. Meanwhile Dujardin had been making what must be admitted to be the first systematic observations upon the living animal, for, as Carpenter has remarked (loc. cit., *ante*, p. 11), d'Orbigny's observations at Esnandes were relatively superficial, and he had been content to

[1] I., p. 119. [2] XVI., p. 832.

[3] The Foraminifera had been noticed and figured, always, however, as microscopic Cephalopoda, in the works of Capt. T. Brown ("Illustrations of the Conchology of Great Britain and Ireland," London, 1827); of Nilsson ("Petrifacta Suecana formationis cretaceæ," Lund., 1827); of the Rev. J. Fleming ("A history of British Animals," Edinburgh, 1828); of Deshayes ("Histoire Naturelle des Vers.," Paris, 1830–32); and "Description des Coquilles caractéristiques des Terrains" (Paris, 1831); and several other works for which the student may refer to Brady's Bibliography in the 'Challenger' Monograph. In 1828 Deshayes had published in the Ann. Sci. Nat., xiv., p. 225, a "Mémoire sur les Alveolines" (referred to, *ante*, p. 19), and in 1829 Fischer de Waldheim had published a paper on his discovery in Russia of the genus Fusulina (Bull. Soc. Imp. Nat., Moscow, i., p. 329). In none of these works had any significant contributions been made to our knowledge of the group.

rest satisfied that the extruded pseudopodia were the tentacles of a Cephalopodous animal. The first announcement of Dujardin appeared in the month of January 1835 (Bibl. II.). In this note he recorded that he had had opportunities of observing living specimens of Miliolidæ (Triloculina, Quinqueloculina), Vorticialis (= Polystomella), Rotalidæ, Truncatulina, Cristellaria, and others; and he was "convinced that the shell was not internal, but, on the contrary, external, and that the animal, entirely wanting in organs of locomotion or even respiration, was composed of a succession of segments or lobes, which proceed by enlarging and enveloping one another successively. No fleshy part (*partie charnue*) is visible on the exterior excepting when a new segment is produced and is not yet invested with shell-matter (*encrouté*)." He crushed the shells, and observed that the substance of the animal is as simple as that of Planarians (*planaires*), and even of Hydra, and he was the first to decalcify the animals with weak acid, and observe that the body is "formed of a series of segments occupying all the chambers of the shell, capable of being unrolled, and presenting an aspect differing according to the genera. Thus in Miliola the segments are like spatulate leaves folded longitudinally; in Polystomella (*Vorticiale*)[1] they are pieces in the form of a V, of which the two arms embrace the preceding pieces and are bordered by lobes or crenelations; in Cristellaria the segments are crescentic, and connected with one another by fleshy tubes whose number varies from one to four, and increase successively in series of five segments. On the other hand, the Rotalia, the 'Melonies' (= Alveolina),[2] Truncatulina, etc., leave, after the treatment with acid, a transparent membrane which envelops the segments and prevents their isolation, and, furthermore, the last two have this membrane furnished with prominent tubes in the intervals of which the formation of the shell takes place." As a result of these observations he concludes that these creatures cannot be classed either with Mollusca or with any of the groups already established in the animal kingdom, and proposes for them the name "Symplectomères," indicating thereby that they are "formed of parts folded together."[3]

In June of the same year he returns to the subject (Bibl. III.).

[1] The generic name Polystomella was given by Lamarck in 1822 in substitution for his original name Vorticialis (Lamarck, "Extrait Cours Zool.," 1812, p. 122; and "Histoire des Animaux sans Vertèbres,' Paris, vii. (1822) p. 625). De Blainville in 1825 ("Manuel de Malacologie," 1825–27, p. 374, pl. vii., fig. 6) used the term Vorticialis, but d'Orbigny in the "Tableau Méthodique" restored Lamarck's name Polystomella (p. 283).

[2] As d'Orbigny justly pointed out in one of the first notes which he published on his return from America, Dujardin had mistaken something else for this genus, which is not to be found in the living condition on the shores of France.

[3] This notice appeared also in the Bulletin de la Soc. des Sciences Naturelles de France, No. 3, 1835.

He points out that the chambers of the shells are filled with a very contractile rose or orange-coloured animal-matter of the consistency of thick mucus, capable of extension in threads, and filled with irregular granulations. From the interior of Miliola he had seen protruded a soft mass analogous to the interior substance, which changed its form slowly under the Microscope.[1] He had made some observations on Miliolina, Cristellaria, and Vertebralina living on algæ at a depth of one metre. He observed that when a washing of these animals was placed in a glass vessel one sees them after a few hours attached to all its sides, independently of the direction of light, from which he concluded that they are not heliotropic.[2] He observed the pseudopodia spread out and radiating from each "centre of adherence," and that, measuring ·01 at their bases, they extended to a distance five times the diameter of the shell, becoming of extreme tenuity. By means of these pseudopodia the animal crawled at a rate of about 5–7 mm. in an hour. He made the further highly interesting observation that in time the animals crawl up to the surface level of the water and "continue to crawl along its surface hanging below it like certain gasteropod mollusca." This observation was made by myself in my tanks at Selsey in the year 1915, and does not appear to have been made by any other zoologist between 1835 and that date.

Dujardin pointed out, quite accurately, that Polystomella crawls more slowly than Miliolina, and that the form to which he had given the name *Gromia oviformis* was slower still. His account of the formation of the pseudopodia and the use made of them in crawling (*reptation*) is complete, and since his day nothing has been added to our knowledge of this phenomenon. "One cannot see in this," he says, "veritable tentacles; it is a primary animal substance which extends itself and grows somewhat after the manner of roots; the extreme slowness of the movement alone is sufficient to prove this." He then notes the fundamental difference in the manner of the extrusion of the pseudopodia in perforate and imperforate genera. He concludes, again, that they must be classed among the lowest forms of life, and regard being had to the above observations he abandons the term "Symplectomères" and proposes the name by which the group has since been known, "Rhizopoda."[3]

In a third note, published in November of the same year (1835)

[1] It will be observed that this is a new observation. He had previously said that no part of the body was extruded excepting for the formation of new chambers.

[2] This is not entirely accurate; a certain measure of heliotropism has been established by later observations.

[3] This paper attracted a good deal of attention on its publication. See notices in Le Temps (June 24) and l'Echo du Monde Savant (June 26).

in the Comptes Rendus (Bibl. IV.), he records having successfully kept Foraminifera from the English Channel alive in Paris, and calls attention to the fact that the pseudopodia are "of a glutinous consistency, almost resembling molten glass," with nodosities which move in one direction or the other; they are retractile, liable to ramify, to anastomose, and to coagulate, serving as feet by which the animal crawls, and by their appearance of radiciform fibres well justifying the name Rhizopoda." He observes that the body-plasm is identical in all species, and that it never leaves the shell excepting after the death of the animal, and he invites inspection of these phenomena by members of the Academy.

These three notes, important as they are, are really prolegomena towards a much more extended paper on the subject which was published in the Ann. Sci. Nat. in December of the same year (Bibl. V.). In this he describes how he kept Foraminifera alive in his tanks at Toulon through July and August, 1834, and others from the Channel which, collected in November, were living "in renewed sea-water" in Paris at the end of February, after all the Isopods, Annelids, and Crustacea were dead. He describes *Gromia oviformis* at length (p. 345), (and gives an admirable figure, op. cit. pl. ix. fig. 1) from tufts of *Jania rubens*, from the Mediterranean, laying stress on its rate of movement, which he states to be 1 mm. in 33 minutes. These *Gromia* must have been moribund, my observations of several years giving an average rate of progression of at least 1 cm. in an hour.[1] Nevertheless, Dujardin's notes on keeping Foraminifera alive, in this paper, may with advantage be studied by observers of these organisms in the present day. He goes on to describe the living Miliolina, and gives us the interesting information that he had shown them to d'Orbigny, on his return from South America, who recognized in the pseudopodia his "*tentacules nombreux*" of 1825,[2] blaming the imperfections of his Microscope for not having recognized their true nature.[3] Dujardin observed —and his observation has been verified by myself and others— that when a Miliolid is dying it extrudes its protoplasm in the form of "rounded and more or less symmetrical lobes," or in an expanded mass, a circumstance which had led de Blainville to connect the creatures with Planarians (*planaires*). The description which he gives in this paper (p. 348) of the protrusion of protoplasm and formation of pseudopodia is, as far as my researches enable me to say, more minute and exact than any that has ever

[1] XXVIII., p. 232. [2] I., p. 245.

[3] V., pp. 346–7. (Note.) See p. 10, where I have discussed d'Orbigny's early Microscope. The instrument which he used in his later work is now in the possession of Mme. Henri d'Orbigny, who has favoured me with a photograph which is reproduced on Plate VI, fig. 2. The maker is unknown, but Mme. d'Orbigny has understood that it was specially constructed for d'Orbigny after his return from South America in 1834. This opinion is entirely borne out by what we know of the French Microscopes of that date.

Fig. 1.

Fig. 2.

Fig. 1. The " Fleuriau de Bellevue " microscope, preserved at La Rochelle.
Fig. 2. D'Orbigny's later microscope, in the possession of Mme. Henri d'Orbigny.

been published since his day;[1] and he calls attention to their extreme tenacity when the animals are disturbed or the vessel containing them is shaken.

The question of their modes of nutrition greatly exercised his mind, and he arrived at no conclusion, stating with some pertinence "ce n'est pas expliquer une fonction que de lui assigner un appareil." In like manner he fails to come to any definite conclusion as to the reproductive processes of the Foraminifera, though he seems (p. 351) to have observed the development of amœbulæ inside a Miliolina. Finally, in this paper he notes the presence of chitinous linings to shells, both perforate and imperforate; he seems to anticipate Butschli's observations on the streaming movements akin to those of protoplasm in fine emulsions (p. 355), and for protoplasm he invents the term "sarcode," which was used for many years to designate the protoplasmic body-substance of the Rhizopoda.[2] How far his observations applied to all the forms described by d'Orbigny was, as we shall see (*post*), a matter which gave him some doubt and difficulty.[3] In this fourth paper of 1835 Dujardin first announced his recognition of the fact that *Polytrema miniaceum* (Pallas) was not a Zoophyte, but a true Foraminifer, an observation which has escaped all writers on the group, except one or two, who date his discovery from 1841 in the work abstracted in Appendix J. (see p. 102).

These observations of Dujardin, which, I agree with Carpenter, inaugurated "the third period with which our knowledge of the true nature of the Foraminifera really commenced,"[4] may be said to have been awaiting d'Orbigny on his return from South America. Later, in 1841, Dujardin found a place for the Foraminifera among the Infusoria (Bibl. VI.), though he appears to do so with some sense of incongruity. His work, "Histoire Naturelle des Zoophytes—Infusoires" (Paris, 1841), in the "Suites à Buffon," contains a recapitulation and amplification of the 1835 papers and need not concern us here, though it is of great interest, and I have given an abstract of these final conclusions in Appendix J.

Let us see what d'Orbigny had to say about it all when he returned and found his "Céphalopodes Microscopiques" tottering to an enforced abdication of their hitherto undisputed throne.

He took advantage of the first opportunity which offered itself, namely, in the Introduction to the Cuba Memoir, to point out[5] that whilst he was in America he had recognized that these

[1] Excepting, perhaps, the elaborate treatise of C. B. Reichert, "Ueber die Contractile substanz (*Sarcode, Protoplasma*) und ihre Bewegungs-erscheinungen bei Polythalamien und einigen anderen niederen Thieren," Abh. k. Ak. Wiss. Berlin, 1866, pp. 151–293 (pls. i–vii).

[2] Cf. XXI., pp. 436–7; XXIII., p. 166.

[3] See also XVII., p. 7.

[4] XVII., p. 7.

[5] VII., p. xxvii.

animals could no longer be classed with the Cephalopoda, but that owing to the press of work following upon his return he could not publish everything at once, and he was consequently anticipated by Dujardin, to whose scientific attainments he pays a well-merited tribute, recapitulating the facts recorded in his first note (Bibl. II.). D'Orbigny calls attention to the fact that he informed de Férussac of his change of opinion immediately upon his return (in February 1834), but that nevertheless de Férussac in his "Aperçu historique sur les Céphalopodes" (Paris, 1834, p. 81) republished the original error "without communicating with me," and cited the Foraminifera as the third Order of the Cephalopoda.[1] Both de Férussac [2] and de Blainville [3] expressed in Reviews the erroneous opinion that Dujardin was in too great a hurry to establish a new class of animals, the former adhering to the belief that the pseudopodia were probably Cephalopodan tentacles. D'Orbigny reviews the article in question (Bibl. III.) and calls attention to the discrepancy alluded to in note 1, p. 39, *ante*, but seems to have overlooked Dujardin's third note (Bibl. IV.). In reviewing Dujardin's fourth note (Bibl. V.) he suggests that the Foraminifer whose pseudopodia protruded from pores on the edge of the final chamber was a Peneroplis and not a Cristellaria, which may have been the case, though the aperture of Cristellaria might by looseness of diction (to which, however, Dujardin was not prone) be made to answer Dujardin's description. D'Orbigny, however, says most properly, "nevertheless these errors do not detract at all from the intrinsic merits of his observations, which are merely applicable to other genera."

We have seen (*ante*) that Dujardin exhibited his living Foraminifera to d'Orbigny; it is curious that the latter never saw or recognized the anastomosis of the pseudopodia. He records

[1] In his "Histoire Naturelle Générale et Particulière des Céphalopodes Acétabulifères vivants et fossiles" (Paris, 1834–48, i., p. 50). The omission is the more remarkable as de Férussac was cognizant of the work of Dujardin, to whom he refers, saving himself to a certain extent, however, by suggesting certain doubts as to whether the Foraminifera should form a single series, and that some have an internal, and others an external shell. De Férussac's work, however, shows other signs of carelessness; for instance, he says that Linné quoted in his synonymies Gronovius, Martini, Murray, Favanne, Schroeter, and Walker and Boys, none of whom published their works till long after the appearance of the twelfth edition of Linné. De Férussac had died in the year 1836, and d'Orbigny completed the work from notes confided to him by Mme. de Férussac in 1837. He points out in his substituted Introduction that de Férussac was always too ready to accept as new species any drawings submitted to him without comparing them with the originals, and that consequently many useless and misleading plates for his work were published in 1835, before d'Orbigny began his revision of the material. De Férussac published eleven "livraisons" of his work before his death (96 pp.), with the plates. The whole of these were suppressed by d'Orbigny, who wrote a new Introduction and Part I, dated 1839. From the twelfth "livraison" onwards the work was entirely d'Orbigny's.

[2] Magazin de Zoologie (Bulletin Zoologique), 1835, p. 104.

[3] Le Réformateur, No. 292, July 28, 1835.

Dujardin's observations,[1] and in another place [2] he says that they touch often, but are not amalgamated, and that one can follow them with difficulty until they separate again. But both here and in the Vienna Monograph [3] he falls back upon Dujardin for his general descriptions of pseudopodia.

It will be seen by what has gone before that d'Orbigny fully and generously admitted the work of Dujardin, and it is not true that (as the severe Carpenter says) [4] he ignored Dujardin's genus Gromia in all his subsequent writings. On the contrary, he calls attention to it in the Cuba Memoir,[5] both in the Introduction and the work itself, and again (practically in the same words) in the Vienna Monograph.[6]

The citation of these notes of d'Orbigny in the Cuba Memoir brings us naturally to the group of Memoirs published by him in 1839–40, of which the Cuba Memoir was probably, and is generally taken to be, the first in order of date.

VII.—The Cuba Memoir.[7]

The order of date in which the four Memoirs dated 1839–40 were actually published is wrapped in some degree of confusion, and can only be arrived at from casual notes to be found scattered through them, and from the synonymies of some of the species recorded in them. There is no doubt that immediately on his return from South America (February 2, 1834) he addressed himself to his great work on his voyage, which was not completed until 1847. He quotes the earlier volumes in the Cuba Memoir,[8] and later, in his Introduction, he says, "I am publishing at this moment three other local faunas—(1) that of the Canary Islands . . .; (2) that of South America in my 'Voyage dans l'Amérique Méridionale (*une partie spéciale*)'; (3) fauna of the white chalk of the Paris Basin." [9] The Cuba Memoir is quoted in the Canary Islands Memoir; he says [10] that he is in course of publishing it, but as he quotes it by page in his synonymies [11] it was clearly

[1] VII., p. xxix.
[2] Op. cit., p. xxxiii (note).
[3] XII., p. 5.
[4] XVII., p. 63.
[5] VII., p. xxix and p. 2.
[6] XII., pp. 3 and 20.
[7] "Histoire physique, politique, et naturelle de l'Ile de Cuba par M. Ramon de la Sagra, Directeur du Jardin Botanique de la Havane, etc. Foraminifères par Alcide d'Orbigny," Paris, 1839, 8vo, pp. xlviii and 224. With an atlas of 12 plates, large folio. There was also an edition in Spanish, 4to (180 pp.), published in Paris in 1840. This latter is the edition referred to in Brady's works; the date and the pagination differing from the French edition have introduced some confusion in references and synonymies.
[8] Vol. i. See VII., p. viii, note (1).
[9] VII., p. xlvii, note (1).
[10] VIII., p. 123, note.
[11] E.g., on pp. 124, 134.

MICROSCOPY.

A. Instruments, Accessories, etc.*

(1) Stands.

Spencer Mon-objective Binocular Microscope.† — The great feature of this instrument is that it is a binocular adapted for use with any standard microscope objective, from the lowest to the highest power oil-immersion objective. Both eyes are used at all times. The oculars are separated by simply turning a knurled ring on the right-hand tube, which is the most convenient position possible, involving a horizontal sliding movement capable of accommodating any pupillary distance from 50 to 75 mm. A knurled ring on the left tube serves as a correction collar to focus for the left eye independently of the right eye. A shutter is fitted inside, just below each eye-piece, operated by little handles at either side of the instrument. These shutters serve a double purpose—to be absolutely sure that one is seeing equally well with each eye; also, by closing of the left eye, to focus for the right eye by means of this side fine-adjustment. The tubes containing the eye-pieces are set at an angle of 4° from the perpendicular, which brings the point of convergence about 17 inches from the eye at the average pupillary distance. The eyes work normally without strain, and instantly blend the two images into one with the same ease as they do when viewing any ordinary object.

The instrument is made in two models, Nos. 1 and 2. No. 1 is fitted with a revolving mechanical stage, 120 mm. in diameter; and No. 2 has a plain rectangular stage, 110 by 112 mm.

(2) Eye-pieces and Objectives.

Notes on the Calculation of "Thin" Objectives.‡—In this paper, T. Smith arrives at formulæ for the calculation of the curves of thin achromatic objectives, when two aberration conditions have to be satisfied. A two-lens objective satisfying the conditions as a rule cannot be cemented, because the curvatures of the inner surfaces are unequal. He gives formulæ for the calculation of a triple objective satisfying the conditions, but with only two glass-air surfaces. Numerical examples are worked out, illustrating the application of the formulæ to the calcu-

* This subdivision contains (1) Stands; (2) Eye-pieces and Objectives; (3) Illuminating and other Apparatus; (4) Photomicrography; (5) Microscopical Optics and Manipulation; (6) Miscellaneous.

† Spencer Lens Co., Buffalo, N.Y., Catalogue, 1917.

‡ National Phys. Lab., Collected Researches, xiii. (1916) pp. 181–94; and Proc. Phys. Soc. Lond., xxvii. pt. 5 (1915).

lation of an astronomical object-glass, and the kinds of glass are determined with which a cemented doublet satisfies the conditions for this case.

Spencer Demonstration Ocular.*—This apparatus, as its name implies, is for demonstration purposes. It is a short tube, with an eye-piece at one end and a cap at the other. The cap is attached to the top of the body-tube of any compound microscope. The instructor looks through the eye-piece, directly over the tube, and at the same time the student looks through the eye-piece at the outer end of the demonstration ocular. A pointer, conveniently operated by a small knurled handle just below the eye-piece (over the microscope tube) is operated by the instructor, who is thus able to point to the exact detail to which he desires to call attention.

Choice of Glass for Cemented Objectives.†—It is well known that a telescope objective consisting of two compound lenses can be so constructed as to be simultaneously free from chromatic and spherical aberrations and from coma, provided proper forms are given to the components. When these are to be cemented together the three conditions can only be satisfied if a careful choice is made of the kinds of glass used. Tables have been published giving all the particulars necessary for the construction of such objectives when the corrections are required for an object at infinity. T. Smith's note, under the above title, deals with the changes in the kinds of glass to be employed when the objective is required to be free from these aberrations for objects at some finite distance.

(3) Illuminating and other Apparatus.

Spencer Delineascopes.‡—The Spencer Company have lately added Models 2 and 3 to their previous series of Delineascopes, or projection lanterns. No. 3 is a larger model than No. 2. The following notes refer to No. 2. This apparatus accomplishes both "opaque" and lantern-slide projection. The illuminated "opaque" area is 6 × 6 inches and will accommodate postcards, photographs, books, maps, small objects, etc. By an entirely new construction of base the entire operating end and sides of the apparatus are open and free from obstruction, thus facilitating ease of handling. The illumination is obtained from a Mazda bulb in its Mogul porcelain receptacle, and by an ingenious arrangement of interior mirrors the illumination of the opaque material and its screen picture is 20 to 25 p.c. more brilliant than is usually obtained with similar apparatus. The Mazda is gas-filled and of 400-volt power, and is attachable to any 110-volt incandescent lighting socket. Alternating or direct current may be used. The large projection objective is 4 inches in diameter and 16 inches equivalent focus. The method of supporting and focusing this large objective is entirely new, and is said to be free from the usual objections and to give results which are all that can be

* Spencer Lens Co., Buffalo, N.Y., Catalogue, 1917.
† National Phys. Lab., Collected Researches, xiii. (1916) pp. 197–208; and Proc. Phys. Soc. Lond., xxviii. pt. 4 (1916).
‡ Spencer Lens Co., Buffalo, N.Y., Catalogue, 1917.

desired. The change from the projection of opaque material to lantern slides, or *vice versa*, is accomplished simply by turning the handle at the side of the apparatus. The screen picture is 6 × 6 feet, while No. 3 gives an 8 × 8 feet picture.

Illumination for Distinguishing intra vitam Colour Reactions.* N. A. Cobb remarks that in order to distinguish with accuracy among

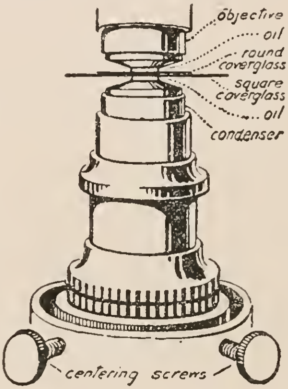

FIG. 1.

intra vitam colour reactions, it is necessary to be very particular about illumination. The best optical arrangement tried is the use of one apochromatic objective as a condenser for another apochromatic objective. The author has been using with success a 2 mm. as a condenser for a 2 mm. or 1·5 mm. apochromatic objective. This allows of fine colour distinctions being made.

The use of an ordinary apochromatic objective as a condenser neces-

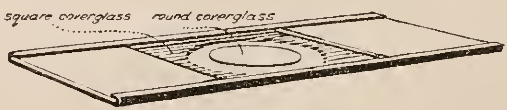

FIG. 2.

sitates the use of a special object-slide, consisting essentially of a carrier and two cover-glasses. The object is mounted between the cover-glasses (fig. 1). The substage of the microscope should have a centring arrangement and a rack-and-pinion or screw-focusing adjustment (fig. 2). A little experience with an apparatus of this sort, in which all known precautions are taken to remove colour from the optical system, leads one to distrust the ordinary Abbe substage condenser where fine distinctions are to be made between colours, especially if the colours are of similar character.

* Science, xlvi. (1917) p. 169 (2 figs.).

(4) Photomicrography.

Photographic Foucault-pendulum.*—E. F. Pigott has designed a photographic arrangement for supplementing the visual method of observation usually adopted in connexion with Foucault's well-known pendulum for demonstrating the diurnal rotation of the earth on its axis. He uses a large hollow heavy bob fitted internally with a small glow-lamp and a short focus lens. The gyrations of the light-spot are recorded on a sheet of bromide-paper placed below, and a permanent record free from personal equation is thus obtained.

Measuring the Focal Length of a Photographic Lens.†—The principal focus of a lens of focal length f is at a distance $f\mathrm{F}/f'$ from that of the combination of focal length F formed by placing in front of the first lens another of focal length f'. T. Smith points out that this suggests a simple method of finding the focal length of a photographic lens, which can be divided into two parts, each capable of producing a real image of a distant object. Let f and f' be the focal lengths of the two components, and F that of the complete lens. Set up the whole lens in the camera and focus a distant object sharply on the ground-glass. Now unscrew the front component of the lens from its mount without disturbing the rest of the lens, and measure the distance d through which the ground-glass has to be moved for the same object to be sharply focused by the back component used alone. Then $d = f\mathrm{F}/f'$. Next take the whole lens out of the camera and reverse it, so that what is usually the back component is now in front. Focus as before with the complete lens for a distant object, and measure the displacement of the ground-glass necessary to focus the same object when the component now in front is removed. Denote this by d', then $d' = f'\mathrm{F}/f$; and, therefore, $\mathrm{F}^2 = dd'$. This method avoids the difficulty of measuring exactly a transverse magnification, and also is not subject to errors arising from want of parallelism of object and image, from distortion and other oblique aberrations. The author gives several developments of his method.

(5) Microscopical Optics and Manipulation.

Tracing Rays through an Optical System.‡—The most troublesome calculations which have to be made in computing an optical system are those relating to rays not lying in an axial plane. The methods hitherto used are trigonometrical, and the formulæ most extensively employed are those of Von Seidel; but T. Smith points out that, although these equations have the advantage of being in a form suitable for logarithmic computation, the process is very tedious—nine equations have to be solved for each surface—and the method does not readily indicate what modifications should be made in the system when the ray does not emerge as is desired. An algebraic method is preferable, pre-

* Journ. and Proc. New South Wales, l. (1916) pp. 262–9 (1 pl.).
† National Phys. Lab., Collected Researches, xiii. (1916) pp. 167–8; and Proc. Phys. Soc. Lond., xxvii. pt. 2 (1915).
‡ National Phys. Lab., Collected Researches, xiii. (1916) pp. 171–7; and Proc. Phys. Soc. Lond., xxvii. pt. 5 (1915).

cisely because it is free from this objection, and the fact that it is not as well suited for logarithmic work is of no importance where a calculating machine is employed. The author proceeds to develop his algebraical equations, which have the advantage of checking one another. Moreover, if the performance of the optical system should prove unsatisfactory, it is probable that a comparison of certain corresponding quantities would suggest what modifications are necessary to amend the system in the direction desired.

(6) Miscellaneous.

Ultra-microscopic Investigation of the Tanning Process in Jellies.*—W. Moeller gives a further description of the conditions of formation of laminated structures in the action of aqueous solutions on jellies. The formation of an insoluble salt by the interaction of an electrolyte in the aqueous solution and a second electrolyte in the jelly is not an essential condition in the production of such structures. It has been found that an aqueous solution of silver nitrate when left in contact with a gelatin jelly containing no added electrolyte gives rise to the formation of alternating layers. The laminated structure would seem to be produced when any ionizable salt diffuses into a jelly. The same heterogeneous structure results when gelatin jellies are subjected to the action of tanning solutions. It is considered that the ultra-microscopic observations cannot be interpreted satisfactorily in terms of the hypotheses previously set forward, and that the rhythmic lamination can only be accounted for in terms of the structure of the jelly. The author's view that gelatin consists of a fibrillated substance (α-gelatin), the spaces between the fibrils being filled by a structureless substance (β-gelatin), is made the basis of an explanation of the rhythmic effects which are the result of the diffusion processes which occur when jellies are brought into contact with solutions of salts.

B. Technique.†

(1) Collecting Objects, including Culture Processes.

Medium for obtaining Anaerobes in Exudates.‡—E. S. Harde finds that the following medium gives good results :—20 p.c. gelatin to which is added 2 c.cm. of beef or veal. The tubes are then incubated at 37·5. It is important to sow the tubes with much exudate. Pure cultures are then made in the usual way.

Method for the Rapid Determination of Bacillus diphtheriæ.§—S. Costa, J. Troisier, and J. Dauvergne use the following medium :—Horse

* Kolloid Zeitschr., xx. (1917) pp. 257–70. See also Journ. Chem. Soc., ii. (1917) p. 454.

† This subdivision contains (1) Collecting Objects, including Culture Processes; (2) Preparing Objects; (3) Cutting, including Embedding and Microtomes (4) Staining and Injecting; (5) Mounting, including slides, preservative fluids, etc. (6) Miscellaneous.

‡ C.R. Soc. Biol. Paris, lxxx. (1917) p. 661.

§ C.R. Soc. Biol. Paris, lxxx. (1917) pp. 678–80.

serum, 100 c.cm.; glucose, 30 p.c., 10 c.cm.; tincture of litmus, 30 drops; sulphuric acid, 1 p.c., 3 c.cm. This medium is distributed into Petri capsules and then coagulated in an autoclave for seventy-five to eighty minutes. On removal from the autoclave the condensation is poured off, and if necessary the capsules are dried in a stove. In this medium the diphtheria colonies are red, the diphtheroids blue, while the contaminations do not grow at all or very scantily.

Amygdalin as Nutriment for Aspergillus niger.*—H. J. Watermen states that earlier observations have shown that amygdalin is resolved into dextrose, benzaldehyde and hydrogen cyanide by the extract from the cells of *Aspergillus niger*. This does not occur with the living cells, and in these circumstances the amygdalin is absorbed and assimilated by the mould which multiplies in the amygdalin solution. The experiments now described show that the organism will not develop if any considerable proportion of the amygdalin is already hydrolysed. The retardation is mainly due to the benzaldehyde, the action of which is possibly due to its ready solubility in fats, and on the other hand to its rapid oxidation to benzoic acid. The behaviour of amygdalin and its products of hydrolysis towards the cells of *Aspergillus niger* affords an indication of a general method for the introduction of narcotic substances into living organisms.

Spirochæta forans.†—H. Reiter has isolated an organism, which he calls *Spirochæta forans*, from the venous blood of a patient suffering from pains in the joints, splenic enlargement, conjunctivitis, cystitis and fever of a week's duration. The organism grew freely in ascitic fluid broth and stained readily with alcoholic fuchsin, methylen-blue and Giemsa. The number of coils displayed by the parasite vary with the age of the cultures, the younger forms having the appearance of vibrios. The fully grown *S. forans* is similar in appearance to *Treponema pallidum*, but is stouter and stains with less difficulty.

Growth of Anaerobic Bacilli in Fluid Media under apparently Aerobic Conditions.‡—S. R. Douglas and others record experiments which demonstrate that anaerobic bacilli will grow both more rapidly and also from a smaller implantation when, in addition to the usual anaerobic conditions, some porous substance, such as potato or asbestos wool, is added to the culture medium.

Action of Spinal Fluid in Stimulating the Growth of the Meningococcus.§—C. Shearer records experiments the results of which show that there is present in normal spinal fluid some substance that greatly increases the rate of growth of the meningococcus on an artificial culture medium. They clearly demonstrate that this power, in the case of human spinal fluid, is relatively greater than that shown by blood or

* Proc. K. Akad. Wetensch. Amsterdam, xix. (1917) pp. 922–7. See also Journ. Chem. Soc., i. (1917) p. 502.
† Centralbl. f. Bakt., 1te Abt. Orig., xxxix. (1917) pp. 176–80.
‡ Lancet, Oct. 6, 1917, pp. 530–2.
§ Lancet (1917) ii. pp. 714–5.

nasal secretion ; that, volume for volume, spinal fluid brings about a much thicker growth of the meningococcus than do the same volumes of blood or nasal secretion.

Bertetti, E., & G. Finzi—**Sulle proprietà dei sieri di animali iperimmunizati contra la morva e sulla scelta degli animali per la preparatione di sieri ricchi in anticorpi antimorphosi.**
[Deals with the possibility of obtaining anti-glanders sera from various animals.] *Atti d. R. Accad. d. Lincei*, xxvi. (1917) pp. 131–5.

(2) Preparing Objects.

Investigating Cytoplasmic Inclusions of Germ-cells.* — J. B. Gatenby fixed most of his material, germ-cells of Lepidoptera, in strong Flemming without acetic acid, or in Champy's fluid. Sections were stained on the slide with iron-hæmatoxylin, Ehrlich's hæmatoxylin and Orange G, methyl-blue eosin, Mayer's acid hæmalum, pyronin and methyl-green, Breinl's process, or the carmin stains. Alizarin and crystal-violet and iron-hæmatoxylin were used especially for mitochondria.

Regaud's formol bichromate gave useful results with smears of testes. These were first fixed in osmic vapour, and then soaked for a short time in Regaud ; afterwards they were placed in 90 p.c. alcohol for several hours. They were then stained in iron-hæmatoxylin. As a rule in such preparations the mitochondria alone were stained. Afterwards Bensley's permanganate of potash and fuchsin stain was used, but no stain was found to approach iron-hæmatoxylin for certainty and usefulness.

Investigating Pharyngeal Gland-cells of Earthworms.† — J. Stephenson employed Zenker's fluid and sublimate-acetic for fixing the embryos and smaller worms, including the adults of *Helodrilus parvus* ; some specimens of *Pheretima* were similarly treated. Narcotization with chloreton and fixation by 10 p.c. formalin were employed for most of the adult specimens of *Pheretima* and *Helodrilus caliginosus*. For staining, the most generally useful method is some degree of overstaining with Delafield's hæmatoxylin, differentiation with acid-alcohol, and counter-staining with alcohol-eosion. Dobell's modification of Heidenhain's iron-hæmatoxylin method also gave excellent results. In addition, Heidenhain's original chrom-hæmatoxylin method was used. This gave unsurpassed differentiation of epithelial cells (skin, pharynx, œsophagus), but was useless for the cells of the pharyngeal mass. Van Gieson's stain and borax-carmin, followed by picro-indigo carmin, were useful in differentiating the connective-tissue, and in distinguishing it from the muscular fibre.

Maclicquer, J.—**Instructions for the Collection, Preparation, and Conservation of Marine Animals.**
[The instructions are copious and careful, and the monograph is illustrated with numerous engravings.]
Publicaciones de la Junla de Ciencies Naturalo di Barcelona, i. (1917), 55 pp. (3 pls.).

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* Quart. Journ. Micr. Sci., lxii. (1917) pp. 412–3.
† Quart. Journ. Micr. Sci., lxii. (1917) pp. 260–1.

(4) Staining and Injecting.

Solution for Staining Protozoa and Blood-corpuscles.* — T. Watabiki makes the solutions in the following way:—Solution 1: methyl-blue (sic) 1; absolute alcohol, 10; carbonate of soda, 1; distilled water, 90. This mixture is incubated for two days at 37° C. Solution 2 consists of yellow water-soluble eosin, 1; distilled water, 200. The two solutions are mixed, and then incubated for twenty-four hours at 37° C. The dry powder, 0·3–0·5 grm., is called methylen-azureosine. The final solution consists of methylen-azureosine, 0·5; methyl-alcohol, 150; neutral glycerin, 150. Staining of preparations is done in the usual way. Leucocytes and bacteria stain in three to five minutes; Protozoa take from five to thirty minutes.

Demonstrating the Presence of Spirochætes in the Urine in Cases of Trench Fever.†—A. T. Nankivell and C. E. Sundell adopted the following procedure:—Ten c.cm. of urine are centrifuged at high speed for fifteen minutes. The supernatant fluid is pipetted off and 5 c.cm. of distilled water added. The fluid is again centrifuged for fifteen minutes and the supernatant fluid pipetted off. Films are then made by placing three loopfuls on a slide. The preparation is then dried in an incubator. The majority of the specimens were stained by a modified Fantana silver method. The film is washed for two minutes with a solution of 8 p.c. formalin and 1 p.c. glacial acetic acid. The film is then washed in absolute alcohol, and when nearly dry is washed with distilled water and then flooded with a hot 5 p.c. solution of tannic acid, containing 1 p.c. of carbolic acid. After allowing the mordant to act for two minutes the film is washed in distilled water. A 2 p.c. silver nitrate solution, to which a trace of ammonium hydrate is added, is pipetted over the film until a dark brown colour is obtained. The slide is then washed with distilled water and afterwards dried in a current of cold air. The film should be mounted in Canada balsam. The spirochætes appear jet black against a grey or brown background. With dark ground illumination they are white. With Giemsa's stain they stain pale red with a tinge of blue, but with dark ground illumination they are yellow. An alternative staining to Fontana or Giemsa is carbol-fuchsin. The spirochætes stain pink by this method.

(6) Miscellaneous.

Micro-chemical Reaction for Calcite.‡—St. J. Thugutt states that calcite when intermixed with zeolites can be recognized by the following reactions: The powdered mineral (grains about 0·1 mm. diam.) is heated on platinum foil over a Tecla burner for fifteen seconds and then treated with N/10 cobalt nitrate. The calcite becomes coated with a thin skin of blue basic cobalt salt, whilst the zeolites are unaffected. Removing

* Kitasato Archives of Exper. Med., i. (1917) pp. 153–6.
† Lancet (1917) ii. pp. 672–4.
‡ Journ. Chem. Soc., ii. (1917) p. 508.

excess of the cobalt solution and adding N/10 silver nitrate, the bases of the zeolites are soon replaced by silver (diluted with potassium chromate), whilst the basic cobalt salt becomes black, owing to the formation of $Co(OH)_3$, and this quickly reduces the silver salt, producing a deposit of metallic silver on the calcite.

Metallography, etc.

Ancient Peruvian Bronzes.*—A detailed description is given by C. H. Mathewson of the results of a metallographic examination of a number of ancient bronze articles collected at Machu Picchu, in Peru, by the National Geographic Society—Yale University Peruvian Expedition of 1912. In the first part of the paper the author points out the possibilities and limitations of metallographic investigations in regard to the determination of the past history of such specimens. The investigation has revealed a considerable amount of knowledge concerning the methods used by the Incas in producing the articles—e.g. conditions of casting, mechanical working, and annealing—but it is not possible by metallographic methods alone to establish their age. Chemical analyses of the articles studied are given. They were irregular in composition, ranging from 3 to 13 p.c. tin, but they were remarkably pure. Their purity, together with the fact that one article consisted of practically pure tin, leads to the conclusion that the Incas were acquainted with tin in an elementary state, and that the bronzes were made by alloying purified copper and tin and not by smelting the mixed ores. All contained a certain amount of sulphur, some much less than others, recognizable under the microscope as cuprous sulphide. There is evidence that the Incas had attained considerable skill in the art of casting, but they were not acquainted with the use of addition agents for deoxidizing purposes, as the castings are frequently unsound and consequently lacking in hardness and strength. Perforations were obtained by casting rather than by mechanical means, thus avoiding the difficulty of obtaining tools to pierce such a tough material as bronze. No evidence was obtained that the articles had undergone any special heat treatment. The structures were generally non-uniform and of small grain size, such as is characteristic of bronze worked at low temperatures. The author discusses in general the relation between the rate of grain-growth in bronze and temperature of annealing, time of annealing, and extent of cold-work previously received, in connexion with its bearing upon the interpretation of the structures of the ancient bronzes. Numerous photomicrographs of etched sections taken from the articles investigated are given, together with diagrams illustrating the articles, and the positions to which the etched sections correspond.

Methods and Results of Etching.†—A general account of the methods of metallographic etching and etching phenomena is given by

* Amer. Journ. Sci., xl. (1915) pp. 525–98 (46 figs.).
† Stahl und Eisen, xxxv. (1915) pp. 1073–8, 1129–35 (21 figs).

J. Czochralski. Three types of etching are distinguished and discussed: (1) crystal-boundary etching, (2) crystal-field etching, (3) crystal-figure etching, each type being illustrated by photomicrographs. The effect of cold-working upon structure is considered. The last part of the paper is devoted to a discussion of the methods of polishing specimens, and the application of different etching reagents, including heat-tinting and electrolytic methods of etching. A table is included which shows the reagents to be used to bring about the three types of etching for most of the common metals and their alloys.

Alloys of Iron and Boron.*—The constitution of alloys of iron and boron containing up to 11 p.c. boron have been studied by N. Tschischewsky and A. Herdt, by taking cooling curves and by microscopic examination of a series of alloys, which were prepared by melting together pure Swedish iron and requisite amounts of ferro-boron containing 23·7 p.c. boron. For the examination of structures the alloys were slowly cooled, and etched with sodium-picrate. The polished surfaces of eutectic alloys present a more "pearly" appearance than the corresponding steels, so that the eutectic can be termed "boron pearlite." This eutectic becomes perceptible at 0·08 p.c. boron, and appears as thin pearlitic lines separated by masses of ferrite. As the boron-content increases, the pearlitic veins increase in width, till at 3·1 p.c. boron the eutectic composition is reached. With further increase in boron-content crystals of boride (Fe_2B) appear. The boride assumes well-defined prismatic forms, and is coloured, when etched, with sodium-picrate, and may be termed "boron cementite." The alloy containing 8·85 p.c. boron consists entirely of long prismatic crystals of the boride. Polished sections of alloys exceeding 9 p.c. boron were very difficult to prepare owing to brittleness. The equilibrium diagram prepared from the results shows the formation of a eutectic on solidification at 3·1 p.c. boron and a temperature of 1135° C. All alloys show a change in the solid at about 760° C., corresponding to the transformation of gamma- to alpha-iron.

Cementation of Iron by Hydrocarbon Gases.†—F. C. Langenberg describes experiments with a specially designed electric furnace in which specimens of pure iron were subjected to the action of (1) illuminating gas, (2) acetylene, under varying conditions with regard to temperature, time, rate of flow and pressure. The furnace could be evacuated before heating up, thus no oxidation of the specimens occurred, and the amount of carbon absorbed was determined by noting the increase of weight and the depth of the cemented case by the microscopic examination of transverse sections. Under certain conditions it is shown that the gases actually exert a decarburizing action. This occurs with slow rates of flow, and is due to deposition of carbon from the gas before reaching the temperature of the hot portion of the furnace. A specimen of white iron was reduced in carbon-content from 2·5 to 6·5 p.c. by this action. The structure of the decarburized white

* Rev. Soc. Russ. Métallurgie, i. (1915) pp. 535–46, through Rev. Métallurgie xiv. (1917) Extraits, pp. 21–7 (7 figs.).

† Journ. Iron and Steel Inst., xcv. (1917, 1) pp. 129–53 (12 figs.).

iron and of other decarburized specimens showed peculiar streamers of ferrite running from the edge to the centre. By inserting a length of solid carbon in the hot part of the furnace this decarburizing action was avoided. The degree of carburization was found to increase with increase of rate of flow of gas, temperature and pressure. A sudden increase in the amount of carbon absorbed occurred between 890° and 900°, which is considered to correspond with the beta-gamma allotropic change in pure iron. There is a limiting temperature between 710° and 810° below which carburization will not occur. The effect of pressure holds up to a critical value (which varies with the temperature) beyond which increase of pressure has very little effect. The character of the cemented cases does not conform to the prevailing view that hydrocarbons give cases high in cementite. With atmospheric pressure the carbon-content of the case did not exceed the eutectoid ratio under any conditions, and hypereutectoid layers in the case were only obtained by the use of high pressures. Several photomicrographs are given illustrating the character and depth of cemented cases produced under different conditions.

Influence of Surface-tension on the Properties of Metals.*—A further acconnt is given by F. C. Thompson of the theory of the existence of surface-tension forces operating in metals at the junctions between the crystals and the inter-crystalline films of amorphous modification. The author also replies to criticism of the views previously put forward. Analogies are drawn from the phenomena noted with metallic crystals in the presence of the liquid metal. The rounding of the angles of dendrites of metals, such as lead and tin, withdrawn from the residual liquor during solidification, is attributed to similar surface-tension forces acting between the liquid amorphous condition and the solid crystalline condition. Explanations are given, based on the theory, of the structural re-arrangements which follow the annealing of plastically deformed ferrite and of other phenomena. Surface-tension forces are at work in the granulation of pearlite produced by long annealing of high carbon steels at temperatures of about 650° C., as an examination of structures intermediate between the lamellar and spheroidal forms shows that the carbide plates break up into drops before coalescence occurs.

* Journ. Iron and Steel Inst., xcv. (1917, 1) pp. 155-74 (7 figs.).